ARTICLE

Digital Maturity Models: A Characterisation Study Based on a Systematic Literature Review

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ABSTRACT

Knowing the characteristics of digital maturity models is fundamental to achieving an effective evaluation of organisations regarding the use of digital technologies. To this end, this article analyses, through a systematic literature review, the approaches used by digital maturity models. 40 models were analysed, and it was noted that the characteristic "dimensions", responsible for the structuring of the models, varies little or not at all according to the domain of application, hindering flexibility in the use of the models and making a more realistic organisational assessment impossible. Thus, a grouping of the dimensions was prepared, favouring a future investigation toward the development of a collaborative methodology able to better define and prioritise the dimensions according to the organisational domain, thereby providing greater effectiveness in the preparation and application of a digital maturity model, as well as allowing a better vision of the progress of digital transformation.

KEYWORDS

digital maturity models, digital transformation, dimension prioritisation, systematic review of literature.

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Modelos de Maturidade Digital: Um Estudo de Caracterização Baseado na Revisão Sistemática de Literatura

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RESUMO

Conhecer as características dos modelos de maturidade digital é fundamental para possibilitar um eficaz processo de avaliação das organizações quanto ao uso das tecnologias digitais. Para tanto, este artigo tem como objetivo analisar, por meio de uma revisão sistemática da literatura, as abordagens utilizadas pelos modelos de maturidade digital. Com o delineamento metodológico, obteve-se a análise de quarenta modelos. Como resultado, percebeu-se que a característica "dimensões", responsável pela estruturação dos modelos, praticamente não varia de acordo com o domínio de aplicação, dificultando a flexibilidade na utilização dos modelos e impossibilitando uma avaliação organizacional mais realística. Assim, foi elaborado um agrupamento das dimensões, favorecendo uma investigação futura para o desenvolvimento de uma metodologia colaborativa capaz de melhor definir e priorizar as dimensões de acordo com o domínio organizacional, proporcionando maior efetividade na elaboração e aplicação de um modelo de maturidade digital, além de permitir uma melhor avaliação do progresso da transformação digital.

PALAVRAS-CHAVE

modelos de maturidade digital, transformação digital, priorização de dimensões, revisão sistemática de literatura.

1. INTRODUCTION

From effective combinations of best practices and available resources, digital maturity models (DMM) are increasingly used with the aim of determining the behaviour manifested by organisations (Dutta et al., 2021), building on their skill levels with digital technology to get the best out of digital transformation (DT) (Ivančić et al., 2019). DMM models seek to elucidate the path of improvement through digitisation efforts and to reveal weaknesses and strengths to determine actions, using qualitative and quantitative means that are clearly communicated and well documented (Kırmızı & Kocaoglu, 2022). Although digital technologies are the requirements for the DT of organisations, Dutta et al. (2021) highlight that, for the desired level of digital maturity, organisations should prioritise the importance of supports such as work organisation, people, and properties, as the main subsidies to technology in the execution of procedures that can help to obtain the best level of performance.

As a result of the COVID-19 pandemic, DT became more evident and essential not only to compete, but also to adapt to a new survival scenario (Marks & AL-Ali, 2020). The pandemic forced many sectors of the economy to develop new business models resulting from the combination of traditional and digital business models that allowed companies to maintain their activities by adding value propositions for a new market (Soto-Acosta, 2020).

Digital Transformation has become a widespread trend in the modern world, presenting different levels of influence on the nature of socio-economic processes and bringing changes to society, business, and the management of organisations. DT determines directions in the transformation of management, such as: development of digitalisation strategies, business model and process transformation, automated services, remote work, capacity to analyse large volumes

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of data, flexibility and agility in management decisions, etc. All of these changes are reflected in policies aimed at data protection, incentives for innovation, changes in the work regime, and technological advances, among others (Shatilova et al., 2022).

Even in the face of the development of some models that aim to guide organisations regarding their level of digital maturity as a competitive factor, Schumacher et al. (2016) highlight the uncertainty of organisations regarding basic concepts, such as the vertical and horizontal integration of digital systems embedded throughout the value chain. The authors emphasise the importance of concrete projects capable of providing guidance and supports related to their specific domain and their particular business strategy. Although DMM have their benefits well defined, Ifenthaler and Egloffstein (2020) also highlight that many existing models are criticised for their lack of suggestions and actions that organisations can take to improve their maturity level. The authors note the lack of a descriptive purpose that can measure the current state and be used as a diagnostic tool, a prescriptive purpose that provides improvement measures through maturity, and a comparative purpose for benchmarking (Kırmızı & Kocaoglu, 2022).

With the aim of enhancing knowledge in relation to the DMM developed by various authors, this study establishes, by means of a Systematic Literature Review (SLR), an analysis of the approaches used by 40 DMM in the years 2011 to 2021, in order to answer the following research questions:

- **Q1** - *What are the characteristics (dimensions, functionalities, and requirements) of the DMM?*
- **Q2** - *Which DMMs prioritise dimensions according to the application domain?*

The results provide a conceptual basis for the development of DMM, through a grouping of 18 dimensions that stood out in our analysis as agents in the evaluation process of organisations, fundamental to the DT process.

Considering the relevance of the dimensions to assessing the current state and progress of DT in organisations, for future research the authors propose: (i) a more in-depth study of dimension parameterisation through a participative methodology (Delphi), based on the knowledge and reflections of a broad group of experts from various organisations, in order to examine each significant dimension for the progression of the relevant maturity levels in the conception of DMM, providing an explicit correlation with the progress of DT; (ii) the development of a generic digital maturity model supported by a multi-criteria methodology, with the purpose of establishing a framework to assessing the current state of DT in organisations, prioritising the dimensions according to the domain.

2. DIGITAL MATURITY

With the aim of improving the strategic competitive advantage of organisations, DMMs aim to assess the level of digital transformation of an organisation and guide, by means of a roadmap, the achievement of the desired level of digital maturity, providing vital innovations in the creation of value for organisations (Kırmızı & Kocaoglu, 2022; Gökalp & Martinez, 2021). For Kljajić Borštnar and Pucihar (2021) and Ifenthaler and Egloffstein (2020) digital maturity is an evolutionary process divided into a sequence of levels leading to the desired maturity state in which the logical path from the initial state to the final maturity state should be pointed out. However, Rossmann (2019) emphasises that digital maturity clearly refers to the formation of specific capabilities to manage DT that are segmented into digital capabilities (strategy, technology

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expertise, business models, customer experience) and leadership capabilities (governance, change management, culture).

Digital maturity enables organisations to move toward the achievement of DT, Gollhardt et al. (2020). Gökalp and Martinez (2021) highlight the goal of DT to add value to the business in a change seeking the better performance of the organisation by optimising processes, increasing productivity, and building new market segments through continuous information processing. Currently, the focus of organisations is on changing their paradigms in this new digital market and developing methodologies that can help to achieve value-added DT to their business (Rautenbach et al., 2019; Peixoto et al., 2022), and make their products/services more flexible to meet expectations for increased global competition and integration through new configurations of their value chains (Vereycken et al., 2021).

From this perspective, organisations have sought to adapt their business model at a dynamic pace in line with technological progress. These changes, according to Múnera et al. (2020), lead to the fundamental need for support in organisations that are in this process of transition, with the purpose of improving their capabilities by way of a targeted and consistent DT, improving the quality of services and products in accordance with the characteristics of each sector, and contributing with the maturation of the organisation in line with emerging technologies (Gökalp & Martinez, 2021). For Gollhardt et al. (2020), DT goes beyond its social aspect of implementation and use of new technologies. The authors observe that DT is mainly related to changes in business models and strategies, in addition to corporate culture and other important factors to respond to the fierce competition of a volatile market, with new competitors and more demanding customers.

As DT is a comprehensive project that involves continuous improvement at all organisational levels (Yan et al., 2021), a holistic description study that can assist organisations in a digital process from the beginning (at the micro level) to the development of DMM that contribute to the evaluation process of organisations (at the macro level as a strategic competitive advantage that is management-oriented and technology-oriented to be used as self-assessed measurement tools) is necessary and of great importance (Kırmızı & Kocaoglu, 2022).

2.1. Digital Maturity Models (DMM)

Digital Maturity Models are applied to assess the current situation of technology use in the organisation, prioritising improvement measures so that the firm can reach the desired maturity stage (Becker et al., 2009), effectively guiding the DT (Teichert, 2019). The DMM should be developed to assess organisations as to the degree of maturity through dimensions that can guide organisations to reach their best digital maturity through actions necessary for the achievement of the respective DT (Múnera et al., 2020), adding value and making the companies more competitive.

Researchers are currently devoting greater attention to the DMM concepts with the aim of developing models with objective and better-defined assessment methods. What DMM proposes is to capture the maturity of an organisation through exclusive dimensions. Some models present the operationalisation of criteria in their dimensions, but assessment methodologies remain poorly defined (Gollhardt et al., 2020). One definition that clearly addresses the purpose of DMM is advocated by Gollhardt et al. (2020, p. 96), who emphasise: "A maturity model consists of a sequence of maturity levels for a class of objects, and represents an anticipated, desired, or typical evolution path of these objects in the form of discrete stages. Typically, these objects are organisations or processes".

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Peixoto et al. (p. 410, 2022) points out the importance of DMM in identifying gaps in order to plan actions that can help organisations to achieve the state of digital maturity, and further emphasizes: "DMM specifically reflect the status of a company's DT". For Ifenthaler and Egloffstein (2020), the purpose of DMMs is to pinpoint strengths and weaknesses of organisations through the identification of discrepancies that exist between the organisational design and the developed competencies. Múnera et al. (2020), on the other hand, defend the thesis that DMMs are evaluation instruments that aim to identify the deficiencies that may negatively affect the effectiveness of an organisation's DT.

As defined by Gollhardt et al. (2020), DMMs have three functionalities:

i. Descriptive - directed only to the evaluation of the business;
ii. Prescriptive - refers to the assessment and classification in stages (levels) of maturity, guiding the organisation to achieve them;
iii. Comparative - refers to the study of internal and/or external benchmarking.

What is expected are more comprehensive DMMs in which all functionalities (descriptive, prescriptive, and comparative) are integrated. More complete DMMs should enable greater flexibility and representativeness of dimensions and levels according to the changes of the context in which the organisation operates (Gollhardt et al., 2020) and offer extensive guidance (including roadmaps) to improve organisational processes in different domains (Gökalp & Martinez, 2021).

Also in the quest for the development of DMM with clearer and more objective assessment methods, Rautenbach et al. (2019) identified the fundamental requirements that should be practiced for the development of DMM. Among these requirements are: (Req1) the model should enable organisations to assess the digital dimensions in which they are creating value; (Req2) the model should clearly indicate and explain the different levels of digital capability maturity for each digital dimension; (Req3) the levels of digital capability maturity should be distinct, each including all the previous levels; (Req4) the model should allow organisations to assess their perception of the maturity of their digital capability within each of the digital dimensions identified; (Req5) the template should present the results of the evaluations in a clear and concise manner; (Req6) the model should allow organisations to assess their progression in the DT journey.

The incentive is the search for a business solution of undefined DT levels from the incorporation of requirements and the applicability to the business problem and with scientific grounding (Gollhardt et al., 2020), focusing on the development of more effective DMM.

3. METHODOLOGY

Our methodology consists of a synthesis of evidence through a systematic literature review (SLR) as an essential tool for the formulation of new research (Muka et al., 2020). Table 1 was prepared by adopting the PRISMA protocol (*Preferred Reporting Items for Systematic Reviews and Meta Analyses*) (Regona et al., 2022) in order to provide the reproducibility of the study. According to Snyder (2019), a number of standards and guidelines address how literature reviews should be reported and structured. One of these standards is PRISMA, developed for systematic literature reviews and meta-analyses.

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We performed an SLR, which aims to systematically analyse research questions (Rautenbach et al., 2019), examining 40 DMM. Our SLR is an update of the work by Teichert (2019), who examined 22 DMM. We restricted our period of investigation to encompass works published from 2011 to 2021 in order to extend and build upon Teichert's (2019) sample with the aim of identifying new knowledge gaps to answer research questions.

According to Moher et al. (2008), a review can be updated and include new questions to be answered from an existing body of knowledge. The survey was updated based on searches in the Scopus, Web of Science, and EBSCO databases. Our search identified an additional 18 DMM, as reported in Table 1.

Table 1
Stages of Systematic Literature Review

1. Formulation of the research question	Q1: What are the characteristics (dimensions, functionalities, requirements) of the models?
	Q2: Which models prioritise dimensions according to the domain definition?
2. Location and selection of studies	1. Databases: *Scopus, Web of science*, EBSCO
	2. Filter: Period: Studies published from 2011 to July 2021;
	3. Definition of the search thesaurus: "Digital Transformation Maturity" OR "Digital Maturity Levels" OR "State of Digital Transformation" OR "Phases of Digital Transformation"
3. Critical evaluation of the studies	It was divided into three parts:
	1. First selection - analysis of title and abstract: Exclusion: not addressing a new DMM; Inclusion: tackling a new DMM;
	2. Second selection - Definition of eligibility criteria and analysis of the study according to these criteria: C1 - Type of study: Conference papers, journal articles; technical reports (consultancy), and e-book; C2 - Language: English, Spanish, Portuguese, and German C3 - Full text; Exclusion: does not meet at least one of the criteria; Inclusion: meets all criteria.
	3. Third selection - analysis of the full text: Exclusion: does not answer the research questions; Inclusion: answers the research questions.
4. Data collection and analysis	Variables identified: title, author, year of publication, vehicle (type, name, and quartile), DMM, origin of the model, dimensions (axes), maturity levels, and methods used in the assessment process.
5. Interpretation of data	Characterisation of the domains, dimensions, and functionalities of the models under study;
	Characterisation of the models according to the fundamental requirements for DMM development;
	Analysis of the ability to prioritise the dimensions by domain specific to the organisation under study.

Source: authors, according to the PRISMA steps (PRISMA, 2022; Moher et al., 2009).

From the inclusion and exclusion criteria stated in Table 1, which express the objective of the research process determining the selection of studies that present a new model of digital maturity, 40 eligible studies were selected, as presented in Table 2.

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Table 2
Article Selection

| Databases	Identification		Selection (Title/Abstract)		Eligibility (Criteria)		Inclusion (Text Analysis)	
	Results	Duplicates	🗑	✔	🗑	✔	🗑	✔
SCOPUS	19	6	6	7	1	6	2	4
Web of Science	45	4	26	15		15	3	12
EBSCO	15	6	4	5		5	3	2
Teichert (2019)	-	-	-	-	-	-	-	22
Total	79	16	36	27	1	26	8	40

Source: authors.

4. RESULTS

After the evaluation of the studies, a total of 40 DMMs were identified. The general descriptions of the DMMs and the definition of the dimensions were analysed, observing the influence of the domain to be studied by the models on the determination of the dimensions, and the criteria used for the defined assessment process.

4.1. Number of studies published per year

Figure 1 shows the evolution within the period established in the study. The rate of development of studies in recent years has decreased, but remains substantial, as the selected studies do not refer to existing DMM applications but to the development of new DMMs contributing effectively to future investigations in view of the needs of organisations to adapt to DT standards to better meet the principles of I4.0.
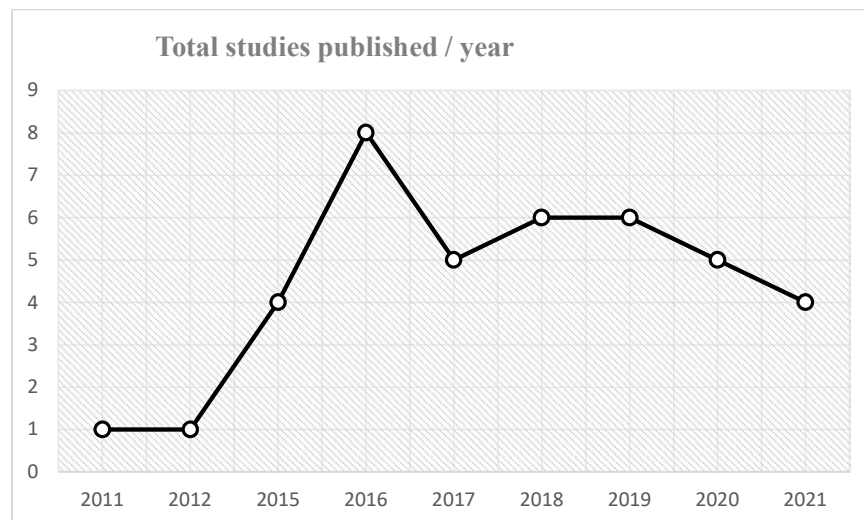
Figure 1. Total Studies Published per Year
Source: authors.

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4.2. Description of the proposed models

Table 3 presents the description of the 40 models proposed, highlighting characteristics inherent to each model with the purpose of contributing to the analysis of the study. The DMM characteristics refer to the dimensions in which the models are assessed to define their level of maturity; while the domain is related to the branch of activity of the organisation. The method for developing the model informs the assessment and data collection methodology in defining the dimensions, adapted to the characteristics of the organisations, with best practices.

In the investigation of the studies presented in Table 3 some important approaches to model characterisation are worth highlighting regarding their value in contributing to the development of new models. The first of these is the domain, with emphasis on the manufacturing domain that characterises the first models developed, mainly in the years 2016 (emphasis on the general domain, but with application to manufacturing organisations) and 2017, as also showed in Figure 2.

The characterisation of the manufacturing domain is justified by the fact that organisations adopt technologies in automated production processes, but insufficiently, because, as addressed by Ivančić et al. (2019), some co-factors are of utmost importance for the achievement of digital maturity and may be lacking, such as the overall organisational configuration that supports a digital culture, and efficient integrated information systems. With regard to the methods used in the research for the development of the models, it is still a great challenge because most studies are still influenced by the earliest models with regard mainly to the issue of dimensions. In the earliest models, the classical approach of fixed and comprehensive dimensions prevail, except for those that present a very specific domain study.

Figure 2 explores the characteristics of the models in relation to the domain in the study period, i.e., it refers to the domain for which the models were developed over time.

As of 2019, the models presented in the study are mostly characterised in the services domain (Figure 2), with an emphasis on SMEs developed as of 2018, which is justified by the importance in the economy, as addressed by Gollhardt et al. (2020).

It is also worth highlighting the development of studies aimed at services in 2020 (in its entirety) and 2021 (Figure 2), stimulated by the sense of urgency caused by the COVID-19 pandemic, as addressed by Rodríguez-Abitia and Bribiesca-Correa (2021), with emphasis on the development of models aimed at the education sector.

Table 3

Description of Digital Maturity Models

ID	Author	Model Name	Dimensions	Domain	Model Focus	Model development method
M1	Kljajić Borštnar and Pucihar (2021)	–	Organisational Capacity; Digital Capacity	General (SMEs)	Academic	LR; PM
M2	Rodríguez-Abitia and Bribiesca-Correa (2021)	Integrated multidimensional digital transformation model.	Digital Strategy; Leadership and Culture; Digitalisation; Logistics; Digital Capability	HEI	Academic	LR; PM
M3	von Solms and Langerman (2021)	Smart Digital Treasury Model (SDTM)	Digital Leadership; Technical Knowledge; Data; Technological Infrastructure; Process Automation	Banking Sector (Services)	Academic	LR
M4	Yan et al. (2021)	–	Strategy; Resources; Processes; Capacity; Performance	General	Academic	LR; PM
M5	Gollhardt et al. (2020)	–	Culture; Ecosystem; Operations; Governance; Strategy	Telecom Service	Academic	LR; PM
M6	Ifenthaler and Egloffstein (2020)	MMEO	Infrastructure; Strategy and Leadership; Organisation; People; Culture; Technology	Education	Academic	LR; PM
M7	Marks and AL-Ali (2020)	–	Learning; Skills; Research; Planning and Governance	HEI	Academic	PM
M8	Múnera et al. (2020)	–	Strategy; Customer; Ecosystem; Operations; IT; Innovation	Service	Academic	LR; PM
M9	Rytova et al. (2020)	–	HDI; Telecommunication; Technology; IT; Organisational Structure; Services; Digital Capability; Resources; Digital Economy	Public Sector	Academic	Analysis of other models
M10	Álvarez Marcos et al. (2019)	–	Corporate Strategy; Technology; Organisational and Professional Convergence; Digital Intensity; Transformation Management	Service	Academic	PM
M11	Doneva et al. (2019)	UniDigMaturity	Quality Policy; Programme; Learning; Certification and Admission of Students; Learning Resources; Information Management; Public Information; Monitoring of Course Programmes; Quality Assurance	HEI	Academic	Analysis of other models
M12	Ivančić et al. (2019)	–	Strategy; People; Organisation; Customers; Ecosystem; Technology; Innovation	General	Academic	PM

Table 3
Cont.

ID	Author	Model Name	Dimensions	Domain	Model Focus	Model development method
M13	Jaico et al. (2019)	–	Digital Culture; Organisational Culture	HEI	Academic	LR; PM
M14	Rautenbach et al. (2019)	–	Customers; Technology; Strategy and Leadership; Business Models; Product Offering; People and Organisation, Culture	General	Academic	LR; PM
M15	Renteria et al. (2019)	Enabler-Based Digital Government Maturity Framework (EDGMF)	Leadership; Regulatory regime; Strategy; Organisation; Governance; Technology; Data	Government Institution	Academic	Analysis of other models
M16	Balaban et al. (2018)	Framework for Digitally Mature Schools (FDMS)	Planning, Management and Leadership; Learning; Digital Skills; Culture; Infrastructure	Schools	Academic	LR; PM
M17**	Canetta et al. (2018)	–	Strategy; Processes; Technology; Products and Services; People	Manufacturing	Academic	PM
M18**	Colli et al. (2018)	360DMA	Governance; Technology; Connectivity; Value Creation; Competence	Manufacturing	Academic	LR; PM
M19	Durek et al. (2018)	DMFHEI adapted	Leadership; Planning and Management; Quality; Research; Technology; Learning; Digital Culture; Resources and Infrastructure	Education	Academic	PM
M20	North et al. (2018)	"DIGROW"	Organisational Growth; Strategy; Digital Capability; Processes	General (SMEs)	Academic	–
M21**	Zeller et al. (2018)	Acatech Industrie 4.0 Maturity Index	Resources; Organisational Structure; Information Systems; Culture	Manufacturing	Academic	PM
M22**	De Carolis et al. (2017)	DREAMY (Digital REadiness Assessment MaturitY model)	Processes; Control; Technology; Organisation	Manufacturing	Academic	PM
M23**	Kane et al. (2017)	MIT SMR	Technology; Digital Resources; Processes; Business Models	General	Professional	LR; PM
M24**	Leino and Anttila (2017)	VTT Model of Digimaturity	Strategy; Business Models; Customers; Organisation; People and Culture; Technology	Manufacturing	Academic	PM

Table 3
Cont.

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| ID	Author	Model Name	Dimensions	Domain	Model Focus	Model development method
M25**	PWC (2017)	PWC (2017)	Strategy; Infrastructure; Risk Management; Skills; Clients; Ecosystems; Technology; Governance; Leadership; Culture	General	Professional	PM
M26**	Remane et al. (2017)	–	Digital Impact; Digital Readiness	Manufacturing	Academic	LR; PM
M27**	Berghaus and Back (2016)	–	Customers; Innovation; Strategy; Organisation; Processes; Collaboration; IT; Culture; Transformation Management	General	Academic	PM
M28**	Gill and VanBoskirk (2016)	Forrester's Digital Maturity Model 4.0	Culture; Technology; Organisation; Data	Manufacturing	Professional	PM
M29**	KPMG (2016)	Digital Readiness Assessment (DRA)	Strategy; Infrastructure; Risk Management; Skills; Clients; Ecosystem; Governance	General	Academic	–
M30**	Leyh et al. (2016)	SIMMI 4.0	Vertical Integration; Digital Product Development; Technology	Manufacturing	Academic	LR
M31**	PWC (2016) – Industry 4.0	PWC Digital Maturity Model	Business models customer access; Digitisation services; Digitisation and integration of vertical and horizontal value chain; Data; IT; Compliance, security, legal and tax; Organisation, employees and digital culture	Manufacturing	Professional	PM
M32**	Schumacher et al. (2016)	Digital Capability Framework (DCF).	Strategy; Leadership; Customers; Products; Operations; Culture; People; Governance; Technology	Manufacturing	Academic	LR; PM
M33**	Uhl and Gollenia (2016)	Digital Capability Framework (DCF)	Innovation Management; Transformation Management; IT Excellence; Customer; Employees; Operational Excellence	General	Academic	PM
M34**	Valdez-de-Leon (2016)	–	Strategy; Organisation; Customer; Technology; Operations; Ecosystem; Innovation	Telecom services	Professional	LR; PM
M35**	Lichtblau et al. (2015)	–	Strategy and Organisation; Employees; Data; Smart Products; Smart Operations; Smart Factory	Manufacturing	Academic	PM
M36**	McKinsey (2015)	Digital Quotient (DQ)	Strategy; Digital capability; Technical capability; Organisational structure	General	Professional	–

Table 3
Cont.

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ID	Author	Model Name	Dimensions	Domain	Model Focus	Model development method
M37**	Neuland (2015)	–	Strategy; Leadership; Products and Services; Operations; Culture; Employees; Governance; Technology	General	Professional	LR; PM
M38**	Bloching et al. (2015)	Roland Berger	Digital Data; Automation; Connectivity; Customer	Industry	Professional	PM
M39**	Westerman and Mc-Afee (2012)	MIT/ Capgemini	Governance; Resources; IT; Customer involvement; Operations; Business models	General	Professional	Analysis of other models
M40**	Strategy and Booz (2011)	–	Digital input; Digital processing; Digital output; Infrastructure	Industry	Professional	–

Notes. LR-Literature review; HEI-Higher Education Institution; HDI-Human Development Index; ICT-*Information* and Communication Technologies; PM- Participatory Methods.
**Teichert* (2019, p. 1679-1680).
Source: authors.
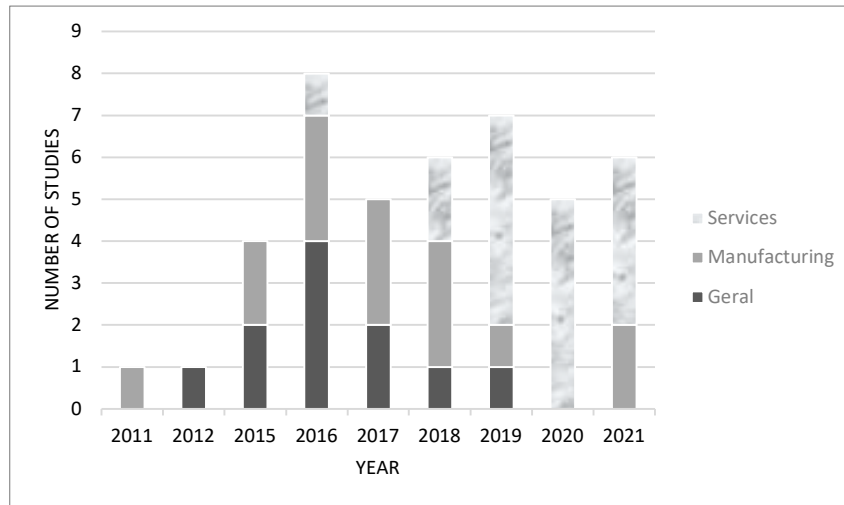
Figure 2. Characterisation of Studies by Domain/Year
Source: authors.

5. DISCUSSION

Despite the improved performance that goes along with the development of new DMMs, many problems remain with regard to the assessment of the DT of organisations, stimulating new studies with the purpose of assessing the maturity levels of an organisation (Rytova et al., 2020). The maturity dimensions vary very little amongst the different models, as highlighted by von Solms and Langerman (2021), although having the same objective, i.e., to quantitatively measure the digital maturity of organisations. This standardisation of the dimensions included in many models is due to the lack of an aggregation methodology that can assist in understanding the prioritisation of the dimensions according to the characteristics of each domain.

Also according to von Solms and Langerman (2021), one of the major difficulties found in the literature is the assessment process, especially when it refers to a larger number of dimensions, which can make the assessment more complicated. Also, when there are a greater number of dimensions to take into account in the assessment process, it becomes more difficult to find a methodology that can be well understood by the organisation undergoing the assessment.

In order to achieve the objective of the study and highlight the role of the development of DMM in the evaluation process of organisations, the following are presented: (i) the main analyses of the results obtained, emphasising the DMM that contributed effectively to the proposed research questions; (ii) a summary of the characterisation of each digital maturity model identified; and (iii) agenda for future work.

5.1. CHARACTERISTICS OF THE MODELS: WITH REGARD TO DIMENSIONS

Regarding the characterization of the dimensions, Table 4 presents the result of the research based on the models investigated by the authors. Although the aim of the dimensions is to be directly linked to covering all business areas essential to the DT process (Gollhardt et al., 2020), it is observed that many of the models concentrate their assessment on similar dimensions (Table 4), regardless of the domain of the organisation, with a representativity percentage of 89% of the dimensions of the models of general domain in relation to the models of specific domains, highlighting only two dimensions from models developed for the assessment of educational institutions.

Table 4

Frequency of Dimensions per Digital Maturity Model

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Models	T	Str	Org	LC	DC	Op	Pe	RI	PS	Le	Ct	Pl	I	TS	Gv	D	Ec	Sr
M1			✓		✓													
M2		✓		✓	✓	✓												
M3	✓		✓					✓						✓		✓		
M4		✓				✓		✓				✓						
M5		✓		✓		✓								✓		✓		
M6	✓	✓	✓	✓			✓	✓										
M7										✓		✓		✓				✓
M8	✓	✓				✓					✓		✓			✓		
M9	✓		✓		✓		✓	✓	✓									
M10	✓	✓			✓								✓	✓		✓		
M11							✓	✓	✓		✓		✓			✓		
M12	✓	✓	✓					✓			✓		✓				✓	
M13				✓														
M14	✓	✓	✓				✓		✓		✓							
M15	✓	✓	✓	✓						✓				✓		✓		
M16	✓			✓	✓			✓				✓						
M17	✓	✓				✓	✓		✓									
M18	✓								✓					✓	✓			
M19	✓			✓				✓		✓		✓						✓
M20		✓	✓		✓													
M21	✓		✓	✓				✓										
M22	✓		✓			✓												
M23	✓		✓			✓		✓										
M24	✓	✓	✓				✓				✓							
M25		✓		✓				✓			✓	✓		✓	✓		✓	
M26					✓													
M27	✓	✓	✓	✓	✓						✓		✓	✓				
M28	✓		✓	✓													✓	
M29		✓						✓			✓	✓		✓	✓		✓	
M30	✓	✓							✓									
M31	✓		✓		✓							✓				✓		
M32	✓	✓		✓		✓	✓		✓		✓			✓				
M33	✓					✓	✓				✓		✓					
M34	✓	✓	✓			✓					✓		✓				✓	
M35		✓				✓	✓		✓							✓		
M36	✓	✓	✓		✓													
M37	✓	✓		✓		✓	✓		✓						✓			
M38	✓										✓					✓		
M39	✓		✓			✓		✓			✓				✓			
M40	✓							✓								✓		

Notes. T-Technology; Str-Strategy; Org-Organisation; LC-Leadership and Culture; DC-Digital Capability; Op-Operations; Pe-People; RI-Resources and Infrastructure; PS-Products and Services; Le-*Learning;* Ct-Customers; Pl-Planning; I-Innovation; TS- Talents and Skills; Gv-Governance; D-Data; Ec-Ecosystems; Sr-Search.

Source: authors.

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From this perspective, the study highlights two models, the one proposed by Doneva et al. (2019) and the one proposed by Balaban et al. (2018). The first one by Doneva et al. (2019) pertains to the assessment of Higher Education Institutions (HEIs), with defined dimensions comprising all areas of the organisation basing itself on the institutional regulation and assessment process defined by the European Standards Guidelines (ESG). The ESG focus on teaching, learning, evaluation, and learning support activities.

The second model is the Framework for Digitally Mature Schools (FDMS), developed by Balaban et al. (2018), which presents a structure of dimensions specific to the domain under study, based on the assessment system of pre-tertiary schools in Croatia. In the FDMS, each dimension is related to a specific area that determines the level of improvement of teaching-learning through the use and application of technologies.

For an effective assessment process, all areas of the organisation should be analysed without the maturity level being calculated individually (Valdez-de-Leon, 2016). It is also essential to characterise specific dimensions that can involve all areas of the organisation that are important to the DT process and continuous improvement at all levels of the organisation (Yan et al., 2021).

Considering the importance of the dimensions in the development process of the models presented, we performed an analysis that resulted in the grouping of the dimensions by similarities (Table 4). The grouping represents the frequency of the dimensions for each model, providing a better diagnosis through the set of data presented.

The dimension "Organisation" stands out, mainly with regard to the descriptions of its subdimensions, while overlooking mediating factors as highlighted by Ifenthaler and Egloffstein (2020), such as the fact that showing a high level of maturity among employees may, nevertheless, not imply better organisational performance.

The "Technology" dimension has also been the subject of important considerations by the authors, mainly because it is inherent to all the dimensions and is seen as pivotal for the achievement of digital maturity. However, models that prioritise this dimension must take into account the accelerated pace of technological development, which affects the entire transformation management process (Gollhardt et al., 2020).

Dimensions structured for evaluation of education organisations stood out as being influenced by government policies (Marks & AL-Ali, 2020), focusing on teaching, learning, assessment, and learning support activities related to the Educational Institution (Doneva et al., 2019), differing from the dimensions structured by the other models.

Note that the results show a linearity in the definition of the dimensions in most of the models independent of the domain, as already highlighted. This is evident despite the authors' attempt to define methodologies that could help in the decision of the best structure of dimensions defined for the process of evaluation of the digital maturity.

The identification of dimensions that can meet the specific areas and activities of the organisation is essential for the adoption of a successful assessment process, with the purpose of providing better results with less effort and greater benefit to the business. Leyh et al. (2016) also highlight that the choice of dimensions should be directly related to the organisation's strategic positioning, there being no need for the implementation of all dimensions of the model to be applied. It is worth mentioning that the dimensions have different relevance for each domain to be evaluated.

5.2. Model features: in relation to Functionalities

Despite the importance of a development and guidance plan for organisations to reach digital maturity, based on the results obtained, most of the models analysed in this study are not prescriptive and do not present an action plan that can help organisations (Teichert, 2019). The importance of prescriptive models lies in providing the organisation with a clear perspective of its digital maturity, as highlighted by De Carolis et al. (2017), in order to better adapt to digital technologies and provide a better development of the corporate environment. Comparative models, on the other hand, are directed to the study of external and/or internal benchmarking and provide an evaluation oriented to the changes of the context in which the organisation operates (Gollhardt et al., 2020).

The model developed by Kljajić Borštnar and Pucihar (2021) stood out in the prescriptive and comparative aspect, supported by a multicriteria methodology, where each dimension was subdivided into attributes based on a decision model methodology for evaluating the analysis of alternatives (but the model was somewhat complex). For the definition of the dimensions the authors drew upon their literature review and existing models.

The second highlighted model was developed by Balaban et al. (2018), who based their research on the practical application of their model in 151 schools. The authors examined the correlation between the dimensions and classified the levels of assessment aimed at guiding best practices for the achievement of digital maturity.

With regard to the third model highlighted in relation to its descriptive, prescriptive, and comparative features, Rodríguez-Abitia and Bribiesca-Correa (2021) focused on determining the level of digital maturity of a HEI. The authors compared HEIs to organisations from a variety of domains, believing in the possibility that a better data structure could assist the organisation to achieve digital maturity. Rodríguez-Abitia and Bribiesca-Correa (2021) address the comparative methodology as a differentiator for new studies.

Bloching et al. (2015) analysed the digital situation in German industry by conducting a benchmarking process between manufacturing organisations, emphasising the lack of awareness regarding DT still seen as cost cutting (43% of survey responses from top executives). Some models still address relevant information that can guide organisations in their self-assessment process in the search for strategic planning to achieve digital maturity, however, as stated by Remane et al. (2017), this information is superficial because it does not offer a more complete analysis of the assessment results.

5.3. Characteristics of Models: in relation to the fundamental requirements for the development of DMM

Despite the standardization in the definition of the dimensions structured from models used as reference, the models presented in this study were able to define elements linked to the corresponding dimensions, providing the organisation with the opportunity to analyse its strengths and weaknesses that influence the assessment process, highlighting those that deserve special attention to achieve better results. Although the levels of digital maturity between the models are not significantly different, they are defined between 3 to 6 levels and are distinct. Most of the models presented the description of the necessary components in each dimension to assist in the diagnosis, defining evaluation goals and helping the organisation to improve its degree of digital maturity from a descriptive structure of its level of digital capability.

The models developed by Yan et al. (2021), Doneva et al. (2019), Ivančić et al. (2019), and Rautenbach et al. (2019) did not define the levels of digital maturity. Although these are models

that are in the development phase, it leads to difficulty in establishing the performance assessment criteria that can lead organisations to a more effective process of their digital maturity level.

The other models clearly present the levels and an assessment scale according to the established dimensions, but Jaico et al. (2019) defined the method of data treatment in determining the digital maturity level of the organisation and Canetta et al. (2018) provide, through the sum of the results of each dimension, the personalised characterisation of the digital maturity of the organisation. The model developed by Kljajić Borštnar and Pucihar (2021) assesses the level of digital maturity through an aggregate value analysis of the multi-attributes of the dimensions "digital capabilities" and "organisational capabilities", investigating the weaknesses and strengths to establish actions needed to improve the condition of the organisation's digital maturity.

Although Durek et al. (2018) also use a multicriteria method for the assessment of digital maturity, the level of digital maturity is determined from the assessment of the influence of only the criteria in the process (scale of influence multiplied by the relevance of each criterion), while (Rytova et al., 2020) establishes for the assessment of the level of digital maturity, factors of equal relevance, developed on a "fuzzy" scale of values.

On the DT issue, it is subtended that raising the level of digital maturity is raising the level of DT of organisations as a continuous process in redefining the digital capabilities of business models (Kljajić Borštnar & Pucihar, 2021; Ivančić et al., 2019), employing important technologies for the development of the digital culture of organisations, involving improvement at all levels of the organisation.

Yan et al. (2021, p. 171) explicitly define, as a goal of the development of their digital maturity model, the understanding of the DT of organisations through a holistic description. Ivančić et al. (2019) and Rautenbach et al. (2019) highlight the challenges that organisations face in the light of DT, through the DMM.

The model developed by Kljajić Borštnar and Pucihar (2021) emphasises its importance for future changes in the DT path. However, it is worth noting that their assessment process has an emphasis on modelling the attributes that makes up only two dimensions, digital capability and organisational capability. It can thus be seen that the models analysed do not make a direct correlation of DT progress from the DMM dimensions.

5.4. Models that prioritise dimensions according to the application domain

Faced with a scenario of dimensions defined from various DMMs, selecting significant dimensions for the process of evaluating the digital maturity of an organisation is of fundamental importance for understanding the relevance of each dimension according to the organisational domain, in order to offer greater value in the process of evaluating the organisation. We see in this study that for the development of the DMM, as mentioned by Gollhardt et al. (2020), that most authors did not prioritise the dimensions in accordance with the domain, disregarding the objective of the dimensions and their link to the nature of the organisation, essential to the digital transformation process.

Only two authors used methods for prioritisation. Kljajić Borštnar and Pucihar (2021) prioritised attributes rather than dimensions, and Durek et al. (2018) was the only one to develop a methodology for prioritising dimensions, although this methodology refers to a single specific domain.

The model of Kljajić Borštnar and Pucihar (2021) presents an assessment process based on prioritisation founded on a multi-attribute methodology whereby prioritisation is applied to the attributes that the model defines for its two dimensions (digital capabilities and organisational capabilities). The authors develop a tree structure and attribute values, and then apply the model to the assessment of Small and Medium Enterprises (SMEs).

Durek et al. (2018) developed a methodology for prioritising the dimensions to assess the level of digital maturity from a hybrid multi-criteria approach – Analytic Hierarchy Process / Analytic Network Process (AHP/ANP) – determining the weights of the dimensions using ANP, while the weights of the attributes pertaining to each dimension were determined using the AHP.

However, despite their attempt to use a dimension prioritization methodology that could solve the DMM gaps, Durek et al. (2018) highlight that the hybrid methodology of weighting the weights was not adequate. They further emphasize the need to involve a larger number of experts in the data collection of the prioritizations. It is worth noting that their methodology was applied to a specific domain (evaluating HEI) i.e., the prioritization was limited to a single domain.

5.5. Characterisation of the DMM identified

Table 5 presents a summary of the results obtained with respect to the characterization of the 40 DMMs identified. The table characterizes each model according to the following issues: number of dimensions, functionalities, requirements, and the models that used dimension prioritization methodologies.

5.6. Agenda for future work

The results of this work highlight several important limitations that should be considered in future research related to the following topics:

Most DMMs are presented as descriptive, limited to the simple assessment of the level of digital maturity;

Almost no DMMs present a rigorous methodology for selecting the dimensions (89% present similar dimensions);

The direct correlation of DT progress in relation to the DMM dimensions is not explicit;

The DMMs do not prioritise their dimensions according to the domains, enabling a generic approach model to be applied to different domains by meeting their specificities.

As a contribution to solving the limitations listed above, this work proposes, as a future agenda, the application of the participatory Delphi methodology (Belton et al., 2019), based on the knowledge and reflections of an extended group of experts from various organisations, with the purpose of establishing a meaningful analysis of each dimension for the progression of the relevant maturity levels in the design of generic DMM. The analysis should provide an explicit correlation with the progress of DT and be applied according to the domain of the organisation being assessed. Moreover, a generic digital maturity model will be proposed, supported by a multicriteria methodology, with the purpose of establishing a framework to assess the current state of the DT of the organisations, prioritising the dimensions according to the domain to be assessed, and providing adequate processes so that the organisations can reach the highest levels of digital maturity.

Table 5

Summary of the Results - Characterisation of Digital Maturity Models

Models	Dimensions	Features			Requirements						Prioritisation	
	Total	Prescriptive	Descriptive	Comparative	Req1	Req2	Req3	Req4	Req5	Req6	Yes	No
M1	2	✓	✓		✓	✓	✓	✓			✓	
M2	4		✓		✓							✓
M3	5	✓	✓		✓	✓	✓		✓			✓
M4	4		✓		✓							✓
M5	5		✓		✓							✓
M6	6		✓		✓	✓	✓	✓	✓	✓		✓
M7	4		✓		✓							✓
M8	6		✓		✓	✓	✓	✓		✓		✓
M9	6		✓		✓	✓	✓	✓				✓
M10	6		✓		✓	✓	✓	✓				✓
M11	5		✓		✓							✓
M12	7		✓		✓							✓
M13	1		✓		✓	✓	✓					✓
M14	6		✓		✓	✓	✓	✓				✓
M15	7		✓		✓							✓
M16	5	✓	✓		✓	✓						✓
M17	5		✓		✓							✓
M18	4		✓		✓							✓
M19	6		✓		✓		✓	✓			✓	
M20	3		✓		✓		✓					✓
M21	4		✓		✓	✓	✓					✓
M22	3		✓		✓		✓					✓
M23	4		✓		✓		✓					✓
M24	5		✓		✓		✓					✓
M25	8		✓		✓		✓					✓
M26	1		✓		✓							✓

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Table 5
Cont.

Models	Dimensions	Features			Requirements						Prioritisation	
	Total	Prescriptive	Descriptive	Comparative	Req1	Req2	Req3	Req4	Req5	Req6	Yes	No
M27	8		✓		✓	✓	✓	✓				✓
M28	4		✓		✓		✓					✓
M29	7		✓		✓		✓					✓
M30	3		✓		✓		✓					✓
M31	5		✓		✓		✓					✓
M32	8		✓		✓		✓					✓
M33	5		✓		✓		✓					✓
M34	7		✓		✓		✓					✓
M35	5		✓		✓	✓	✓					✓
M36	4		✓		✓		✓					✓
M37	7		✓		✓		✓					✓
M38	3		✓	✓	✓		✓					✓
M39	6		✓		✓		✓					✓
M40	3		✓		✓		✓					✓

Source: authors.

6. CONCLUSIONS

The development of this SLR was focused on the characterisation and functionalities of the digital maturity models, with the aim of organising a structure of the influence of the dimensions in the process of assessing the digital maturity of organisations. Forty DMMs were analysed, totalling 225 dimensions, of which 168 were from models developed by academics and 57 from professional models. Upon analysis, the dimensions were grouped according to their similarities.

Although most models have used literature review and interviews with experts as a methodology for the definition of the dimensions, they overlooked a more in-depth study of the parameterisation of these dimensions that would consider the differing relevance of the dimensions in the evaluation process of organisations operating in different domains. Only three models presented prescriptive characteristics, but, with unclear methodologies; the remaining models were predominantly presented as descriptive and provided no evidence of their effectiveness in the process of evaluation of the digital maturity of an organisation.

Aiming to provide greater effectiveness, we envisage a model that can be adapted to different domains and organisations, with flexibility in the framework of dimensions adaptable to specific processes, offering an advanced and diagnostic assessment, with emphasis on the orientation of best DT practices as a factor for value addition and organisational competitiveness.

A possible limitation of this work is the use of three databases for the selection of new studies, although the databases used are leaders in the international scenario of scientific research. It is suggested to expand this number of sources in future updates of this SLR.

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