Maturity Models in Information Systems: A Review and Extension of Existing Guidelines

Completed Research Paper

Tobias Mettler
University of Lausanne
IDHEAP, Rue de la Mouline 28
1022 Chavannes-près-Renens
tobias.mettler@unil.ch

Omar Ballester
University of Lausanne
IDHEAP, Rue de la Mouline 28
1022 Chavannes-près-Renens
omar.ballester@unil.ch

Abstract

Maturity models (MM) enjoy great popularity among scholars and practitioners, particularly for addressing the novel challenges in IS design and management of IS projects. However, MM research is harshly criticized by rigor-centered academics because of methodological shortcomings. This is because existing design principles for MM development often are insufficiently applied. In this research, we conduct a scoping review of the academic MM literature. Informed by the analysis of MM literature, we pinpoint existing methodological weaknesses of MM research and offer suggestions on how to improve extant design principles for MM development. The presented guideline extensions apply to the complete MM design process from problem definition to results presentation and cover eight design principles. Our results contribute to increased relevance and rigor in MM research. Further, they motivate further research on empirically and longitudinally validating MM's impact in practice and on the mechanisms of how MM supports organizational learning.

Keywords: Design guidelines, maturity models, capability assessment models

Introduction

An output of scholarly IS research that enjoys great popularity and led to some real-world impact in practice, yet receives harsh criticism from rigor-centered academics, is the concept of maturity model (MM). Diverse purposes are attributed to these models, for example, they are used for assessing organizational development and growth, or for the benchmarking of process and outcome improvements (Mettler et al. 2010). Nevertheless, the list of epistemological and methodological flaws of MM seems to be endless (see Bach 1994; Benbasat et al. 1984; Debrí and Bannister 2015; Iannacci et al. 2019; King and Kraemer 1984; Pereira and Serrano 2020; Wendler 2012). Yet, this has not stopped private and public organizations to use MM, specifically for getting a grip on the uncertainty posed by the new challenges of the digital transformation. For example, the Pan American Health Organization (2021) and the National Health Service (2021) in England apply a digital maturity self-assessment tool for monitoring the extent to which individual organizations within their health system are capable of meeting the objectives outlined in the international or nation-wide information infrastructure strategy. Similarly, in the private sector companies like IBM (2021), Microsoft (2021), or SAP (2021) have developed (and use themselves) MM for supporting organizations in their delicate transition from traditional to digital forms of working. Following Van Looy et al. (2017) the demand for MM in practice is considerable. It would, therefore, be unwise to condemn and/or ban MM completely from our discipline's research agenda and cede this topic over to engineers or computer scientists. We believe that our discipline's socio-technical orientation predestines IS scholars for developing rigorous, meaningful, and transformative MM which ultimately support the IS discipline in taking a leading position in the current digitalization revolution.

Therefore, instead of criticizing the immaturity of the conducted work in the area of MM (Pereira and Serrano 2020), our aim with this paper is to (i) gain a deeper understanding of the possible reasons why certain IS scholars see MM as being flawed or erroneous, and (ii) to detail, or extend where necessary, the existing design principles for MM so that prospective authors put their work on more solid theoretical grounds. In line with Lasrado et al. (2016), our objective is to contribute to the development of "theoretically informed, methodologically rigorous, and empirically validated maturity models". To do that, we first conduct a review of the extant literature to get an overview of the most influential studies that guide the current development and evaluation of MM. We then present our critical reflection and new account of MM design guidelines. We conclude with a discussion on continuing research gaps and possible avenues for future research.

Literature Review

As suggested by Webster and Watson (2002), it is generally a good strategy for starting a research journey by "analyzing the past to prepare for the future". Consequently, to improve our general understanding of the literature on which IS scholars base their MM research design choices, we conducted a scoping review of articles published at major international IS and management-related journals and conferences. Out of our scope were publication outlets of other fields (e.g. industrial or software engineering), as well as non-reviewed or non-full-length articles (e.g. case reports, editorials, extended abstracts, tutorials, or perspectives papers).

Search and selection of articles related to maturity models

Based on the recommendations outlined by Rowe (2014), we applied a systematic search and screening procedure within the specified limits, which are summarized in Figure 1.

SEARCH

Journals: Acad Manag Exec, Australasian J Inf Syst, Behav Inf Technol, Calif Manage Rev, Comm ACM, Comm AIS, Data Knowl Eng, Database, Decision Sci, Decision Support Syst, E J Inf Syst, Electron Mark, Harvard Bus Re, Hum Comp Interact, Inf Man, Inf Syst, Inf Syst J, Inf Syst Res, Inf Technol People, Int J Electron Comm, Interfaces, J AIS, J Comp Inf Syst, J Database Man, J Inf Technol, J Man Inf Syst, J Oper Res Soc, J Strateg Inf Syst, Man Sci, MIS Quarterly, MIT SMR, Scan J Inf Syst

Conferences: ACIS Proc, AMCIS Proc, ECIS Proc, ICIS Proc, PACIS Proc

Keywords: "maturity model", "maturity assessment model", "capability maturity model", "capability assessment model", "CMM*"

Search: Web of Science (on Topic), AISeL (on Abstract, Subject)

197 retrieved articles

SELECTION

Exclusion criteria:

Duplicates: Each article is considered only once
Language: Only articles published in English language
Format: Only full length journal or conference articles (i.e. no editorials, extended abstracts, tutorials, or posters)
Topic: Only articles sufficiently discussing research (e.g. design theories, review of knowledge base) or practical issues of maturity models (e.g. proposed instantiation for a specific domain, evaluation of a proposed model)

129 articles included in the literature review

Figure 1. Literature review search and selection procedure.

	Source	*Appli-cation*	*Meta/ review*	*Total*
Conference	ACIS	7	2	9
	AMCIS	42	-	42
	ECIS	15	2	17
	ICIS	6	1	7
	PACIS	11	-	11
Journal	Behav Inf Technol	1	-	1
	Comm ACM	4	-	4
	Comm AIS	-	1	1
	E J Inf Syst	2	-	2
	Electronic Markets	1	-	1
	Harvard Bus Re	2	-	2
	Inf Man	10	-	10
	Inf Syst	1	-	1
	Inf Syst J	1	-	1
	Inf Syst Res	1	-	1
	Inf Technol People	3	-	3
	J AIS	1	-	1
	J Comp Inf Syst	1	-	1
	J Inf Technol	3	-	3
	J Man Inf Syst	2	-	2
	Man Sci	4	-	4
	MIS Quarterly	4	-	4
	Scan J Inf Syst	1	-	1
	Total	123	6	129

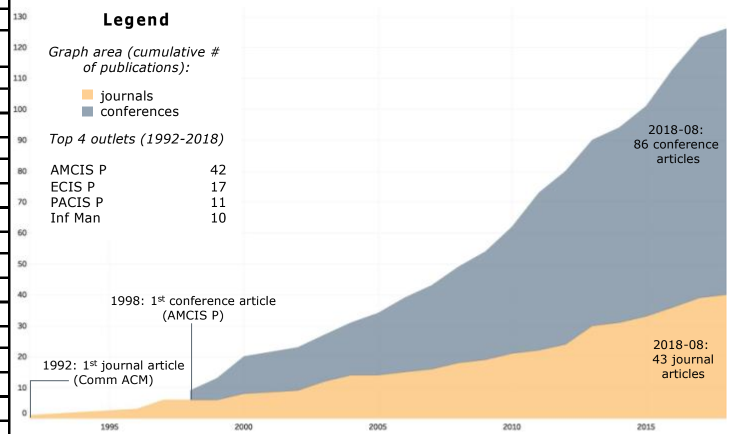

Figure 2. Articles included in the review.

We started our review by exploring the bibliographic databases Web of Science (on topic) and the AIS Electronic Library (on abstract or subject) using "maturity model", "maturity assessment model", "capability maturity model", "capability assessment model", or "CMM*" as keywords for the timespan between 1988 and 2018. Our search yielded 197 articles. Excluding duplicates, papers not written in English, and not sufficiently discussing research (e.g. design theories, review of knowledge base) or practical issues of maturity models (e.g. proposed instantiation for a specific domain, evaluation of a proposed model), we ended up with a sample of 129 articles out of which 86 were published at conferences and 43 in journals (see Figure 2).

34.1% of the identified articles originate from the United States, 16.3% from Germany, 8.5% from Australia, 6.2% from Switzerland, 5.4% each from the United Kingdom and the Netherlands; only a few articles originate from Asia, Africa, or Latin America. 123 articles were propositions of new MM or evaluation studies of existing models, 2 articles were review studies (whereas the one published in a journal is the extension of the one that was previously presented at a conference), and 4 articles provided methodological guidance for the development and evaluation of MM.

Analysis of bibliographic coupling

Based on the identified set of articles and given our interest in the foundations on which authors of MM studies base their work, we analyzed the bibliographic coupling of the identified articles using the VosViewer toolset (Waltman et al. 2010). As mentioned before, the conceptualization of MM has been as diverse as its areas of application (Fraser et al. 2002; Mettler et al. 2010; Van Looy et al. 2013). This form of bibliometric analysis allows us, on the one hand, to identify the relatedness of conducted work, and on the other hand, to see which articles have a particular impact on IS scholars concerned with the topic of MM. Figure 3 illustrates the bibliographic coupling of the references used in the 129 articles we identified with our systematic search. Different than co-citation networks, which display the frequency with which two publications are cited together by another publication, bibliographic coupling concentrates on showing the overlap in the reference lists of publications.

When contemplating the bibliographic coupling of a specific area of work, as in our case for maturity models, it is important to note that relatedness is expressed by the link between two items that both cite the same document and not necessarily relatedness of application area (Leydesdorff 2008). The impact is commonly expressed by citation counts (bubble size in our figure) assuming that the reference of one's work in the subsequent literature is a valid indicator of the work's influence and significance for the rest of the research community (Lowry et al. 2007). However, as Clarke (2007) highlights, "whether the influence of work or author was of the nature of notability or notoriety, remains generally ignored by citation analysis" (p.3) given that every citation counts equally. It also remains unclear if a citation is an expression of paying homage to a rigorous, well-crafted, scholarly piece of work, a substantiation or correction of one's work (in case of a self-citation), a critique to extant published work of others (Hansen et al. 2006), or the result of a reviewer's accommodation, coercive journal practice, or the deliberate manipulation (in case of excessive self-citation) of one's personal authority (Ioannidis 2015).

To improve readability, we only display publications which have been cited at least 3 times within our set of identified MM papers. The number of visualized items (121) should therefore not be misunderstood with the number of retrieved MM papers (129).

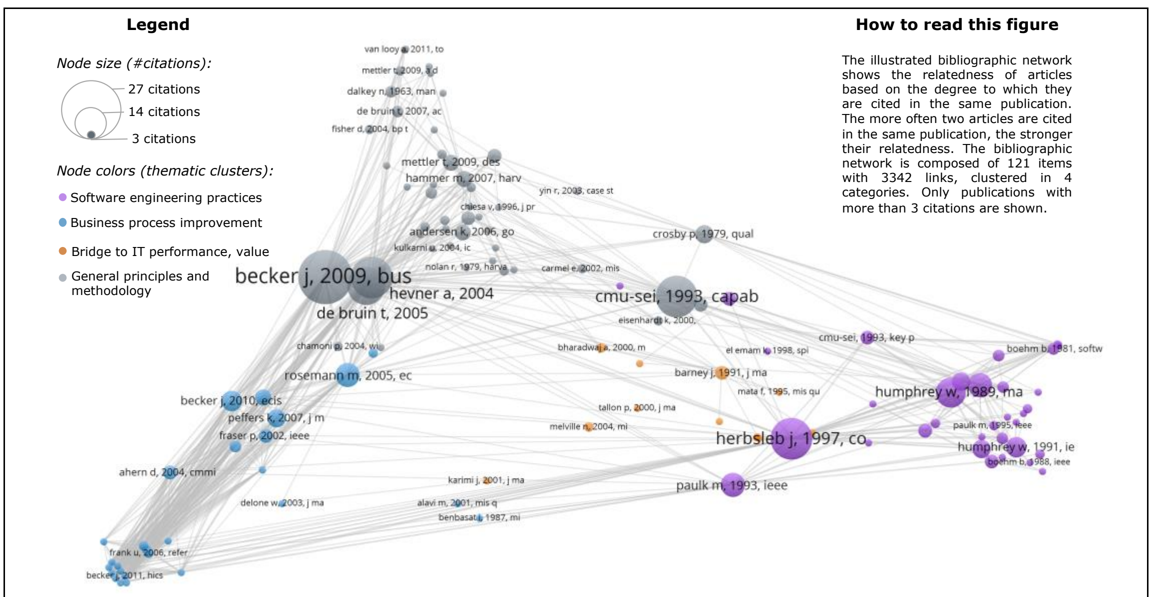

Figure 3. Analysis of bibliographic coupling in MM studies.

That said, we identified four thematic clusters in the identified set of MM papers: Articles marked purple, represent the origins of the MM concept in IS. Thematically, these articles are centered on software engineering practices (e.g. Boehm 1981; Humphrey 1989) and the Capability Maturity Model (CMM) (e.g. Herbsleb and Goldenson 1996; Paulk et al. 1993) or successional models like ISO/IEC 15504 also known as SPICE (software process improvement and capability determination). Articles citing these documents often follow the idea that "maturity" can be expressed by a number of levels (typically three to six), a descriptor for each level (such as the CMM's differentiation between initial, repeatable, defined, managed, and optimizing processes), a generic description or summary of the characteristics of each level as a whole, a number of dimensions (such as the 'process areas' in CMM), a number of elements or activities for each dimension, and a description of each element or activity as it might be performed at each level of maturity (Fraser et al. 2002). The articles marked blue (e.g. Becker et al. 2010; Frank 2006; Rosemann and Bruin 2005), are frequently cited within scholarly work related to business process modeling or the overall improvement of business processes, beyond software engineering processes alone. Yet, the conceptualization of "maturity" remains often the same as in the previous thematic cluster. A small number of articles marked orange (e.g. Barney 1991; Bharadwaj et al. 1999; Melville et al. 2004) is commonly used to bridge the topic of MM with the literature on IT effects, performance, or value. Lastly, there is a fourth thematic cluster that addresses general principles and methodological questions. The articles herein provide multiple views on how to comprehend and how to design MM. It is this type of literature we will subsequently focus on to discuss some fundamental issues. Particularly, we would like to analyze and detail the guidelines defined by Becker et al. (2009), which themselves ground their line of thought on the seminal work by Hevner et al. (2004). As the analysis of the bibliographic coupling revealed, it stands out as one of the primary sources guiding the design and evaluation of a large number of MM studies in the IS discipline.

A New Account of Maturity Model Design Guidelines

As mentioned previously, multiple guidelines have been formulated for improving our understanding of MM. In general, we can group these guidelines into three categories: guidelines explaining how to design MM (e.g. Becker et al. 2009; De Bruin et al. 2005; Lasrado et al. 2016), guidelines describing how to plan the organizational implementation and learning with MM (e.g. Ahern et al. 2004; Kulkarni and St. Louis 2003), and guidelines considering both aspects (e.g. Mettler 2011; Pöppelbuß and Röglinger 2011). In this paper, we focus only on design guidelines, specifically the often-cited guidelines by Becker et al. (2009) shown in Table 1 below, because of their wide acceptance in the IS discipline. Given that these guidelines represent high-level prescriptive knowledge, it has been the job of each researcher to adequately interpret and implement them into their research design; so far, this has not necessarily led to a reduction of criticism regarding the concept of MM (Pereira and Serrano 2020). On the contrary, we observe that these well-intentioned guidelines are often used as legitimation for a rigorous research process, even though designers of MM do not determine how they dealt with each guideline and developed and evaluated their models.

#	*Guideline*	*Description*
1	Problem definition	The prospective application domain of the maturity model, as well as the conditions for its application and the intended benefits, must be determined prior to design.
2	Comparison with existing maturity models	The need for the development of a new maturity model must be substantiated by a comparison with existing models. The new model may also just be an improvement of an already existing one.
3	Identification of problem relevance	The relevance of the problem solution proposed by the projected maturity model for researchers and/or practitioners must be demonstrated.
4	Multi-methodological procedure	The development of maturity models employs a variety of research methods, the use of which needs to be well-founded and finely attuned.
5	Iterative procedure	Maturity models must be developed iteratively, i. e., step by step.

6	Evaluation	All principles and premises for the development of a maturity model, as well as usefulness, quality and effectiveness of the artifact, must be evaluated iteratively.
7	Scientific documentation	The design process of the maturity model needs to be documented in detail, considering each step of the process, the parties involved, the applied methods, and the results.
8	Targeted presentation of results	The presentation of the maturity model must be targeted with regard to the conditions of its application and the needs of its users.

Table 1. Guidelines for the design of maturity models by Becker et al. (2009)

Review of guidelines

As stated before, it is our goal with this paper to pinpoint some crucial sources of criticism and to offer some suggestions on how to translate and implement these guidelines, which we describe next.

Problem definition

The point of departure in developing a MM, according to Becker et al. (2009), should be a sound understanding of the prospective application domain, the conditions for its application as well as a clear idea of the intended benefits. From a design science research (DSR) perspective, this translates to getting a proper understanding of the problem space (i.e. the concrete decision-problem to be solved) before dealing with the solution space (i.e. the range of available solutions), which is reflected by the subsequent guideline 2. Given that DSR is an iterative approach to problem-solving (Simon 1996), it also means to define a stop criterion for the build/evaluate cycle (Hevner et al. 2004) respectively to have, a priori, an exact scheme of how to assess the utility of the newly developed decision aid. If we take a positivistic perspective, the first guideline implies a clear conceptualization of how to comprehend and measure "maturity" as well as a definition of the hypotheses to be tested by the MM. Moreover, it also involves the identification of contextual and other factors that may confound the hypothesized cause-and-effect relations.

The issue that we observe here is that many of the identified MM do not specify the (optimization) problem nor the goal function, which frequently leads to harsh criticism particularly during the subsequent evaluation of the MM (see guideline 6). If we take "digital transformation" as a fictional subject of a MM, it is not obvious what exactly to optimize, nor is there an all-embracing definition of this concept. What does digital transformation encompass? Do we face a linear optimization problem as frequently assumed by MM? And most importantly, what is "maturity" in this context? It has become common, nevertheless it remains often unsustained, to define "maturity" as the extent to which a specific (business) process is explicitly defined, managed, measured, controlled, and effective (e.g. Fraser and Vaishnavi 1997; Paulk et al. 1993). This definition of "maturity" stems from the initial research on software engineering practices and the CMM (see the purple thematic cluster in Figure 3), which clearly relates to a process. However, not everything that is conceptualized by a MM is a process! For instance, if we would measure the maturity of an apple (i.e. an object), we would most probably not center on the process (e.g. from blossom to rotten apple mush) but measure a concrete feature (e.g. fruit sugar level) that approximates our view on different maturity stages. There is currently an overemphasis to conceptualize "maturity" as a process, although not everything described in a MM is a process (Bach 1994). If we think about our fictional example, we could imagine different views on the "digital transformation", beyond the process perspective (Kane et al. 2017; Westerman et al. 2012). For example, we could concentrate on digital assets (technology-centric maturity) or human skills or organizational capabilities (people-centric maturity) needed to succeed in the new digital turn. We need both, a clearly defined process and an up-to-date workforce and infrastructure to manage this transition. The designers of MM need to be aware of the fact that they will require different measurement scales and approaches for estimating the maturity of people's capabilities or technological maturity. There is a difference between the subject under investigation (this might be a process but could also be something different) and the possible evolution of the subject (which is a process but not necessarily always a linear one).

Besides, researchers need to be aware of the goal function they want to optimize. What path does the MM prescribe? What is being optimized (e.g. efficiency, quality, speed, flexibility)? As Teo and King (1997) stated, there are multiple and possibly equifinal maturation paths. As shown by Mettler and Rohner (2009), it could make sense to define multiple paths depending on distinct situational needs (e.g. cost reduction, risk aversion) or contextual factors (e.g. organization size, industry). Moreover, in the case of a multiple-goal function (i.e. optimization of several parameters), the designers of MM need to have a clear understanding of main effects and interaction effects, as organizations will have to make some trade-offs along the way. Also, they need to account for the fact that optimizing the maturity of something does not always follow a linear path. To reduce criticism, it is therefore absolutely crucial to not only describe the application domain and intended benefits of the MM but also to make the goal function and the specific problem the MM is trying to solve explicitly (and which aspects are possibly not covered to reduce bias).

Comparison with existing maturity models

The second of Becker's et al. (2009) guidelines addresses the issue that there are a lot of MM out there, both from academia and practice, often dealing with the same or similar problem. For example, Lacerda et al. (2018) identified 33 MM related to software improvement; Rossmann (2018) found 25 MM on digital maturity; Röglinger et al. (2012) analyzed 10 MM in the area of business process management (BPM); Proença and Borbinha (2016) compiled a list of 22 practice-based MM in the area of information management; our research has found 123 articles on MM applications in IS. As shown in Figure 2, MM have particularly received much attention in the last couple of years. From a DSR perspective, it is crucial to not re-invent the wheel respectively, as discussed by Gregor and Hevner (2013), to position the developed model as either an improvement (i.e. new solution to a known problem), an exaptation (i.e. known solution extended to a new problem), or as invention (i.e. new solution to a new problem), however, the latter will rather be the exceptional case. Taking a positivistic stance, it would be important to revisit the theoretical underpinning of the existing MM. According to Biberoglu and Haddad (2002), the lack of a theoretical basis and/or empirical evidence to "proof" the significance and accuracy of prediction is perhaps the biggest criticism of positivist researchers towards MM. Recently, there have been a lot of theoretical advancements in the area of nonlinear dynamics which could be beneficial for the improvement of the predictive power of MM (e.g. such non-linear models are used in weather forecasting or neurons to explain chaotic, counterintuitive, yet non-random behavior of a system). For example, Iannacci et al. (2019) apply the trajectory-turning point theory to better explain the transition from one maturity stage to another. Regardless of the adopted research paradigm, designers of MM must make explicit what solutions (or explanations) exist that can potentially be used as an alternative to their developed model.

Identification of Problem Relevance

A central postulate of Becker's et al. (2009) guidelines is that the proposed MM is useful for practitioners and/or researchers (note that this does not necessarily mean that the model truly predicts the future, although one would certainly wish that the prescribed actions lead to the desired outcomes). This emphasis on utility and relevance, rather than the truthfulness of research outcomes has been widely discussed in the DSR literature (e.g. Iivari 2007; Purao 2013) – we will thus not repeat what already has been debated before. But how to demonstrate the practical relevance of a MM? Existing guidelines do not specify in detail what to do. For Becker et al. (2009), a MM seems to be relevant when the proposed solution either addresses a problem that has not adequately been solved before (see guideline 2), or there is a sponsor or demand for developing a MM. Do researchers developing MM need to conduct market research or actively look for sponsorship then? We think this would go too far and is certainly not intended. However, we believe that the purpose of this guideline is to reflect upon the necessity for and opportunity of a new MM a priori. Developing models always has been popular among researchers. Supply frequently exceeds the demand for new models and can easily provoke a "yet another modeling …" badinage.

When do practitioners need guidance? Mettler (2011) was among the first to describe the paradoxical situation that the necessity for a new MM is usually highest when technology or practice is emerging. This typically collides with few observable cases in practice required to build and sufficiently test the proposed maturation paths. For Mettler (2011), practical relevance is given in situations when best practice standards or a "dominant design" are missing, making future developments and investment decisions most uncertain for organizations. Heuristics and simple decision aids, such as maturity grids or stage-gate models, are in this situation often extremely useful because more complex comparative methods, such as benchmarks, cannot be applied due to a lack of reference cases (beyond some pioneering organizations). Recommended improvements are therefore highly speculative but valuable to shed some light into a dark tunnel of insecurity and ignorance.

However, this conflicts with positivistic thinking that aims at building reliable and valid prediction models. To get to reasonable sample sizes for statistically testing a maturation path, researchers require lots of observable cases. But if the adoption of a certain technology, process, or skillset is common sense, the developed MM might not be of much use for practice as most organizations already undergone a digital transformation. For example, today we can prescribe accurate maturation paths for the introduction of database management systems, however, practical relevance is limited given the fact that most organizations already have introduced databases a long time ago.

There is, unfortunately, no simple recipe to respond to this criticism and outlined paradox. A way out of it could be to concentrate on problems or phenomena that are not new, but where the common practice still occurs without sound evidence (Pereira et al. 2021).

Multi-methodological Procedure

According to Becker et al. (2009), the development of MM requires the researcher to apply multiple methods "[…] the use of which needs to be well-founded and finely attuned". What kind of research methods are particularly suitable for the development of MM is not mentioned. De Bruin et al. (2005) propose to use expert-based approaches, such as the Delphi technique or focus groups, to "populate" the initial model. In reviewing the state-of-the-art, Becker et al. (2010) found that the preferred qualitative approaches are case studies and action research, whereas surveys and historical data analysis were the most common quantitative approaches to build and evaluate MM. Besides empirical approaches, there exist also a range of theoretical or logic-based approaches, such as the use of the trajectory-turning point theory (Iannacci et al. 2019), set theory (Lasrado et al. 2016), or the Rasch algorithm (Lahrmann et al. 2011), that frequently offer more robust predictions than purely judgment-based approaches. In this sense, we would like to detail this guideline by highlighting two crucial points: First, a rigorous MM requires some sort of systematic and evidence-based approach to building and testing the model. As Wendler (2012) showed, empirical (i.e. qualitative, quantitative) or other methods are still rarely used during the conceptual design of a MM. To reduce general criticism towards MM, therefore, we need to put our predictions and improvement suggestions on more solid scientific grounds. Second, we need diversification and mixing of empirical and theoretical/logic-based approaches. While empirical approaches are useful to capture attitudes and expectations of domain experts, logic-based approaches provide additional decision-making support in the absence of observable cases and precise information (see guideline 3). The most persuasive evidence comes through a triangulation of different MM design approaches, mixing rich empirical data with logic.

Iterative Procedure

Building upon Hevner et al. (2004) central postulate to comprehending "design" as a search process composed of multiple "generate/test cycles", the guidelines by Becker et al. (2009) stipulate to build MM iteratively. For them, this essentially means to breakdown the development of a MM into smaller steps, each of which produces a concrete result – more specifically a document; similarly, De Bruin et al. (2005) present their MM development framework.

We oppose this view firstly because we believe that a textual description of a MM as final research output is frequently not enough to unfold practical value (see guideline 7). Secondly, and more importantly, we think that one of the key design principles propagated by Herbert Simon (1996), namely the trial-and-error search procedure, which has also been adopted by Hevner et al. (2004), gets essentially lost. As Simon (1996) argues, we need to "divide one's eggs among a number of baskets that is, not to follow out one line until it succeeds completely or fails definitely but to begin to explore several tentative paths, continuing to pursue a few that look most promising at a given moment." Iterative to our view means not only to ponder about how to disassemble and improve the different bits and pieces needed to develop a MM but also to critically reflect on the overall goal and impact one wants to achieve with a MM. As we mentioned before, lots of MM studies do not have a clear idea of a stop criterion for the build/evaluate cycle (see guideline 1), nor do they define a priori what intentions (i.e. design goals) do they have and what contextual and other parameters (i.e. design assumptions) are relevant for a purposeful application of the model. Frequently, multiple attempts (back-and-forth), angles of analysis, and versions of models are needed to get a precise idea of the problem and solution space. Leading researchers to believe that MM are developed using a streamlined procedure is bogus. However, we are well aware of the issue that reviewers of scientific journals and conferences will request such a simplified presentation for publication of the MM study (see guideline 7).

Evaluation

To reduce criticism towards MM and to increase scientific rigor, Becker et al. (2009) solicit researchers of MM studies to thoroughly evaluate their models in terms of usefulness, quality, and effectiveness by using various research methods (see guideline 4). However, they leave open how these three evaluation criteria should be operationalized and what is the subject of this evaluation – that is the process, the outcome, or both. If we take "quality" as an example, this could relate to multiple things. From a design-oriented perspective it could mean the quality of the design process (e.g. is the procedure of how the MM was designed fault-tolerant?) or the quality of the design product (e.g. does the MM sufficiently satisfy the decisional needs of practitioners?). The same issue we could illustrate for the criterion of "usefulness" and "effectiveness". To reduce confusion along the way, we suggest defining – a priori – a concrete and detailed scheme for assessing both, the process and the outcome of the MM development depending on the situational objectives of the research project. On the one hand, this gives a clear point for orientation concerning the iterative trial-and-error search (see guideline 5) because it forces researchers to reflect on crucial design goals, procedures, and products. On the other hand, it allows practitioners to better judge if the quality of the proposed model corresponds to their standards for organizational decision-making.

In developing this scheme, it is equally important to differentiate between expectations (i.e. what practitioners think the MM will do for them) and impacts (i.e. observable effects within organizations). While it is easier to survey practitioners' attitudes and beliefs (with a cross-sectional design), it would give the MM a much stronger grounding when researchers would also consider studying the short-term and/or long-term effects of the model-based decision-making in organizations (with a longitudinal design). This leads us to believe that a purely design-oriented evaluation of the produced artifact's form and functioning and its reception in practice is not enough to dispel the concerns of positivist reviewers.

Following De Bruin et al. (2005), the reasons for fierce criticism towards MM lies in the insufficient emphasis of researchers on testing the model's validity (e.g. does it accurately prescribe a maturation path?), reliability (e.g. are the proposed improvement suggestions described precisely enough?) and generalizability (e.g. is it applicable to all contexts and situation types?). The fact that researchers often fail in evaluating their MM in this regard is certainly related to the lack of observable cases, as we mentioned before (see guideline 3). Also, we observe certain difficulties in the conceptualization and measurement of a "moving target". As Mettler and Pinto (2018) argue, the idea that maturity can be studied using linear and fixed stage models needs rethinking. Different from biological entities, whose evolutionary process cannot be repressed (at the most, accelerated or decelerated), it is possible for socio-technological entities to dynamically move backward and forward as well as towards multiple, partially contradictive directions. This is because the properties (or features) of technology relate to individuals' subjective goals and perceptions (Leonardi 2011); or in other words, a technological entity (or artifact) consists of a material part, which is independent of its use and the context in which it is used, and a social part relative to a person's perception and, hence, dependent on individual experience, knowledge, culture, or ability to perceive (Davern et al. 2012; Treem and Leonardi 2013). "Maturity" thus is the result of a continuous and ongoing debate to a changing landscape of economic, socio-cultural, politico-legal, and technological beliefs, objectives, and conditions. Therefore, what is "mature" today must not necessarily be "mature" tomorrow; or what works in one context, must not necessarily work in another (Mettler and Pinto 2018). In making some statements about the reliability and validity of a MM, researchers must, therefore, describe for which purposes (what), recipients (who), timeframe (when), and context (where) they developed and tested their MM. We advise designer of MM to be more cautious in generalizing the usefulness, quality, and effectiveness of developed MM by refraining from using a "one size fits all" mentality. Even extremely successful MM, like CMM, has shown to be limited for certain contexts such as for small and medium-sized companies (Huang and Zhang 2010). Moreover, there are new developments, such as DevOps, crowdsourcing, and others that might render some of the suggested practices obsolete. The evaluation should, therefore, be taken as an opportunity to reflect more critically about the exact scope of application and possible expiration date of the developed MM as well as to present some empirical evidence about the positive impacts the model generated within organizations, and not just exhibit the subjective opinions of a handful self-appointed experts.

Scientific Documentation

Following Becker et al. (2009), the "[…] design process of the maturity model needs to be documented in detail, considering each step of the process, the parties involved, the applied methods, and the results". The documentation should include (i) a reference to existing models (see guideline 2), (ii) a description of the steps of design and evaluation processes (see guideline 5), and (iii) a specification of the outcome of the design process (i.e. the final MM). We observe two issues here: First, the analyzed literature has a strong emphasis on the detailed description of the design product, not the process. It remains often vague on which basis a MM was developed; besides, it often lacks an empirical evaluation of its face validity or credibility if the existing sample does not allow for quantitative analyses (see guideline 6). This gives MM this "negative touch" of being arbitrary, subjective, unverifiable, or sliding into the mystic realm of popular science. Second, when describing the design product, most researchers content themselves with a textual description of the form – and in rare cases also the functioning – of the MM. Only a few (software) instantiations of MM exist; this albeit the fact that there are new possibilities of freely storing, disseminating and getting credit from code (e.g. https://zenodo.org, https://www.journals.elsevier.com/softwarex). As is happening right now in other scientific disciplines, we need to establish a new culture that propagates software as (equally valuable) research output. We need to create some synergies between science and practice in terms of expected outcomes, but also how we appreciate and reward research, otherwise, MM will not fully unfold its potential or practical value, as we describe next.

Targeted Presentation of Results

The last guideline should remind researchers that there is something beyond a scientific paper, where usually the development and evaluation of the MM is presented. According to Becker et al. (2009), a MM needs to be presented in a way that it reflects "[…] the conditions of its application and the needs of its users." Again, there is no detailed account of what this could exactly mean. With respect to MM originating from academic research, we observe that a lot of emphasis is given to the detailed description of the structure and form of the MM (see guideline 7). Because of page limitations and other restrictions in scientific publishing, however, researchers often forget to specify how to correctly use the model (and how it was evaluated; see guideline 6). The proper deployment and governance of organizational learning with a MM is far from being something obvious. For De Bruin et al. (2005) it is, therefore, crucial that designers of MM also reflect upon the mode of application (e.g. self-assessment with a software, assisted assessment, or external assessment with a survey instrument), the key informants (e.g. generalists vs. specialists that are needed to respond to specific assessment items), as well as the coverage (e.g. single respondent at single location vs. multiple entities in different locations) needed to get to meaningful decisions. We would go further and also highlight the necessity to describe strategies that explain how to interpret assessment results, how to deal with ambiguous findings (e.g. in case multiple respondents within the same organization assess the current situation differently or have different priorities concerning the maturation path), or how to purposefully integrate an MM-based learning cycle within an organization. As already Pfeffer and Sutton (1999) observed, there is often a "knowing-doing gap" in practice: existing MM help to identify "white spots" or "improvement potential" in an organization, but seldom disclose how to effectively perform these actions or describe how to conduct the assessment and learn from this exercise. Besides the scientific documentation of the MM, we would equally recommend formulating implementation guidelines that describe how exactly to apply the model, how to structure the learning, and what resources are needed to do this effectively so that a MM unfolds practical value.

Summary and Conclusion

We started our exposé by discussing the duality between practical pertinence of and harsh criticism towards MM by researchers. Believing that a compromise between rigor and relevance is possible, we conducted a thorough analysis of the extant literature with the objective to detail, or extend where necessary, the existing design guidelines. With Table 2, we would like to recapitulate our main findings and illustrate what researchers need to consider in responding to potential criticism.

#	*Guideline*	*Potential criticism*	*Proposed extension*
1	Problem definition	▪ Neglecting to concretize the specific matter that is subject of the evolutionary process (i.e. a process, a material object, a skillset, …) ▪ Not differentiating between the subject under investigation and the evolution of the subject (i.e. the concept under study is always conceptualized as a process) ▪ Assuming that the maturation path is always linear and equifinal	Researchers should thoroughly define the subject under investigation and the goal function; it should become clear what "maturity" means and if the proposed maturation path envisages a linear, single-objective optimization (e.g. cost improvement, risk reduction, efficiency increase) or is designed for coping with non-linear, multi-objective optimization problems (e.g. trade-offs, contextualization)
2	Comparison with existing maturity models	▪ Renouncing to illustrate how the new MM is different from existing ones ▪ Providing a list of existing MM without revisiting their conceptualization of maturity, goal function, and theoretical underpinning	Researchers should clearly state to what extent the new model is an improvement or exaptation of existing solutions; it should become clear how the new model differentiates in terms of theoretical assumptions, operationalization, practical goals, and envisioned application domain from other models
3	Identification of problem relevance	▪ Inferring that there is an instinctive legitimacy for a new MM when no other model currently exists that deals with the selected subject ▪ Assuming that there is a demand for a new model when there is a sponsor ▪ Assuming that a more complex MM (as compared to an existing one) will be more relevant for practice	Researchers should thoroughly assess the opportunity and/or necessity for developing new MM beforehand; it should become clear that there is a real need in practice (beyond a single, sponsoring unit); the current decision-making situation must be explained in more detail to justify the design of a particular type of MM (e.g. heuristics for emerging or extremely complex phenomena, sophisticated mathematical models for established topics)
4	Multi-methodological procedure	▪ Not using any empirical and logic-based approaches to develop a new MM ▪ Relying on purely judgmental or expert-based methods	Researchers should triangulate the findings from empirical and logic-based methods; a mixing of judgmental and more theory-based evidence is highly recommended
5	Iterative procedure	▪ Not thinking in iterations, but in a streamlined, step-by-step design process ▪ Not specifying a clear starting point and stop criterion of the design process	Researchers should make transparent to what extent the design process was, indeed, an iterative endeavor; it should become clear how many iterations the presented MM has undergone, what were the initial design goals and hypotheses, and why the iterative procedure has come to an end

#	*Guideline*	*Potential criticism*	*Proposed extension*
6	Evaluation	▪ Neglecting to concretize the criteria and perspectives applied for evaluating the new MM ▪ Not attempting to measure observable impacts of the MM use, instead of basing the evaluation on a priori subjective beliefs and attitudes only ▪ Omitting to specify the contextual, temporal, and other parameters where and when the new MM proved to produce reliable and valid results	Researchers should thoroughly define the criteria and the specific setting of the evaluation and make statements about the reliability and validity of findings; as opposed to the ordinary assessment of expectations, the evaluation of the model's real impact in practice is highly recommended
7	Scientific documentation	▪ Concentrating on the presentation of the form and functioning of the new MM, while omitting to describe the way how the MM was developed ▪ Not making the effort to bringing textual descriptions into a more useable form for academics and practitioners	Researchers should document the design product and process; it should not only become clear how the model functions, but also on which evidence it was developed and tested. Also, possible limiting factors of the model application (e.g. required resources, organization size) need to be made explicit; the documentation beyond a purely textual form is highly recommended
8	Targeted presentation of results	▪ Neglecting to concretize how to apply the new MM and how to deal with ambiguous situations ▪ Not explaining how the organizational learning process can be animated by the new MM	Researchers should make transparent how to use the developed MM and how to deploy it to practice; it should become clear how to set up a model-based assessment, how to interpret assessment results and how to deal with ambiguous findings; a reflection about the ways model-based organizational learning and decision-making can be devised is highly recommended

Table 2. Extended guidelines for the design of maturity models

Limitations and Critical Reflection

We would like to conclude by highlighting some limitations that our paper exhibits. First, our analysis of existing guidelines is restricted to the methodology articles we identified in our scoping review, that is the gray cluster in the bibliographic coupling (see Figure 3). We could learn more when we extend our review to articles outside the IS discipline as well as incorporate findings from practice into our considerations. While this has been our initial wish, it proofed to be difficult to get detailed feedback on the underlying design principles of MM which are successful in practice. Second, even though we screened and refer to a large part of the identified articles, our appraisal is particularly focused on the most widely used design guideline, which currently is the one developed by Becker et al. (2009). Certainly, several more recent studies could be said to have "addressed" some of the mentioned criticism towards MM (Iannacci et al. 2019; Lasrado et al. 2016; Wendler 2012), yet deliberations often remain tight to a specific MM or application domain like BPM – a higher-level consideration of how to fix the constant critique is missing. Hence, the proposed extensions represent the consolidation of a critical reflection process which was stimulated by the literature that is currently used to build and evaluate MM in our discipline. The work we present here cannot be categorized as theory development but most likely as a method development paper. In this sense, we do not present an empirical verification but argue logically how the proposed extensions lead to more reliable and valid models as well as help to establish rigor in this stream of research.

As with any method development effort, we deem it equally important to pinpoint to some issues and thoughts that the presented work does not provide an answer to. For instance, in reviewing and extending the existing design guidelines, we did not discuss some more fundamental problems of MM. One of such challenges is certainly the famous Black Swan Fallacy, which refers to the sense (or rather nonsense) of predicting the future of game-changing events or largely unknown phenomena based on historic, observable cases in practice. Furthermore, given that "maturity" is often a relative concept, dependent on temporal, contextual, and other parameters, it is almost impossible (from a statistical point of view) to prescribe a "maturation path" that is reliable and valid for a large number of organizations or settings. Accordingly, even if a researcher follows all proposed extensions, certain criticism from rigor-centered academics will remain. It is important to notice that this criticism is frequently not only directed towards MM but to the essence what counts as scientific contribution because of different epistemological standpoints. To our view, the most important reference point for evaluating MM is the extent to which a model can generate a real impact in practice.

There we observe another big challenge, that is, that MM cause a falsified certainty or become a self-fulfilling prophecy. Because the concept of maturity and corresponding cause-and-effect relations (e.g. improving activity A leads to result B, which is the necessary starting point for activity C) are in most instances rather unclear, it is often not possible to determine what led to an improvement of the situation. While advocates of MM would most certainly ascribe this positive effect to the application of the model, it could also have been an accumulation of lucky accidents (e.g. a more benevolent assessor and/or a different interpretation of the proposed maturation path). When trying to measure the utility of a MM, it is all the more important to use a longitudinal approach and look for bias in the perceptions of involved practitioners and changes in the procedure since the last maturity assessment.

Opportunities for Future Research

Our paper opens up new avenues for further research in three particular areas. First, the discussed extended guidelines for the design of MM need to be further refined based on concrete applications. Future research must use the proposed guidelines and reflect on the contribution to rigor and relevance in different application domains. The accumulation of application experiences will further substantiate how the presented propositions lead to improved rigor and relevance in MM research.

Second, future MM researchers should not only adopt a problem-centered view as starting point of a design endeavor but also adopt context-centered entry points to the MM development process. This would allow sufficiently addressing the evaluation of a MM's real impact in practice (guideline 6). It would shift the focus from MM development to evaluating with empirical and longitudinal research the MM's impact on the intended goals of application as well as possible wider effects of MM deployment.

Third, our findings particularly place the focus on studying how MM contribute to organizational learning. The effective assistance in MM deployment (guideline 8) requires empirical research effort that intersects with research on the role of reference models for the development of organizational capability (Canhoto et al. 2021; Holmström et al. 2021). Considering that MM are deployed in organizations for diverse purposes, including forced selection, efficient choice, and management fashion (Akhlaghpour and Lapointe 2018), MM deployment must be tailored to these different purposes (Wulf et al. 2017). Further empirical knowledge on how MM support organizational learning will facilitate the specification of guidelines on how to deploy MM in different application scenarios.

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