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Taxonomy Research in Information Systems: A Systematic Assessment

by

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TAXONOMY RESEARCH IN INFORMATION SYSTEMS: A SYSTEMATIC ASSESSMENT

Research paper

Abstract

Sensemaking is gaining importance in today's world that is changing at unprecedent speed and scale. Taxonomies represent an important tool for understanding and analyzing complex domains based on the classification of objects. In the Information Systems domain, Nickerson et al. (2013) were the first to propose a taxonomy development method, addressing the observation that many taxonomies have been developed in an 'ad-hoc' approach. More than five years after Nickerson et al.'s (2013) publication, we examined to what extent recently published taxonomy articles account for existing methodological guidance. Therefore, we identified and reviewed 33 taxonomy articles published between 2013 and 2018 in leading Information Systems journals. Our results were sobering: We found few taxonomy articles that followed any specific development method. Although most articles correctly understood taxonomies as conceptually or empirically derived groupings of dimensions and characteristics, our study revealed that the development process often remained opaque and that taxonomies were hardly evaluated. We discuss these findings and potential root causes related to method design, method adoption, and the general positioning of taxonomy research in the Information Systems domain. Our study proposes stimulating questions for future research and contributes to the Information Systems community's progress towards methodologically well-founded taxonomies.

Keywords: Taxonomy, Typology, Method, Literature Review.

1 Introduction

The world is changing at unprecedent speed and scale, among others driven by digital technologies being adopted in individual, organizational, and societal contexts (Berger et al.; Legner et al., 2017). Hence, volatile, uncertain, complex, and ambiguous environments are emerging together with new technology-driven phenomena (Berinato, 2014). Examples include the 'sharing economy' enabled by digital platforms and 'the fourth industrial revolution' powered by the Internet of Things (Wollschlaeger et al., 2017; Zhang et al., 2018). As understanding the multitude of new and fast-evolving phenomena is crucial for society and research as pre-requisite for further theorizing, tools for sensemaking and analyzing gain importance. In particular, the Information Systems (IS) domain linking 'the natural world, the social world, and the artificial world of human constructions' (Gregor, 2006, p. 613), is at the forefront of developing tools to support sensemaking in the context of socio-technical change (Rowe, 2018). Along these lines, taxonomies represent an important tool for understanding and analyzing complex phenomena based on the classification of objects (Nickerson et al., 2013).

Other disciplines such as natural or social sciences have already engaged extensively in classifying objects of interest into taxonomies to structure knowledge. Presumably, the most prominent example is the periodic table which can be viewed as a taxonomy of elements facilitating the understanding of chemistry (Nickerson et al., 2013). Often used synonymously with terms such as typology or framework, taxonomies have also found their way into the IS domain where the number of IS articles referring to taxonomies (and typologies) has grown significantly (i.e., more than 20%, for details refer to section 3). Examples include taxonomies of digital technologies (Berger et al., 2018), monitoring and controlling systems (Cram and Brohman, 2013; Iannacci and Cornford, 2018) as well as digital marketplaces and platforms (Ghazawneh and Henfridsson, 2015; Guo et al., 2014; Kazan et al., 2018). Taxonomies are empirically or conceptually derived groupings (Nickerson et al., 2013). From a theoretical standpoint, taxonomies on the one hand represent conceptual knowledge as the basis for theory development beyond analysis, e.g., for predicting phenomena or designing artifacts (Gregor and Hevner, 2013; Iivari, 2007). On the other hand, taxonomies are design artifacts themselves (i.e., models) which enable classifying existing and future objects (March and Smith, 1995; Oberländer et al., 2018).

In the IS domain, Nickerson et al. (2013) were the first (and only) to propose a taxonomy development method addressing the observation that many IS taxonomies have been developed in an 'ad-hoc' approach rather than following a systematic and replicable method. Nickerson et al.'s (2013) method incorporates taxonomy development methods from other disciplines, e.g., Doty and Glick (1994) and Bailey (1994). Their iterative seven-step method allows for an inductive as well as a deductive approach. Since the method's publication in the *European Conference on IS proceedings* and the *European Journal of Information Systems (EJIS)* Nickerson et al.'s (2009, 2013) work has been cited more than 300 times indicating substantial diffusion and impact. We know little, however, about how and to what extent existing methodological recommendations on taxonomy development have been adopted in IS research and to what extent IS taxonomies have been developed in a systematic and replicable approach. Hence, we think it is the right time to examine and reflect the current state of taxonomy research in IS and ask the following research question: *To what extent do recently published taxonomy articles in the IS domain account for existing methodological guidance?*

To answer this question, we identified and reviewed 33 taxonomy articles published between 2013 and 2018 in leading IS journals. Following Nickerson et al. (2013), we treat the terms 'taxonomy' and 'typology' synonymously. The review of the taxonomy articles followed iteratively developed assessment attributes building on and extending Nickerson et al.'s (2013) methodological recommendations. This review helps identify patterns and trends in IS taxonomy research and leads to stimulating questions that contribute to the IS community's progress towards methodologically well-founded taxonomies.

The remainder of this article is structured as follows: First, we set the stage by introducing existing taxonomy development methods, in particular Nickerson et al.'s (2013) work. Then, we outline our research method, namely how taxonomy articles were selected and how assessment attributes were developed and applied. We then present and discuss our results. We conclude by highlighting limitations and stimuli to further research.

2 Background

This section sets the stage by firstly reviewing relevant terminologies and by secondly introducing and comparing existing taxonomy development methods in IS and other disciplines.

In the literature, the terms 'framework', 'classification scheme/system', 'typology', and 'taxonomy' are often used interchangeably. On a high level of abstraction, a framework is referred to as a 'set of assumptions, concepts, values, and practices that constitutes a way of understanding the research within a body of knowledge' (Schwarz et al., 2007, p. 41). In a similar way, a unidimensional or multidimensional classification scheme/system organizes knowledge of a field by following specific decision rules to group similar objects into classes (Bailey, 1994; Doty and Glick, 1994). Researchers such as Bailey (1994) and Doty and Glick (1994) describe both typologies and taxonomies as groupings for objects, but differentiate whether these groupings are conceptually derived (i.e., typology) or empirically derived (i.e., taxonomy). Despite this theoretical differentiation, the most commonly used term in the IS literature is 'taxonomy' for both conceptually and/or empirically derived groupings.

Due to many technology-driven changes in recent years, the IS discipline is increasingly asked to analyze, understand, structure, and explain emerging phenomena. However, a sound taxonomy development method has been missing in the IS context (Nickerson et al., 2013), whereas other disciplines such as biology (e.g., Eldredge and Cracraft, 1980; Sokal and Sneath, 1963), social sciences (e.g., Bailey, 1994), and organization (e.g., Doty and Glick, 1994) have extensively studied, developed and refined taxonomy development processes.

For instance, Doty and Glick (1994) introduce 'organizational typologies' as complex theories and demonstrate how resulting conceptual models can be quantitatively evaluated. The authors strongly focus on the concept of taxonomies as 'ideal types' (i.e., unique manifestations of dimension-characteristic combinations) from which real-world objects can deviate. Doty and Glick (1994) do not elaborate on a step-wise taxonomy development method, but rather propose general guidelines for the development process. First, researchers should explicitly mention their grand theoretical assertion. Second, taxonomies must define the complete set of ideal types. Third, researchers must provide complete descriptions of each ideal type by using exactly the same set of dimensions. Fourth, assumptions about the theoretical importance of each dimension need to be stated explicitly. Fifth and finally, taxonomies must be tested with conceptual and analytical models that include the entire set of ideal types.

In social sciences, Bailey (1994) describes two different and mutually exclusive approaches for taxonomy development, the conceptual and the empirical approach. In the conceptual approach, the taxonomic structure is deducted from a theoretical foundation. Researchers can start with one single type, which is then complemented by additional dimensions until saturation and completeness are reached. Alternatively, researchers can start with an over-specified taxonomy before dimensions are eliminated in a step-wise procedure until the artifact is sufficiently parsimonious. In the empirical approach, researchers develop the grouping inductively via statistical, data-based methods such as cluster analysis.

In the IS context, Nickerson et al. (2013) examined taxonomy literature finding that taxonomy development was largely ad-hoc and rarely based on a systematic method. To address this finding, they proposed a systematic, iterative seven-step method that integrates both empirical (i.e., inductive) and conceptual (i.e., deductive) approaches. Thereby, Nickerson et al. (2013) incorporated extant methodological recommendations for taxonomy development from other disciplines, particularly from Doty & Glick (1994) and Bailey (1994) as described above. Their work was first published as conference article in the *European Conference on IS proceedings* (Nickerson et al., 2009), before the journal version appeared in *EJIS* (Nickerson et al., 2013). In this work, we consistently refer to the latter version as the more extensive one that has received significant attention by the IS community (>280 citations).

As shown in Figure 1, the taxonomy development method of Nickerson et al. (2013) starts with the *determination of a meta-characteristic* that is derived from the purpose and future users of the taxonomy. It shall prevent researchers from 'naïve empiricism' in which large amounts of characteristics are randomly examined. Each added characteristic of the taxonomy should be 'a logical consequence of the meta-characteristic' (Nickerson et al., 2013, p. 343). Due to its critical impact on the final taxonomy, the meta-characteristic must be chosen carefully. In the second step, researchers define objective and subjective *ending conditions* for which the iterative taxonomy development method terminates. As different ending conditions may lead to different taxonomies, researchers might want to rely on commonly used ending conditions. Nickerson et al. (2013) therefore propose a list of eight objective and five subjective ending conditions. As a third step, researchers have to decide on the *approach* for the first/next iteration. In contrast to Bailey's (1994) method for taxonomy development, Nickerson et al.'s (2013) method allows the combination of inductive and deductive iterations that each consist of three steps. Researchers are advised to choose an *empirical-to-conceptual* (i.e., inductive) iteration if they have little understanding of the research domain, but if data of real-world objects are available. In this case, a *subset of objects* is randomly, systematically, or conveniently drawn. Then *specific characteristics* that discriminate among the objects are derived from the meta-characteristic and *related characteristics are grouped into dimensions*. Ultimately, each dimension should consist of mutually exclusive and collectively exhaustive characteristics. For deriving the characteristics or for grouping the characteristics into dimensions, further methods can be applied (e.g., Delphi method, statistical techniques) to substantiate the researchers' knowledge and results. If no sufficient data are available, as for example the phenomenon under investigation is newly emerging, or if the researchers already have a substantial understanding of the phenomenon, they are advised to choose the *conceptual-to-empirical* (i.e., deductive) approach. It starts with the *conceptualization of new characteristics (and dimensions)* based on potential similarities and dissimilarities among objects. Researchers thereby rely on their experience and knowledge built from the literature. As before, characteristics of each dimension must be mutually exclusive and collectively exhaustive. The meta-characteristic can provide guidance on the relevance of characteristics. In a next step, researchers *examine objects for these characteristics and dimensions* to examine whether real-world objects occupy all characteristics and dimensions or if characteristics need to be eliminated, refined, or added. The result after each empirical-to-conceptual or conceptual-to-empirical iteration is a *(revised) taxonomy* that is followed by researchers *reviewing ending conditions*. The taxonomy development process continues with the next iteration until all ending conditions are met. Upon finalization of the taxonomy, Nickerson et al. (2013) stipulate an evaluation of the artifact with regards to the 'usefulness for the intended users and the intended purpose' (Nickerson et al., 2013, p. 353).

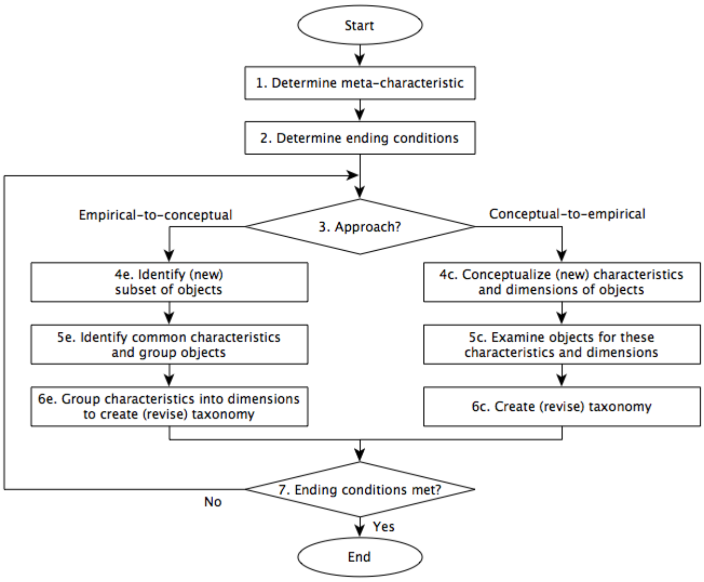

Figure 1. Taxonomy development method by Nickerson et al. (2013)

With their iterative method, Nickerson et al. (2013) provided the first and so far only well-conceived taxonomy development method in the IS context. Their methodological recommendations on the development of useful tools for sensemaking facilitate theories for analysis and beyond.

3 Research Method

We identified and reviewed taxonomy articles from leading IS journals to examine to what extent recently published taxonomy articles account for existing methodological guidance. Below, we first outline our literature review to identify and select the taxonomy articles for our research. Second, we outline the development and application of our assessment attributes.

3.1 Identification of Taxonomy Articles

To identify relevant taxonomy articles in the IS domain, we performed a structured literature review following Webster and Watson (2002) as well as Vom Brocke et al. (2015). First, we specified search terms and time frame based on our research question. Second, we excluded articles that did not comprise a taxonomy as an artifact and/or did not fit our research question.

In order to get an overview of taxonomy literature in IS before and after the publication of Nickerson et al.'s (2013) taxonomy development method in *EJIS*, we utilized a broad set of synonyms and a large time frame. We started our literature review with the search terms 'taxonom*', 'typolog*', 'classif*', and 'framework*' in abstract, keyword, and title as all four terms are viewed as synonyms (Nickerson et al., 2013). To cover an equal timespan before and after Nickerson et al.'s (2013) methodology publication in *EJIS*, our search referred to the years 2007 (January) until 2018 (September). Further, we selected the IS Senior Scholars' Basket of Journals (AIS, 2011) as well as the five leading IS conferences (AMCIS, ECIS, ICIS, PACIS, and HICSS) as sources. Based on the outlined broad search strategy, we found more than 4,500 articles whereas more than 4,000 referred to the terms classification and framework. Considering their over-proportional number of articles and the terms' ambiguous definitions, we decided to follow Nickerson et al.'s (2013) search strategy and focus on taxonomy and typology articles treating 'taxonomy' and 'typology' as synonyms. Table 1 illustrates the distribution of the remaining 216 articles distinguishing between taxonomies and typologies as well as publication period (before and after the publication of Nickerson et al.'s (2013) taxonomy development method). In total, the number of articles has grown by 23% mainly driven by conference publications and articles referring to the term 'taxonomy'. Based on this rising number of taxonomy articles, we can assume rising relevance of taxonomies in the IS domain. Of course, empirically justified statements require further investigations.

Search string	Publication in	Period I: 2007-2012	Period II: 2013-2018
taxonom*	IS Basket of 8	18	**16**
	IS Conferences	79	112
typolog*	IS Basket of 8	13	**14**
	IS Conferences	66	74
	Sum	**176**	**216 (+23%)**

Table 1. Overview of taxonomy literature in the IS domain between 2007 and 2018

In addition, to make sure we covered the most relevant work referring to Nickerson et al.'s (2013) method, we performed a forward search for articles citing Nickerson et al. (2013). We applied Google Scholar as citation indexing service. From the identified articles, the majority referred to the above-mentioned conferences. The only IS journal which comprised more than two articles citing Nickerson et al. (2013) was *Decision Support Systems (DSS)*. In sum, we decided to first focus on the analysis of high-impact publications from the IS Senior Scholars' Basket of Journals after 2013 (30 articles as highlighted in grey in Table 1) plus three *DSS* articles citing Nickerson et al. (2013). This results in a total of 33 articles. We clearly see this as a first step to assess recently published taxonomy articles in the IS domain. Despite the high number of taxonomy conference articles, we aimed at examining the articles from leading high-impact journals first to set a point of reference, before comparing insights with results from conference articles. As a second step and as extension of this article, we plan to assess the identified conference articles promising broader insights across publication formats.

After screening titles and abstracts of the 33 taxonomy articles, we excluded nine as they did not develop a taxonomy as an artifact. In conclusion, 24 taxonomy articles remained for detailed assessment. We are happy to provide the full list upon request.

3.2 Development of Assessment Attributes

To assess the 24 taxonomy articles, we developed assessment attributes referring to the example of Paré et al. (2013) who examined the rigor of ranking-type Delphi studies in the IS domain. We iteratively developed the assessment attributes building on Nickerson et al.'s (2013) methodological recommendations. We added further assessment attributes beyond Nickerson et al.'s (2013) work when we identified relevant patterns throughout the assessment process, e.g., with regards to evaluation. The overview of assessment attributes is shown in Table 2 and divided into three focus areas: Assessment attributes related to the 'research product' (i.e., the taxonomy) and to the 'research process'. We divided the latter into 'development' and 'evaluation & application'.

First, we developed assessment attributes including guiding questions based on Nickerson et al. (2013). To the best of our knowledge, this is hitherto the only well-elaborated taxonomy development method in the IS domain associated with major influence. Further, Nickerson et al. (2013) themselves reviewed IS taxonomy literature as well as taxonomy development methods from other disciplines. We developed our assessment attributes in a two-fold approach: On the one hand, we adopted assessment attributes also used in Nickerson et al.'s (2013) literature review (e.g., inductive versus deductive development approach). On the other hand, we synthesized attributes by reviewing Nickerson et al.'s (2013) method description and translating relevant elements into operational assessment attributes (e.g., ending conditions, evaluation of usefulness for the intended user). It is noteworthy that Nickerson et al. (2013) incorporated methodological recommendations from other disciplines (e.g., Bailey (1994) and Doty and Glick (1994)). Hence, our assessment attributes also cover influences beyond IS.

Second, we validated and refined the initial assessment attributes and selectively added further attributes beyond Nickerson et al.'s (2013) recommendations throughout the assessment process. Therefore, we followed three steps. Initially, three articles were randomly selected and jointly assessed by the three authors to align and calibrate the assessment as well as to refine ambiguous attributes. Next, the remaining 21 articles were assessed in detail by at least two authors independently. In total, one author assessed all 21 articles whereas two co-authors each assessed half of the articles independently which allowed for the calculation of hit ratios as quality measure. When relevant patterns were identified beyond Nickerson et al.'s (2013) recommendations, we discussed the findings and jointly decided whether to add further attributes, e.g., on the evaluation of taxonomies or clustering into archetypes. Only if all authors agreed that a new attribute would benefit the understanding of state-of-the-art taxonomy research, the attribute was added and re-assessed for previously analyzed articles. Overall, an inter-rater agreement of 78% was obtained across all 19 final assessment attributes and 24 assessed articles, which signals a strong agreement between two respectively three authors. In case two authors assessed attributes for the same article differently, the discrepancies were identified, discussed, and a final assessment outcome jointly decided. The assessment of the attribute 'purpose beyond analysis' was the only attribute where we discovered systematic assessment discrepancies. Therefore, all three authors discussed the corresponding assessments in detail where it turned out that the authors had a different understanding regarding the purpose of a taxonomy and whether the purpose referred to the taxonomy artifact itself or to the full article including further analysis. As a result, we jointly decided that the scope of interest was on the purpose of the taxonomy as embedded in a broader context of the article. Further, we defined clear criteria for declaring a taxonomy related to a 'purpose beyond analysis', i.e., clear hypotheses had to be identified for a prediction purpose and design recommendations had to justify a 'design and action' purpose. Along these lines, the authors' final review focused on the 'objective operationalization' of the assessment criteria. In case an attribute or question did not seem objectively assessible, clear criteria for assessment were defined and applied, and attributes correspondingly reassessed. Table 2 illustrates the final list of 19 assessment attributes including guiding questions. Attributes beyond Nickerson et al.'s (2013) work are marked with an asterisk ('*').

Research product	
Focus of analysis	What is the taxonomy's focus of analysis?*
Presentation form	How is the taxonomy presented?*
Terminology	Which wording is applied?
# dimensions	How many dimensions does the taxonomy have?
Scale level	Which scale level is applied?*
# characteristics (min)	How many characteristics are developed per dimension (min)?
# characteristics (max)	How many characteristics are developed per dimension (max)?
MECE	Are characteristics mutually exclusive and collectively exhaustive (MECE)?
Research process: development	
Method reference	Which reference do authors build on for the taxonomy development?
Method description	Is the research method clearly described?
# iterations	How many iterations are conducted?
Development approach	Which development approach is applied?
# examined objects	How many objects are examined (for development)?
Ending conditions	Do the authors state ending conditions?
Research process: evaluation & application	
Evaluation method(s)	Which evaluation method is used?*
Focus on intended user	Does the evaluation involve the intended users?
Complementary application	Is the artifact's application demonstrated?
Archetypes	Are the findings consolidated into archetypes?*
Purpose beyond analysis	Do the authors leverage the taxonomy for a purpose beyond analysis?*

* = Assessment attributes beyond Nickerson et al.'s (2013) recommendations

Table 2. Overview of assessment attributes

4 Results

Below, we present the results of our study on IS taxonomy research structured along the three focus areas 'research product' (Table 3) 'research process: development' (Table 4), and 'research process: evaluation & application' (Table 5). For each focus area, we present the result table including guiding questions as well as absolute and relative frequencies, before we elaborate on how we assessed each attribute, what our findings imply, and which interdependencies to other attributes we observed. The result tables follow the structure outlined in the method section.

4.1 Research Product

What is the taxonomy's focus of analysis? Our first attribute differentiates whether the taxonomy refers to a newly emerging or an established phenomenon. As theory of analysis, taxonomies are especially relevant to examine not yet fully understood domains such as newly emerging phenomena. However, during our assessment we observed that taxonomies also frequently addressed established phenomena. This is why we included the attribute in our assessment. In this context, we defined established phenomena as well-researched IS topics that have been present in the IS domain before or around the turn of the millennium and emerging phenomena as topics that emerged in the last 15 years. Established phenomena such as monitoring and controlling systems (Cram and Brohman, 2013; Iannacci and Cornford, 2018), knowledge systems (Daniel et al., 2018), and software development in general (Gaskin et al., 2018) were investigated in 54% of the articles. The remaining 46% of the articles referred to emerging phenomena such as the Internet of Things (Oberländer et al., 2018), IT addiction (Vaghefi et al., 2017), and digital marketplaces or platforms (Ghazawneh and Henfridsson, 2015; Guo et al., 2014; Kazan et al., 2018). The latter is particularly driven by advancements from new digital technologies. In conclusion, our assessment indicates the importance of taxonomies for both types of phenomena.

Guiding question	Answer	n	%
What is the taxonomy's focus of analysis?	Established phenomenon	13	54%
	Emerging phenomenon	11	46%
How is the taxonomy presented?	Table	10	42%
	Matrix	6	25%
	Visual	4	17%
	Mathematical set	3	13%
	Textual	1	4%
Which wording is applied?	Taxonomy	14	58%
	Typology	8	33%
	Taxonomic framework	1	4%
	Typological theory	1	4%
How many dimensions does the taxonomy have?	1 to 4	12	50%
	5 to 8	7	29%
	N/A	5	21%
Which scale level is applied?	Nominal	13	54%
	Ordinal	2	8%
	Cardinal	3	13%
	Nominal and ordinal	1	4%
	N/A	5	21%
How many characteristics are developed per dimension (min)?	<5	12	50%
	>5	0	0%
	Situated on a continuum	6	25%
	N/A	6	25%
How many characteristics are developed per dimension (max)?	<5	10	42%
	>5	2	8%
	Situated on a continuum	6	25%
	N/A	6	25%
Are characteristics mutually exclusive and collectively exhaustive (MECE)?	Yes	16	67%
	No	0	0%
	N/A	8	33%

Table 3. Overview of results for focus area 'research product'

How is the taxonomy presented? With this attribute we assessed the form in which taxonomies were presented. As the literature does not recommend any specific presentation forms for taxonomies, we aimed at examining the actually applied presentation forms of taxonomies to identify commonalities and differences. Most taxonomies were presented as tables (42%). Researchers also frequently chose matrices (25%) and creative visualizations (17%), whereas mathematical sets and textual representations accounted for the remaining 17%. If matrices were used, we often observed 2x2 matrices (i.e., two dimensions with each two characteristics) where oftentimes the four quadrants represented four archetypes (i.e., manifestations of specific dimension-characteristic combinations).

Which wording is applied? With this assessment attribute we refer to the terminology used for the research product. Nickerson et al. (2013) stated that 'taxonomy' was the most common term. However, other terms were used interchangeably. Our sample confirms Nickerson et al.'s (2013) findings with the term 'taxonomy' being the most frequent term (58%). 'Typology' is used less frequently (33%). Other articles comprised the terms 'taxonomic framework' and 'typological theory' with 8% in total. Although Bailey (1994) and Doty and Glick (1994) refer to typologies as conceptually derived groupings, a direct link between the terminology and the development approach (inductive versus deductive) could not be observed. In contrast, the majority (63%) of taxonomies was developed in a conceptual approach. If the taxonomy development referred to Nickerson et al. (2013), 'taxonomy' was used consistently as term. If the taxonomy development was put in reference to Doty and Glick (1994), then authors mostly (4 of 5 articles) used the term 'typology'. Further, no evidence was found that typology articles derived archetypes more often compared to taxonomy articles.

How many dimensions does the taxonomy have? Taxonomies are made up of dimensions and characteristics. Nickerson et al. (2013) as well as Bailey (1994) recommend a parsimonious use of dimensions, as an extensive number can exceed the cognitive load. Half of the taxonomies in our sample consist of two to four dimensions. The maximum number of counted dimensions was eight. Most common were taxonomies with two dimensions (33%), which were most often (seven of eight) presented as two-dimensional matrix. It is noteworthy that five taxonomy articles (21%) did not provide clear dimensions and were therefore classified as 'N/A'. Authors of these articles directly presented archetypes without providing details on dimensions and characteristics.

Which scale level is applied? Taxonomy dimensions' characteristics can follow a nominal, ordinal, or cardinal scale. Despite its potential relevance for the application of further methods (e.g., cluster analysis), the literature does not address this attribute with regards to taxonomies. We therefore decided to assess the scales of the taxonomies' dimensions. The majority (58%) of articles built on nominally scaled dimensions. Ordinal dimensions and cardinal dimensions were mostly (six of seven) used when characteristics were situated on a continuum, as demonstrated by Kietzmann et al.'s (2013) ordinal dimension 'organizational alignment' ranging on a continuous scale from 'low' to 'high' and Lu et al.'s (2016) cardinal dimension 'time of entry in an auction' with a continuous scale between 0 and 1.

How many characteristics are developed per dimension? Dimensions can comprise two to many characteristics. As Bailey (1994) and Nickerson et al. (2013) state, a useful taxonomy should be concise. Following their argumentation, an inordinate multitude of dimensions and characteristics might be interpreted as a weakness. In our study, the number of characteristics per dimension ranged between two and 34. Six articles (25%) presented dimensions that did not mention distinct characteristics due to their continuous scale. Another six articles (25%) did not mention characteristics at all and were classified as 'N/A'. As described above, five of these six articles did not state any dimensions either.

Are characteristics mutually exclusive and collectively exhaustive (MECE)? Nickerson et al. (2013) define taxonomies as a set of dimensions consisting of mutually exclusive and collectively exhaustive characteristics. Characteristics are mutually exclusive if objects can never simultaneously occupy two characteristics within one dimension. Characteristics are collectively exhaustive if all objects occupy one of the characteristics within each dimension. When characteristics were complementary (e.g., 'yes' and 'no' in Oberländer et al. (2018)) or clearly exclusive (e.g., 'one-way' and 'two-way' in Varshney (2014)), then we classified the characteristics as mutually exclusive. When characteristics were complementary (e.g., 'e-Ordering' and 'No e-Ordering' in Guo et al. (2014)), situated on a continuum (e.g., 'low' to 'high' in Kietzmann et al. (2013)), or entirely covering the space defined by a (explicit or implicit) meta-characteristic (e.g., 'individual' and 'group' in Nickerson et al. (2013)), then we classified the taxonomy as collectively exhaustive. Most taxonomies (67%) followed Nickerson et al.'s (2013) recommendations regarding mutual exclusiveness and collective exhaustiveness. This attribute could not be assessed for the five articles (33%) that did not provide distinct dimensions and characteristics.

4.2 Research Process: Development

Which reference do authors build on for the taxonomy development? In general, research methods support researchers in conducting and describing their research approaches in a structured, transparent, and replicable manner. Therefore, we were particularly interested in the research methods considered and applied in the assessed taxonomy articles. Against our initial expectations, Nickerson et al.'s (2013) taxonomy development method was only rarely cited and applied in our sample (17%). In contrast, we found that most taxonomies were not grounded on specific taxonomy development methods (58%). Further articles referred to Doty and Glick's (1994) guidelines (21%) and in one case to the generic comments on theory development in social sciences by George and Bennett (2005) (4%). For clarification: the lack of a taxonomy development method does not mean that the articles did not provide any method section at all. However, instead of elaborating on the taxonomy development method, these articles outlined methods, for instance, with regards to an underlying literature review, a case study approach, or hypotheses building.

Is the research method clearly described? With this attribute we assessed the transparency and comprehensibility of the articles' taxonomy development process, irrespective whether a specific taxonomy development method was cited or not. Following Nickerson et al.'s (2013) recommendation on transparent and comprehensible taxonomy development, we assessed whether development steps were clearly stated, explained, and whether (interim) results were presented. Our assessment revealed that half of the assessed articles did not transparently describe all development steps, refrained to present (interim) results, and lacked transparency and comprehensibility in general. In contrast, taxonomy development processes that explicitly followed Nickerson et al.'s (2013) guidance all described their research method transparently and comprehensibly.

Guiding question	**Answer**	**n**	**%**
Which reference do authors build on for the taxonomy development?	Doty & Glick (1994)	5	21%
	Nickerson et al. (2013)	4	17%
	George & Bennet (2005)	1	4%
	N/A	14	58%
Is the research method clearly described?	Yes	12	50%
	No	12	50%
How many iterations are conducted?	1 to 3	1	4%
	4 to 6	3	13%
	N/A	20	83%
Which development approach is applied?	Deductive (conceptual)	15	63%
	Inductive (empirical)	3	13%
	Both, iteratively	6	25%
How many objects are examined (for development)?	0	11	46%
	1 to 99	6	25%
	100 to 1,000	4	17%
	>1,000	3	13%
Do the authors state ending conditions?	Yes	4	17%
	No	20	83%

Table 4. Overview of results for focus area 'research process: development'

How many iterations are conducted? The number of iterations describes how often new distinct data sources or conceptual input (i.e., additional real-world objects or literature) are levered to revise the taxonomy. Nickerson et al.'s (2013) method proposes an iterative development approach. We collected the number of development iterations from the articles' method section or counted if the number was not explicitly stated, but iterations were transparently described. Our results showed that the number of iterations was only stated for taxonomies clearly referencing Nickerson et al.'s (2013) iterative method (17%). Other articles (83%) did not transparently describe iterations.

Which development approach is applied? In each iteration, taxonomy development either follows a deductive (conceptual) or an inductive (empirical) approach. In the literature, Doty and Glick (1994) and Bailey (1994) refer deductive approaches to typologies and inductive approaches to taxonomies. Nickerson et al. (2013) allow for the iteration of both approaches within one integrated taxonomy development method. We documented a deductive approach, if researchers solely used their knowledge and experience gained from the literature to conceptualize dimensions first. We referred to an inductive approach if real-world objects were examined first to derive characteristics and dimensions inductively. Our sample indicates that a mere deductive approach (63%) was used more often than a mere inductive approach (13%). Iterative approaches with both conceptual and empirical iterations accounted for 25% of all articles in our sample. Besides, we found examples of conceptually derived taxonomies, where individual dimensions were not explicitly justified. Nickerson et al. (2013) refer to such cases 'intuitive' or ad-hoc. For instance, Cram and Brohman's (2013) work did not elaborate on why and how they selected the two dimensions 'control practices' and 'control objectives' for their taxonomy on information systems development.

How many objects are examined (for development)? Nickerson et al. (2013) recommend to incorporate real-world objects in an iterative development and revision of the taxonomy with regards to inductive as well as deductive iterations. Therefore, we assessed the particular number of objects which were used during the taxonomy development process, either for the empirical derivation and/or the validation of conceptually derived dimensions and characteristics. We assessed the number of examined real-world objects from the articles' method section and counted the total number of considered objects where necessary. In our sample, only half of the assessed articles (54%) considered real-world objects for the taxonomy development, with a greatly varying number of objects (from 1 to 8,384).

Do the authors state ending conditions? Nickerson et al. (2013) suggest to terminate an iterative taxonomy development process when both objective and subjective ending conditions are met. We screened all articles to find out whether researchers explicitly stated and checked ending conditions. Our results show that ending conditions were rarely specified (83%). In fact, only articles grounded on Nickerson et al.'s (2013) method did explicitly state and check ending conditions (17%).

4.3 Research Process: Evaluation & Application

Guiding question	Answer	n	%
Which evaluation method is used?	Cluster analysis	3	13%
	Case study research	2	8%
	Others	6	25%
	None	13	54%
Does the evaluation involve the intended users?	Yes	3	13%
	No	21	88%
Is the artifact's application demonstrated?	Yes	19	79%
	No	5	21%
Are the findings consolidated into archetypes?	Yes	18	75%
	No	5	21%
	N/A	1	4%
Do the authors leverage the taxonomy for a purpose beyond analysis?	No, focus is on analysis	14	58%
	Yes, for testable hypotheses (prediction)	8	33%
	Yes, for recommendations (design and action)	2	8%

Table 5. Overview of results for focus area 'research process: evaluation & application'

Which evaluation method is used? We understand this attribute as the set of methods used to validate the taxonomy after the development process has terminated. Nickerson et al. (2013) recommend an evaluation of the taxonomy's usefulness for the intended users and with regards to the intended purpose. However, Nickerson et al. (2013) do not specify evaluation methods and target outcomes. Therefore, we assessed if and how researchers evaluated their taxonomy after development. We only focussed on methods explicitly mentioned in relation to the taxonomy, but not used for its development and revision. Our sample reveals that around half of the assessed taxonomies were not evaluated (54%). Articles that incorporated evaluation steps after the taxonomy development applied different methods, among others, cluster analysis (13%), case study research (8%), robustness tests, and Q-sort. In other words, no dominating evaluation method for taxonomies could be identified. However, we found authors referring to a taxonomy evaluation by iteratively testing and revising their taxonomy (e.g., Addas and Pinsonneault, 2015) even though this is considered an inherent part of the taxonomy development process itself. Hence, evaluations, which resulted in a revision of the taxonomy, were not categorized as evaluation but as part of the development process.

Does the evaluation involve the intended users? Nickerson et al. (2013) clearly state that a taxonomy should be evaluated with its intended users to assess its relevance and usefulness. Therefore, we assessed if intended users (beyond the authors) were involved in the evaluation process. We found that if a taxonomy was evaluated, then hardly with the intended users (13% of all articles, 27% of articles with taxonomy evaluation). Only one of the articles grounded on Nickerson et al.'s (2013) method followed this methodological recommendation.

Is the artifact's application demonstrated? We define 'application' as the use of the taxonomy for its intended purpose beyond the evaluation process. The literature does not provide any guidance on the application of taxonomies. As we observed that articles applied taxonomies beyond evaluation, we decided to also assess supplementary methods as described by the authors. The majority of taxonomies were applied in different contexts beyond evaluation (79%). Exemplary applications comprise an analysis of complex real-world objects (Oberländer et al., 2018) or the derivation of competitive strategies with regards to digital platforms building on the taxonomy's conceptualization (Kazan et al., 2018).

Are the findings consolidated into archetypes? Archetypes are manifestations of specific dimension-characteristic combinations and a reoccurring pattern in our sample beyond the recommendations of Nickerson et al. (2013). In three-quarter of all assessed taxonomies, archetypes were provided (one to five archetypes in 50% of all articles and six to ten in 25%). Archetypes were presented e.g., by Oberländer et al. (2018) with their six types of business-to-thing interaction patterns or by Lacity and Willcocks (2017) with their three conflict types. Besides, we identified one article (Iannacci and Cornford, 2018), which does not clearly describe and outline its archetypes, and decided to categorize it as 'N/A'.

Do the authors leverage the taxonomy for a purpose beyond analysis? Building on Gregor's (2006) nature of theory in IS and her positioning of taxonomies as *theories for analysis*, we assessed whether taxonomies are also leveraged for further theorizing beyond analysis. To assess the taxonomy's purpose the authors jointly discussed every article. If taxonomies served as a basis for testable hypotheses, we interpreted this as a first step towards a *theory for prediction*. If taxonomies provided specific recommendations with regards to the design of artifacts, we interpreted this as a first step towards a *theory for design and action*. In sum, we found that half of the taxonomies' focus was on analysis (58%). However, 33% of all articles posed testable hypotheses and 8% derived specific recommendations with regards to the design of artifacts beyond analysis.

5 Discussion

Despite the fact that taxonomies represent an important tool for understanding and analyzing complex domains, Nickerson et al. (2013) found that many taxonomies in the IS domain have been developed in an 'ad-hoc' approach rather than following a systematic method. Five years after Nickerson et al. (2013) have published the first holistic taxonomy development method in IS, our aim was to examine to what extent recently published taxonomy articles account for existing methodological guidance. Our analysis shows that methodological guidelines were primarily followed implicitly with regards to taxonomies as research product. The majority of authors understands taxonomies in line with Nickerson et al. (2013) as empirically or conceptually derived groupings consisting of dimensions that contain mutually exclusive and collectively exhaustive characteristics.

However, our findings on the development and evaluation of taxonomies were sobering: Although the number of taxonomies has grown over the last years, we found few taxonomy articles from high-impact IS journals that followed Nickerson et al.'s (2013) or any other specific development method. Hence, our study revealed that the development process often remained opaque and that taxonomies were hardly evaluated. Those articles that included an additional evaluation of the developed taxonomies hardly involved intended users as recommended by Nickerson et al. (2013). Most probably, the reasons for our findings are manifold. However, we would like to outline three potential root causes relating to method design, method adoption, and the general positioning of taxonomy research in the IS domain. Corresponding stimulating questions might guide reflection on the community's progress towards methodologically well-founded taxonomy research.

First, methodological guidance on taxonomy development in the IS domain is mostly limited to Nickerson et al.'s (2013) iterative seven-step method, which incorporates both a conceptual and an empirical approach. This method design, however, might be too detailed and complex for deriving a sometimes seemingly intuitive artifact such as a taxonomy. Further, besides the detailed method description for taxonomy development, specific actionable practices might be missing to support researchers in following the existing methods, for example with regards to the examination of objects. In contrast to the detailed taxonomy development process, the IS body of knowledge lacks any methodological guidance on taxonomy evaluation and application – a gap that should be addressed by further research. Building on both findings, we raise the question how existing methodological guidance should be adapted and/or extended with regards to taxonomy development, evaluation, and application?

Second, despite extant methodological recommendations, most articles we investigated did not adopt existing methodological guidance in the form of any taxonomy development and/or evaluation methods. Hence, we observed a lack of transparency about development iterations, interim results, objects for validation, ending conditions, and evaluation purposes. Articles based on Nickerson et al.'s (2013) method described taxonomy development and evaluation more transparently and comprehensibly. Hence, we raise the question how to best motivate researchers as well as reviewers to pay more attention on providing transparency with regards to the taxonomy development and evaluation process.

Third, besides method design and adoption, the general positioning of taxonomy research as a tool for sensemaking might have to be strengthened. Only one half of all authors positioned taxonomies as theories for analysis, whereas the other half extended the taxonomies' purpose beyond analysis by deriving testable hypotheses (for prediction) or specific recommendations (for design and action). Thus, researchers might interpret taxonomies as vehicles for further theorizing and therefore pay less attention on providing details of taxonomy development and evaluation. Against this backdrop, we want to stimulate reflection on the general positioning of taxonomies in IS research.

We see our study as 'food for thought' to reflect on the IS community's progress towards methodologically well-founded taxonomy research. In the future, attention needs to be put on method design, method adoption, and the general positioning of taxonomy research in the IS domain. In Table 6, we present a set of corresponding 'stimulating questions' to provoke discussion and further research.

Stimulating question
How should existing methodological guidance be adapted and/or extended with regards to taxonomy development, evaluation, and application?
How can researchers and reviewers be motivated to pay more attention on providing transparency with regards to the taxonomy development and evaluation process?
How should taxonomy research be positioned in the IS domain?

Table 6. Stimulating questions for further research

6 Conclusion

In this work, we assessed to what extent recently published taxonomy articles account for existing methodological guidance. We identified and reviewed 33 taxonomy articles published between 2013 and 2018 in leading IS journals. This review followed iteratively developed assessment attributes building on and extending Nickerson et al.'s (2013) methodological recommendations. Our results were sobering: We found few taxonomy articles that followed any specific development method. Although most articles correctly understood taxonomies as conceptually or empirically derived groupings of dimensions and characteristics, our study revealed that the development process often remained opaque and that taxonomies were hardly evaluated.

As any research endeavor, our work is beset with limitations that need to be kept in mind when interpreting our results. First, we did not include any conference articles into our study, even though they represent an important source of knowledge in the fast-evolving IS domain. Second, low adoption rates of existing methodological guidance might be caused by comparably long review cycles of high-impact IS journals (AIS, 2018). Therefore, we suggest a regular assessment of the evolution of taxonomy research in the IS domain. Third, we might have missed further taxonomy articles since we excluded rather ambiguously and broadly defined synonyms such as 'framework' or 'classification' following Nickerson et al. (2013). Fourth, we performed our assessment relying on the information provided in the assessed articles. We could not assess what was actually done by the researchers. Finally, future research should address the stimulating questions regarding method design, method adoption, and the general positioning of taxonomy research in the IS domain as described in the preceding discussion section.

As a next step, we want to strengthen our study by assessing a broader range of taxonomy articles from other IS journals and conferences. All in all, we hope that this review will serve as a foundation to assist fellow IS researchers in positioning, developing, and evaluating taxonomies in the future.

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