


Tining Haryanti

The Extended Digital Maturity Model

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Article

The Extended Digital Maturity Model

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Abstract: The Digital Transformation (DX) potentially affects productivity and efficiency while offering high risks to organizations. Necessary frameworks and tools to help organizations navigate such radical changes are needed. An extended framework of DMM is presented through a comparative analysis of various digital maturity models and qualitative approaches through expert feedback. The maturity level determination uses the Emprise test of the international standard ISO/IEC Assessment known as SPICE. This research reveals seven interrelated dimensions for supporting the success of DX as a form of development of an existing Maturity Model. The DX-Self Assessment Maturity Model (DX-SAMM) is built to guide organizations by providing a broad roadmap for improving digital maturity. This article presents a digital maturity model from a holistic point of view and meets the criteria for assessment maturity. The case study results show that DX-SAMM can identify DX maturity levels while providing roadmap recommendations for increasing maturity levels in every aspect of its dimensions. It offers practical implications for improving maturity levels and the ease of real-time monitoring and evaluating digital maturity. With the development of maturity measurement, DX-SAMM contributes to the sustainability of the organization by proposing DX strategies in the future based on the current maturity achievements.

Keywords: digital maturity; extended framework maturity; organization sustainability; digital dimension; self-assessment



Citation: Haryanti, T.; Rakhmawati, N.A.; Subriadi, A.P. The Extended Digital Maturity Model. *Big Data Cogn. Comput.* **2023**, *7*, 17. <https://doi.org/10.3390/bdcc7010017>

Academic Editors: Paweł Weichbroth, Jolanta Kowal and Mieczysław Lech Owoc

Received: 16 November 2022

Revised: 10 January 2023

Accepted: 10 January 2023

Published: 17 January 2023



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1. Introduction

The adaptation of digital transformation in the world has massively changed business processes in almost all industries [1]. DX has a potential effect on improving the economy. It is estimated that, by 2030, more than 70% of new value creation in the economy will depend on digital platforms [2]. Digital transformation offers organizations excellent opportunities and high risks [3]. Bughin & Van Zeebroeck [4] suggest that organizations that do not react to digital disruption, or only partially, are likely to take a significant hit to their revenues and profits [5]. Many traditional companies are defeated by the presence of new, more innovative companies [6]. The ride-hailing industry is shifting the existence of conventional taxis [7–12]. The need to transact digitally has developed a new industry in digital wallets [13–15].

During its development, digital transformation carries risks in various dimensions. The technological dimension according to Massimo [16] and van Deursen & van Dijk [17] is the initial stage towards digital transformation. The slow adaptation of technology carries the risk of it being left behind by organizations in competition; in the end, this risk has an impact on the sustainability of the organization. Moreover, the disruptive effects of technology require organizations to transform in order to survive. The magnitude of the role of big data and the development of digital technology such as the internet of things, robotics and artificial intelligence are projected to have an impact on business [6]. The entry of new digital technologies is a clear signal for organizations to change. In addition,

the presence of digital technology also carries risks in non-technological dimensions, such as economic and social risks. Changes in the economic and social structure (workers) are seen in the replacement of human labor in certain areas such as call center services with the help of robots or virtual agents, optimizing logistics flows and reducing supply chain costs through the use of AI and blockchain [6]. This change in the economic and social structure allows for a more efficient management of organizations. The slow change in the management of the socio-economic structure that is not lean and efficient adds to the burden on the organization in its competition. Social risks such as unemployment are another effect of this technology. Global e-commerce sales reached USD 2.3 trillion in 2017, and e-retail revenue is projected to grow to USD 4.88 trillion by 2021 [15]. The shift in sales flows towards digital technologies has had a disruptive impact on conventional sales organizations. Technology adaptation cannot be ignored considering the magnitude of the risks faced. Digital Transformation is a form of gradual change. The measurement of digital maturity helps organizations measure the transformation that has been carried out while at the same time assisting the organization in developing strategies to achieve a better level of transformation in the future

Various opportunities to increase profits and the presence of new industries due to the impact of digitalization require organizations to transform [18–20]. While DX has a significant disruptive impact on businesses and society, organizations are aware of its potential effects. However, many still have no clear roadmap for reimagining the existing processes with emerging technologies [1]. Other research states that many organizations are still trying to organize and implement a digital agenda [5,21,22]. Most research results focus on specific aspects of digital transformation or case studies [18]. The lack of an integrated approach to developing a company-wide digital transformation strategy was also identified by Hess et al. [23], Hyvönen [24] and Ismail [25]. Meanwhile, some academic literature partially discusses aspects of Digital Transformation [26–29]. DX is an ongoing and complicated undertaking that can substantially shape an organization's operations [1]. DX is growing increasingly complex, involving various aspects [6]. Technology is only part of the DT problem that must be solved for organizations to remain competitive in the digital world [30]. Skills, social strata, culture [31] and the role of the government [32] have contributed to the success of DT. Therefore, it is essential to coordinate and manage the different holistic domains of digital transformation [1,33]. Embracing DX requires a comprehensive point of view [33], including heterogeneous and complex processes from the different domains of strategy, human resources, process management, information technology and others [34]. In line with this, it is necessary to monitor the status of DX achievement from a holistic point of view. The objective of the maturity model (MM), which consists of a sequence of different levels of maturity, is to compare the current level of the organization or process with the desired level in terms of maturity by conceptualizing and measuring [22]. The Digital Maturity Model has been widely introduced by academics and practitioners [1]. Existing Digital Maturity Models have various dimensions and stages of maturity [1,35,36]. In addition to various maturity measures, they are not always easily accessible; for example, there may be payments or third-party assistance [1,37]. Meanwhile, measuring the maturity level of Digital Transformation implementation is a necessity as a form of guidance for organizations in knowing the current digital transformation position, evaluating target gaps and realizing digital transformation implementation to determine the right strategy to realize digital transformation as a whole. This is an adaptation response to all forms of change to increase organizational resilience and sustainability [3–5]. Therefore, it is necessary to measure the digital maturity that accommodates various dimensions of supporting digital transformation as a whole [1,5] and can be easily accessed by users [38]. This research seeks to fill the gap in measuring digital maturity models.

This study provides an extended framework of the Digital Transformation Self-Assessment Maturity Model (DX-SA MM), utilizing a comparative analysis of various digital maturity models and qualitative approaches through expert feedback. It poses three research questions:

- 1 How should one holistically analyze and identify framework-extended DX by considering multidimensional aspects?
- 2 How should one determine the current level of organizational DX maturity?
- 3 What recommendations can be offered to increase DX maturity?

This research uses a qualitative–exploratory approach by involving cross-sectoral DX expert informants, cultural experts, community leaders and secondary literature as reference support and taking Indonesia as a case study. The determination of the maturity level uses the basis of the empirical test of the international standard ISO/IEC Assessment known as SPICE. Model evaluation is carried out through an industry case study approach with different sectors, sizes and DX adoptions.

This paper is organized into six sections. The first section is the introduction which provides an overview of the study. The second section presents the background of the study, followed by the research methodology in the third section. The fourth section presents the findings, within which two case studies are presented. The fifth section discusses the results of the study, and the last section concludes the study.

2. Background

2.1. Digital Transformation (DX)

There are various definitions of Digital Transformation from different perspectives [39]. According to Schallmo [40], there is no generally accepted definition for the term “digital transformation”. The term “transformation” expresses fundamental changes in organizations, which have an impact on strategy, structure [5] and the distribution of power [41]. Digital transformation can be seen as a process of the continuous adoption of a significantly changing digital landscape to meet the digital expectations of customers, employees and partners [39]. This adoption process must be actively designed, initiated and executed [42]. McKinsey [43] held that the term “digital” is less about one process and more about how companies conduct their business [44]. DX is defined as an achievement of disruptive technologies that brings new business models and operations across all sectors [1]. The implementation of technology in business processes is only a small part of digital business transformation. In addition, digital technologists must create added value for customers, the business itself and other important stakeholders [40]. Since it has social, technical, technological and managerial effects on organizations, DX must be managed from a holistic perspective [1,6,33,39,45–47].

2.2. Digital Maturity

The term maturity refers to being in perfect condition; it is also a testament to achievement and provides guidance to fix or prevent problems [48]. The maturity model provides large-scale knowledge of the current state of the company and the path to be taken to implement strategies of industry 4.0 [21]. Maturity can be used as an evaluation criterion and described in a comprehensive manner. It is also useful in developing the basic stage to a more advanced final stage [49].

The maturity model in research is a method of measuring the current state of the organization [22], the transformations that have been carried out, the achievements that have been obtained and the paths that must be taken to increase the level of maturity [21]. In the digital context, which is the focus of this research, the measurement in question is a measurement of the current state of digital transformation that has been carried out by organizations. This is transformation that is not just technology [50] but a comprehensive transformation in various dimensions as a unified form of digital transformation. In this study, the digital maturity model is defined as a method for measuring the current state of an organization in terms of digital transformation, strategy, technology adoption [16,51,52] and business process implementation [53].

The measurement results provide information in the form of the current maturity level, so the measurement results can provide an overview for determining future strategies in increasing the maturity level.

The maturity model framework is essential for assessing organizations [54]. There is a difference between readiness and maturity in terms of assessment [22]. Readiness occurs before engaging in the maturation process and makes it clear whether or not the organization is ready to begin the development process [21,22]. The maturity assessment aims to capture the as-it-is state to show the degree of maturity of the organization [22]. Organizations need information gleaned from maturity models to compare their current state with the best practices in business [21]. Therefore, the maturity model helps organizations decide when and why they need to take action to move forward and consider the necessary measures to reach the advanced level of maturity. Digital maturity exceeds the interpretation of technology, which reflects how the company performs tasks and handles the flow of information by IT and what the company has achieved in terms of undertaking digital transformation efforts. These include changes in products, services, processes, skills, culture and abilities regarding the mastery of the change process [53]. Thus, digital maturity can be seen as a holistic concept. Digital maturity is not a static concept because the digital landscape is constantly changing [21]. Therefore, an organization needs to assess maturity over time [52].

2.3. Maturity Level

In general, there are several maturity level models adopted by researchers and practitioners. More than 50% of maturity models are equipped with maturity levels. It will be discussed in the next section. Under these conditions, there are stages of digital maturity, which are often referred to as maturity levels [21,22]. SPICE from ISO is a measurement of the maturity level that has been widely adopted in various cross-sectoral maturity models [1], such as government [55], automotive [56,57] and agility in organizations [58]. The maturity model provides large-scale knowledge about the current state of the company and the path to be taken for the implementation of the Industry 4.0 strategy [21]. Newman, 2020 [35] sets the maturity level, namely, Initiating, Leading, Advancing, Performing and Emerging. Aslanova and Kulichkina [36] have delineated four maturity levels: Beginners, Catching-ups, Off-track and Leaders. The maturity models were developed as a guideline for monitoring important corporate practices [1]. The reference of these models was the progress rate of ad hoc practices and measurable practices that meet measurable conditions [59]. CMM and ISO/IEC 15,504 are widely used maturity-level devices. CMMs focus strictly on software, whereas ISO/IEC 15,504 provides a maturity model reference consisting of a generic process and practice attributes to provide a measurement of organizational capabilities [60]. ISO/IEC 15,504 is enhanced with ISO/IEC 3300xx, which provides a maturity level improvement-based maturity assessment known as SPICE. SPICE has been widely adopted in the measurement of maturity in different domains, such as the measurement of organizational agility [56–58], government [55] and cross-domain [1]. The current research develops DX maturity with a bet maturity level based on SPICE. The main reason for choosing SPICE in determining maturity levels is because, as a part of the ISO/IEC 3300XX family of standards, SPICE is a reference to a maturity model with an established and widely recognized structure. It also features a process assessment point of view and a set of requirements for assessment (ISO, 2015a, 2015b, 2015c).

2.4. Digital Transformation Maturity Model

The maturity model provides guidance on how organizations approach their transformation and charts the path of how organizations can carry out those transformations [39,42]. In general, digital maturity models consist of dimensions and criteria that explain actions or measures that indicate an evolution towards maturity [39,42]. The specific component that describes the main aspects of an action field is called a dimension [61]. This action is measured based on maturity levels consisting of specific and generic practices related to a series of maturity dimensions [39]. Although there have been several maturity models, there are many factors that cause failure in assessing the company's transformation capabilities [21,22], such as partial domain discussion [1,5,21,39,62] and the high cost of

maturity measurement due to the need for third-party assistance. The maturity model should be able to adopt an approach holistically [1,33,52]. Meanwhile, digital maturity measurement is needed at all times, making it easier for organizations to know the current status of transformation while determining the exact roadmap that must be followed to improve digital maturity. The digital transformation maturity model framework used in this study is based on the approach of Becker et al. [5,63] and Neff et al. [34]. After the maturity needs of the model are discussed, the next stage is to identify the existing model maturity framework.

A literature search was conducted to identify existing Digital Maturity Models. The evaluation of the existing maturity models is based on four criteria. The specified criteria are mainly related to the study of Maier et al. [38] on the development of the organizational maturity grid, the MM evaluation criteria in Özcan-Top and Demirors [58] and the maturity criteria in the study of Gokalp and Matinez [1]. They reviewed various maturity and capability models and suggested roadmaps for developing maturity grids with specific decision points. Table 1 lists the criteria used and their description.

Table 1. Criteria used in the evaluation of existing models.

Criterion	Description
Criterion 1 Define Scope	The maturity model has broad characteristics that can be applied in all sectors [1,58]
Criterion 2 Design process	Theory-driven; the maturity model is published in scientific papers that are indicators of academic approaches [1,58]
Criterion 3 Design Product	A detailed description of each supporting component is available Detailed analysis [1,58].
Criterion 4 Application Method	Easy to implement, with the availability of tools/dashboards that can be accessed independently [38]

Previous research on measuring maturity from E. Gokalp and V. Martinez (2021) [1] has general characteristics that can be implemented in all sectors, is built on theory and has detailed descriptions of each component, but tools are not yet available and require a third party to implement the model maturity. The maturity measurement by Aslanova IV and Kulichkina AI (2020) [36] has general characteristics, but the description of the required data needs has not been presented in full, and there are no accessible maturity measuring tools available. The maturity measurement by Schumacher et al. (2019) [51] has special characteristics that cannot be applied to all sectors, and there is no tool to measure maturity that is built on theory and is equipped with a description of each supporting component. Meanwhile, Newman's research (2020) [64] proposes a maturity measurement from the perspective of a practitioner that has general characteristics for use in various sectors and is equipped with an overview of each supporting component, but it does not have the tools available.

Although all DX processes that add value should be considered using a holistic and integrated approach to obtaining the full benefits of DX, no MM meets the overall predetermined criteria

These issues highlight the gap in the research that needs to be addressed. Therefore, this paper aims to fill the gap by developing a maturity model that meets the previously established MM criteria. The Maturity Model presented in this work seeks to extend existing models and tools through holistic domain engagement. The following section explains the stages carried out in this study.

3. Research Method

The maturity model development method in this study consists of three phases (Figure 1). The first is the identification of the problem. As discussed in the previous section, the problem is that no MM has fully met the requirements, thus creating a research gap. This study aims to fill the gap by proposing the development of MMs that organizations can use to monitor the status of their digital maturity levels. A comparative analysis

approach between existing MMs is carried out. The MM proposed in Digital Transformation is defined in accordance with the ISO/IEC 15504-Process Assessment Model (PAM) [58] and ISO 2015 [1], which has been developed in the next version of ISO/IEC 3300xx and is known as SPICE [1,57]. It aims to create a basis for conducting assessments and provide guidance for presenting assessment results with a rating scale. The second phase of DX-SAMM was developed using a maturity model creation stage approach [63]. There are seven stages of model maturity, namely, the definition and identification of problems, the comparison of existing models, the determination of model development strategies, model development, the selection of forms which can be used by the communication targets of the maturity model (base checklist documents, manuals or tools to support the model), the creation of models that can be accessed by users and the evaluation of models. DX-SAMM is an MM artifact developed according to the stages mentioned earlier. At some stages, it employed a qualitative research method [65]. In line with the qualitative characteristics, the initial stage involving defining and identifying the problems was carried out by data collection and a literature review.

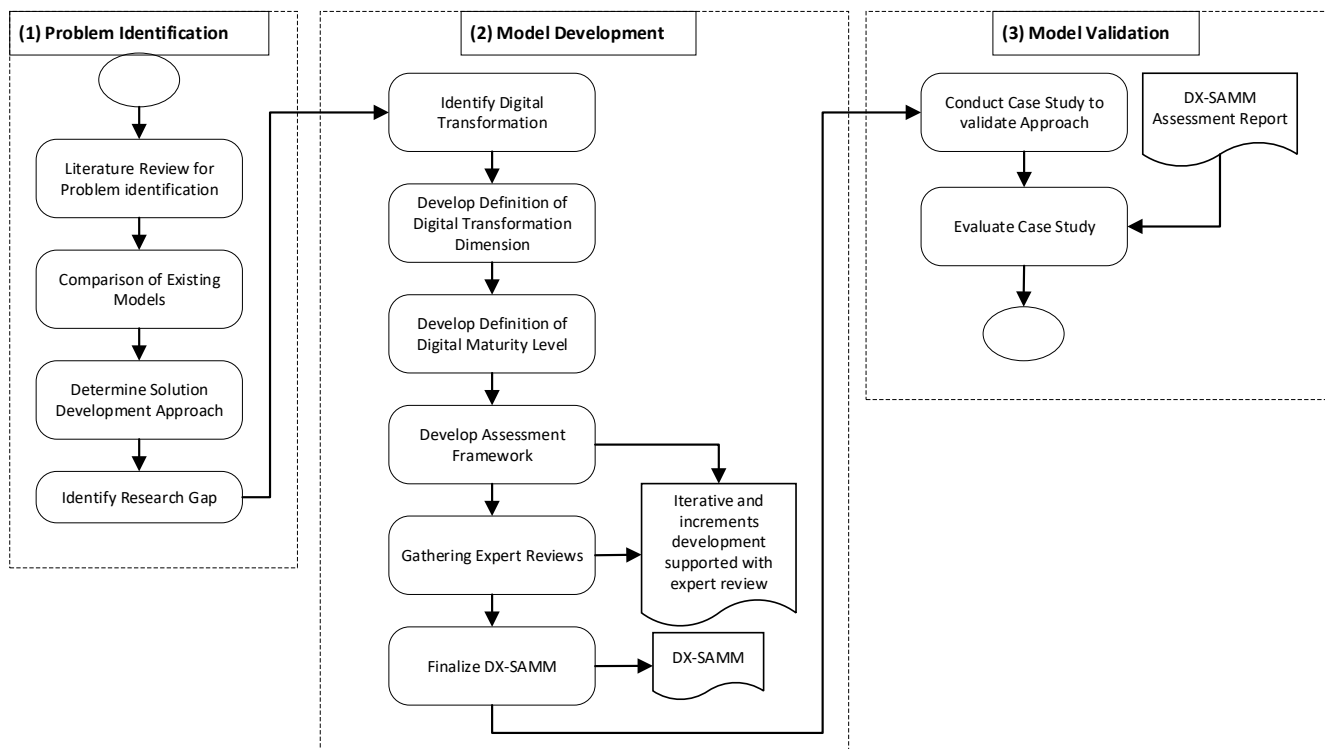


Figure 1. Stages of the Research Method.

The literature search at this stage was carried out through the Scopus and Google Scholar platforms. The Scopus platform was selected as a source of the literature search regarding articles, while Google Scholar is used to search literature with types of material such as theses, dissertations and technical reports. The keywords used include “Digital Transformation”, “Digital Maturity” and “Digital Maturity Model”. The criteria that were not included in this study were “Digitization” and “Digitalization”. This exception is because the Digital Transformation in question is broader than the stages (digitization, digitalization) of the digital itself [5].

The next stage, the comparison of models, was carried out by mapping the MM’s dimensions, maturity level and supporting documents. In this step, a new framework must be determined according to the results of the comparison, namely, comparative analysis [5]. For each dimension defined, additional literature reviews will help define and explain the sub-dimensions. The model development strategy was determined using the ISO-Process Assessment approach by considering the results of the model comparison

and model development. Furthermore, the selection of the form of MM presentation with base checklist documents was equipped with a calculation process and a software tool development to make it easier for users to access MM. The model that had been formed was then evaluated by obtaining expert reviews. The final stage was model validation. The model validation in this study employed the approach of several case studies. Case studies are a design evaluation approach and can be used to validate models [38,58,66].

In this study, the evaluation model was applied to two different sectors, namely, the education sector and the transportation sector. The education sector is used as a case study to measure digital maturity because the organization existed before the rapid development of digitalization. The selection of this case study is expected to show that the current level of digital maturity is more advanced than that before, which was not born digitally. The selection of the second case study is ride-healing, as a form of organization that was born as a response to digital developments. The selection of this case study is expected to demonstrate the level of digital maturity in an organization with a digital backgrounds since the organization was founded.

This evaluation is a form of early-stage evaluation that, in further research, needs to be developed in various sectors, and the implementation of the model needs to be tested. The maturity level is determined based on the satisfaction of criteria for each DX dimension. The processing of achievement data is categorized in FA, LA, PA and NA. The input for measuring maturity was completed by answering questions in the form of a questionnaire. The measurement scale used in designing the questionnaire is a Likert scale. The user determines the level of agreement with the statement by selecting one of the available options.

4. The Extended Digital Maturity Model

4.1. MM Comparative Analysis

A literature review was conducted to identify the existing Digital Maturity Model. The literature review resulted in nearly a hundred articles on digital transformation models and frameworks, but only those from reputable journals and validated dimensions were considered for further analysis. Thus, 44 related Maturity Models were obtained (Table 2). Furthermore, the existing 44 Maturity Models were evaluated based on four predetermined criteria. However, none of these models fully met the established evaluation criteria. M5, M6, M7, M9, M10, M11, M12, M15, M16, M17, M18, M22, M26, M30, M33 and M34 were built for the sector and therefore did not meet the first criterion. M3, M13, M21, M25, M27, M28, M29, M31, M35, M36, M38, M39, M40, M42, M43 and M44 were published as white papers by practitioners, so they did not meet the second criterion. M2, M4, M14, M19 and M37 did not fully describe specific attributes and content. Thus, these models did not meet the third criterion. In addition, M1, M2, M6, M7, M8, M9, M11, M12, M16, M22, M26, M34 and M43 were not equipped with the availability of assessment tools, so they did not meet criterion 4. M3, M25, M27, M26 and M42 provided assessment tools but were neither open-access nor published in scientific papers; hence, they did not meet the second criterion. M37 provided a maturity measurement device, but it was built only for specific sectors (manufacturing), so it did not meet the first criterion.

Table 2. The existing Digital Maturity Model.

No.	Digital Maturity	Author	Organization & Structure	Technology (Connectivity)	Strategy	Customer	Employee	Culture	Process Transformation	Product	Operations	Service	Innovation	Competences	Value Proposition	Value Creation
M1	Digital transformation capability maturity model enabling the assessment of industrial manufacturers	(Gökalp and Martinez, 2021)		v	v		v		v							
M2	Industries 4.0 Maturity Index-Acatech	(Schuh et al., 2018, 2020)	v	v				v								
M3	Digital Maturity Model	(Newman, 2020)	v	v	v	v	v				v					
M4	Digital Maturity Definition and Model	(Aslanova IV and Kulichkina AI, 2020)	v	v	v		v									
M5	Road mapping toward industrial digitalization	(Schumacher, Nemeth and Sihm, 2019)		v		v				v						v
M6	A model for assessing the maturity of Industry 4.0 in the banking sector	(Bandara, Vidanagamachchi and Wickramarachchi, 2019)	v	v	v	v	v			v	v	v				
M7	IMA-Infrastructure maturity assessment	(Williams et al., 2019)		v												
M8	Industry 4.0-MM/	(Gökalp and Demirörs, 2017; Sener et al., 2018)	v		v				v							
M9	A smart manufacturing maturity model for SMEs (SM3E)	(Mittal, Romero and Wuest, 2018)			v		v		v	v						
M10	DPMM 4.0-Industry 4.0 maturity model for the delivery process in supply chains	(Asdecker and Felch, 2018)							v							
M11	A preliminary maturity model for leveraging digitalization in manufacturing	(Sjodin et al., 2018)		v			v		v							
M12	A maturity assessment approach	(Colli et al., 2018, 2019)		v	v									v		v
M13	Deloitte's digital maturity model	(Anderson and William, 2018)	v		v	v	v	v	v							
M14	Development of a Digitalization Maturity Model	(Canetta, Barni and Montini, 2018)		v	v		v		v	v		v				
M15	Maturity and Readiness Model for Industry 4.0 Strategy	(Akdil, Ustundag and Cevikcan, 2018)	v		v				v	v		v				
M16	Structuring Digital Transformation (in Zeiss)	(Gimpel et al., 2018)	v	v		v					v				v	
M17	Organizational Agility Maturity Model	(Gunsberg et al., 2018)	v		v		v	v					v	v		
M18	Company Readiness Evaluation for Digital Business Transformation	(Isaev, Korovkina and Tabakova, 2018)	v	v	v	v					v		v			
M19	Discovering digital business models	(Remane et al., 2017)	v									v			v	
M20	University of St. Gallen dan Crosswalk	(Berghaus, Back and Kaltenrieder, 2017)	v	v	v	v		v	v	v						
M21	PWC, 2017	(Shahiduzzaman et al., 2017)		v	v	v	v									
M22	Dreamy Model-Digital Readiness Assessment Maturity Model	(De Carolis et al., 2017)	v	v					v							
M23	Industry 4.0 Maturity Model	(Gökalp and Demirörs, 2017)	v		v		v		v							
M24	Maturity Model for Digitalization	(Klötzer and Pflaum, 2017)	v	v	v	v		v	v	v			v	v		
M25	Digital Future Readiness Transformation Model	(Schlaepfer and Radowitz, 2017)	v				v	v								
M26	System integration maturity model Industry 4.0-SIMMI 4.0	(Leyh et al., 2017)		v						v						
M27	Open Digital Maturity Model	(Open ROADS Community, 2016)		v	v	v	v	v				v		v		
M28	A digital maturity model for telecommunications service providers	(Valdez-de-Leon, 2016)	v	v	v	v		v			v		v			

Table 2. *Cont.*

No.	Digital Maturity	Author	Organization & Structure	Technology (Connectivity)	Strategy	Customer	Employee	Culture	Process Transformation	Product	Operations	Service	Innovation	Competences	Value Proposition	Value Creation
M29	PWC, 2016	(Griessbauer, Vedso and Schrauf, 2016)	v	v		v	v	v	v	v		v				
M30	A Maturity Model Industry 4.0 readiness	(Schumacher, Erol and Sihm, 2016)		v	v	v	v	v		v	v					
M31	Forrester digital maturity model 4.0/	(Gill and Vanboskirk, 2016)	v	v				v								
M32	Practical Digital Transformation Playbook	(Rogers, 2016)				v		v					v		v	
M33	Smart Manufacturing System Readiness Level (SMSRL)	(Jung et al., 2016)	v	v												
M34	Three-stage maturity	(Ganzarain and Errasti, 2016)							v	v						
M35	Digital Readiness Assessment	(Wallner, 2016)	v	v	v	v	v	v								
M36	Roland Berger	(Berger, 2015)		v		v					v					
M37	Impuls-Industrie 4.0 readiness	(Lichtblau et al., 2015)	v		v		v			v	v	v				
M38	Capgemini Consulting	(Westerman et al., 2011, 2012; Fitzgerald et al., 2013; Buvat et al., 2017) (Catlin, Scanlan and Willmott, 2015; Edelman, 2015; Goran, LaBerge and Srinivasan, 2017)	v		v	v		v	v							
M39	McKinsey	(Rockwell Automation, 2014)						v						v		
M40	The Connected Enterprise Maturity Model (2014)	(Leino et al., 2017)	v	v	v	v	v	v	v							
M41	VTT Model of Digimaturity	(Peyman, 2014)		v	v	v	v	v		v	v					
M42	Digital Maturity Model	(Kane et al., 2015, 2016, 2017; Deloitte Switzerland, ACSC and Chen, 2018)	v					v	v		v					
M43	Deloitte	(Friedrich et al., 2011)														
M44	PWC (Booz and Company)		25	27	24	18	19	20	v 18	13	10	7	5	5	3	2

The fulfillment of the maturity model criteria is presented in Figure 2:

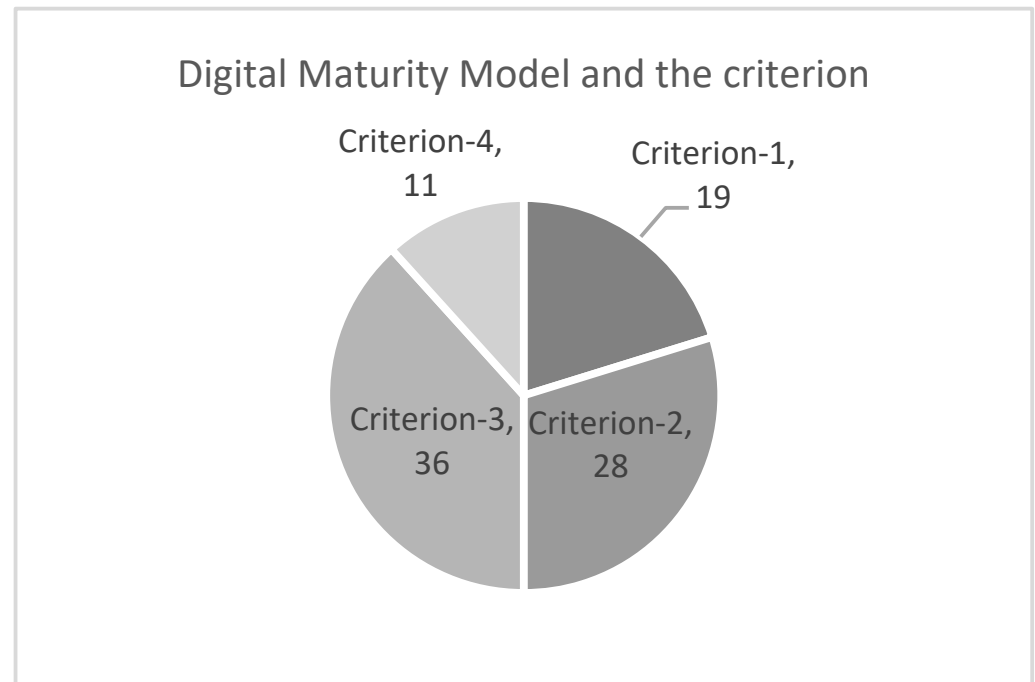


Figure 2. Digital Maturity Model and the criterion.

Based on the results of the suitability analysis of maturity measurement criteria, there is no maturity measurement model that meets all the maturity measurement criteria proposed in this study (Table 1). The maturity models were developed by applying a theoretical approach to MM comparative analysis. After reviewing the literature in the previous section, the models and framework were compared and evaluated according to their dimensions.

The 44 maturity models are presented in Table 2. The comparison of the dimensions of the 44 maturity models identified more than 100 dimensions. Furthermore, the dimension comparison analysis was carried out based on the similarity of the definitions and scope, leaving only 50 dimensions. The fourteen main dimensions that frequently appeared in the maturity framework are presented in Table 2. Several core dimensions were identified based on the comparative analysis of the dimensions of the maturity model. They were: Organization and Structure (24), Technology (22), Strategy (21), Customer (18), Employee (17), Culture (20) and Process Transformation/Business Process (18). These dimensions meet the 40% threshold [5] and will be proposed as a development of the DX maturity model in the next section.

4.2. MM Extended Framework

The dimensions of supporting digital transformation based on the comparative analysis in the previous chapter are then presented in Figure 3. Technology ranks as the second-most widely used dimension in measuring digital transformation, followed by employees as executors of the transformation process and the last ranking of business processes in supporting digital transformation. This research also found that organization and structure rank first in the success of digital transformation. The dimensions found to support digital transformation are grouped into seven groups with a total of 20 indicators (Figure 4).



Figure 3. Extended Framework of Digital Maturity.

Strcuture and Organization	Technology	Strategy	Customer	Employee	Culture	Transformation Process
<ul style="list-style-type: none"> Organizational Structure Management Sustainable Learning Management Organizational Change Management 	<ul style="list-style-type: none"> Information System Security Management Infrastructure 	<ul style="list-style-type: none"> Startegy Development Financial Analysisi Portfolio management 	<ul style="list-style-type: none"> Customer Engagement Customer Esperience Customer Trust 	<ul style="list-style-type: none"> Skill Awareness Continuous Learning 	<ul style="list-style-type: none"> Willingness to change Social collaboration 	<ul style="list-style-type: none"> Business Proses Digitalisasi Business Proses Vertical Integration Business Proses Horizontal Integration

Figure 4. Dimensions and description of DX-SAMM.

4.2.1. Organization and Structure

The organization structure consists of the internal organization and dynamic network collaboration [67,68]. Organizations can be defined as inputs for DX [21]. Achieving digital maturity requires management readiness to change, continuous learning and change in the organization's business processes [36]. Organizations create the structure and functions of an ecosystem to create products and services [69]. Organizations and structures investigate capabilities such as data collection, usage, data analytics and big data tools and data-driven services. Collecting and completing data assessments from various sources, including infra-structures, manufacturing systems and information systems, enables organizations to make real-time decisions regarding current or future operations. Therefore, integrated and automated data flows are essential inside and outside the company [55]. The dimensions of Organization and Structure are described through (1) Organizational Structure Management, (2) Sustainable Learning Management and (3) Organizational Change Management.

4.2.2. Technology

Technology is a crucial driver of digital transformation. Without technology, the digitization process is challenging to carry out [50,70,71]. A high level of digital maturity often requires the high digital competence of employees in the DX process [36]. The technology requirements for each DX project must be defined to ensure its possible success. Some of the technology requirements for DX projects include development, integration, business processes and infrastructure [1]. The use of technology, such as application development, should be based on the principle of agile software development and IT security management. These processes are central to the organization's DX journey. Data processing and security systems are an inseparable part of technology [35,72]. The infrastructure at DX has the sophistication of underlying IT technologies, focusing on the presence and use of computers and computer networks (wired and wireless) as well as the presence and type of connection to the internet, including the use of fixed and cellular broadband or other fixed connections [73]. Technology dimensions consist of the (1) Information System, (2) Security Management and (3) Infrastructure.

4.2.3. DX Strategy

The presence of a strategy can be defined as an input from DX which serves to shape organizations and businesses in the transformation process [21]. DX's strategy leads the determination of a strong vision and roadmap and inspires how existing technologies can create a future with shared values [1]. The strategy must take into account the development that occurs in the future. The DX strategy should also pay attention to legal and tax policies, finances, sustainable guidelines and government regulations [74]. Thus, the content derivatives of the strategy dimension include: (1) Strategy Development, (2) Financial Analysis and (3) Portfolio Management.

4.2.4. Customer

DX provides a space for customer engagement by interacting with an easy-to-use user interface, improving the customer experience. The service reliability increases customer trust [35]. Organizations need partnerships to build a digital ecosystem, such as digitizing customer service delivery and contact [22,75–77]. The internet (mobile) allows for direct access to customers who can offer transparency and a new type of service (Berger, 2015) [78]. Customer dimensions can be derived from attributes such as (1) Customer Engagement, (2) Customer Experience and (3) Customer Trust.

4.2.5. Employee

Human resource readiness and the awareness of technological change are needed to support the digital transformation process. Worker engagement, motivation and participation in strategic changes in an organization are the keys to DX's success [36]. Continuous learning and change management [35] make it easier for organizations to adapt to all forms of change [1]. Knowledge and expertise are gained through the willingness to learn sustainably [22,75]. The Employee/People dimension can be explained through (1) Skill, (2) Awareness and (3) Continuous learning.

4.2.6. Culture

Companies will not be able to achieve the desired agility if they only introduce digital technology without also paying attention to their corporate culture [67,68].

Technology does not add value to organizations unless they have a culture where employees trust, recognize and are ready to accept the system [42]. In addition, the actions that employees perform must be entirely knowledge-based. Environmental knowledge, characterized by trust and social relationships, provides a basis for open knowledge sharing (open communication) without barriers among employees [35]. The Cultural Dimension is characterized by (1) A Willingness to Change and (2) Social Collaboration.

4.2.7. Transformation Process

The Transformation Process describes the extent to which processes are integrated through technology for efficiency. The integration should occur at the internal and external levels of the organization. Companies can use digital technology for enterprise resource planning. They can also use it for internal information, sharing with various organizational functions such as finances, production management, service management and business process digitization [1,55,62,79]. External integration consists of electronic data exchange with public partners and financial institutions [21,73]. The dimensions of Business Transformation are explained through (1) Business Process Digitalization, (2) Business Process Vertical Integration and (3) Business Process Horizontal Integration. The development of a digital maturity model framework with seven groups of dimensions is then proposed as an extended framework of Digital Maturity (Figure 3).

4.3. DX-SAMM

DX-SAMM is built with seven dimensions: Organization & Structure, Technology, Strategy, Customer, Employee, Culture and Transformation Process (Business Process). These dimensions are described in the form of questions that are used as materials for assessing the maturity level. The DX-SAMM assessment adopts an ISO/IEC assessment defined in international standards as nine process attributes (Figure 4). Furthermore, the DX-SAMM dimension is mapped to the process attribute so that it produces generic items in the form of a questionnaire used to assess organizational maturity. Maturity level assessment is carried out by filling out each question item based on that dimension group. Understanding the digital context of organizational transformation is needed in the assessment process so that the results obtained are not subjective. The assessment of process attributes in this document is in accordance with the ISO/IEC 33000xx assessment standard (Table 3).

Table 3. Maturity Levels in ISO/IEC Assessment.

Level	Attribute
5—Optimizing	PA. 5.1 Process Innovation PA. 5.2 Process Optimization
4—Predictable	PA. 4.1 Process Measurement PA. 4.2 Process Control
3—Established	PA. 3.1 Process Definition PA. 3.2 Process Deployment
2—Managed	PA. 2.1 Performance Management PA. 2.2 Work Product Management
1—Performed	PA. 1.1 Process Performance

The scoring scale is then mapped in a Likert scale and used as a score for answers to the questions presented in the questionnaire (Table 4). Based on SPICE, level 2 achievement can be measured if level 1 has been met and the attributes at level 1 have reached the “Fully Achieved” rating. Level 3 achievement can be measured when level 2 is completed and all attributes at level 2 have achieved a “Fully Achieved” rating. These assessment provisions are used as the basis for recommendations for maturity level improvement in DX-SAMM. After the data collection was carried out, the data were processed using a statistical method to analyze the questionnaire. The calculation generated a value that reflects the percentage of the achievement of the maturity process, which then determined an organization’s digital maturity level.

4.4. Maturity Level

DX-SAMM was built to measure the achievement of Digital Transformation in an organization and provide recommendations for corrective steps for optimizing DX achievement. DX-SAMM has six maturity levels adapted from the standard SPICE maturity level (ISO/IEC 3300XX), with adjustments (level image). These levels are level 0—incomplete,

level 1—performed, level 2—managed, level 3—established, level 4—predictable and level 5—Optimizing (Figure 5). The DX maturity level assessment processing with DX-SAMM produces DX achievement status information based on its maturity level while providing a reference for DX improvement at the next level based on the adjusted ISO/IEC 3300XX. It is vital to understand that successful DX occurs gradually. DX-SAMM provides improvement recommendations, including all related dimensions, with a phased approach that depends on the order of maturity levels. Each level is built up from the achievements of the previous level.

Table 4. Achievement Score.

ISO/IEC Assessment		Likert Scale
Scale	Achievement	
0–15%	Not Achieved (NA)	1
15–50%	Partially Achieved (PA)	2
50–85%	Largely Achieved (LA)	3
85–100%	Fully Achieved (FA)	4

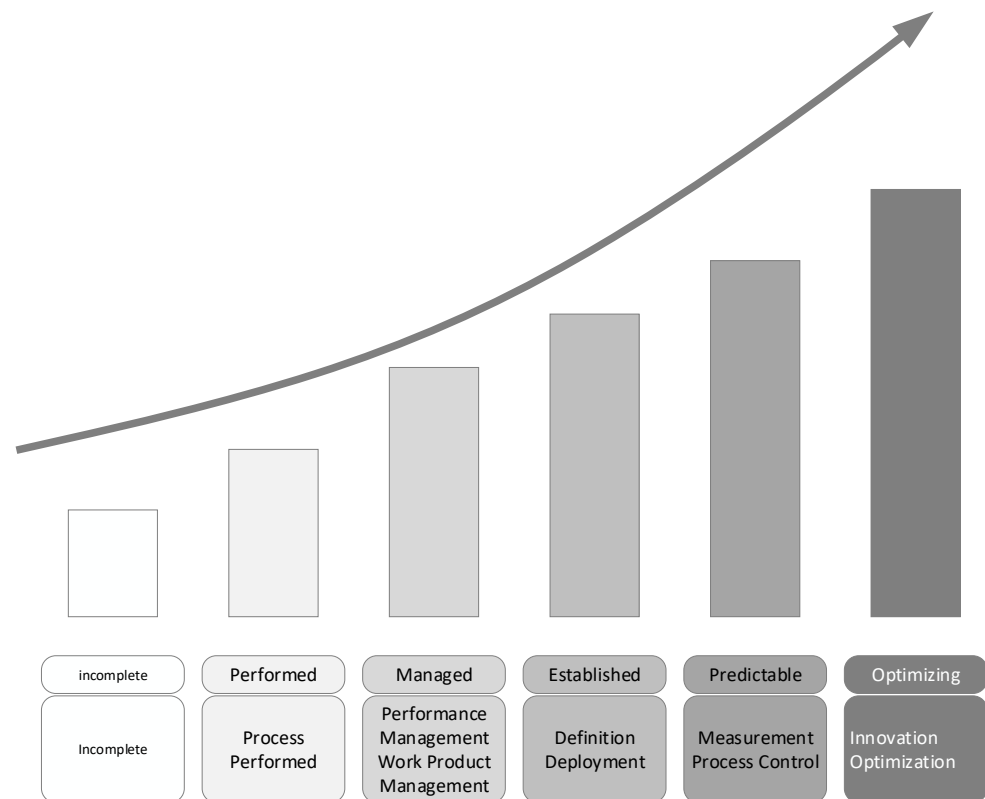


Figure 5. Digital Maturity Level.

Level 0: Incomplete. This level indicates that it has not taken part in DX activities in the organization. Some requirements may exist but are at very low values.

Level 1: Performed. DX planning has been in place and started but has not yet been fully implemented. A vision and transformation strategy have been developed. DX projects have been identified, evaluated and prioritized. The upskilling of the workforce and the digital transformation infrastructure are determined.

Level 2: Managed. The DX process has been well managed. Digital transition activities have been seen and implemented. Existing business processes are digitized through technology. DX activity projects begin, digital infrastructure is used predominantly across

business processes and relationships with third parties are managed digitally. Level 3: Established Assigned Process.

$$J_{(d,a)} = \frac{\sum_{q \in Q_{da}} \frac{\sum_{r \in R} H_{(r,q)}}{|R|}}{|Q_{da}|}$$

$$M_{(d)} = \frac{\sum_{a \in A_d} J_{(a,d)}}{|A_d|}$$

$$M_0 = \text{Min}(M_1, M_2, \dots M_D)$$

H: The result of the value of the Likert scale; *A*: Average value of the attribute; *Q*: Question; *R*: Respondent; *a*: Attributes; *M*: Maturity.

The Digital transition process has been carried out consistently in accordance with the established standards so that the business process integration can go well. The Digital Transformation process has happened on every front. Organizational changes, from the perspectives of human resources and business processes, have become a habit. Level 4: Predictable. Quantitative techniques began to be applied to real-time data collected for products, services or processes. The measurement of the success of the digital transition process is carried out. Horizontal integration, which is cross-network integration at the business level, is implemented. Data analytics on business processes are applied. Level 5: Optimizing. The DX process is evaluated using business process implementation data for continuous improvement. An innovative culture has emerged, and transparent and dynamic cooperation has been created by optimizing the existing system. The DX maturity assessment is carried out by filling out a number of questions based on the dimensions that have been mapped in the standard process attributes. The questionnaire answers are then assessed with the formula provided [21,22] and score limits to determine their maturity level (Table 5). The results of the calculation of digital maturity (Equations (1)–(3)) are further mapped based on the threshold value of the maturity level [21]. In general, the assessment process for DX-SAMM is presented in Figure 6.

Table 5. Limit value to determine maturity level.

Maturity Level	Limit Value	
	Low	Tall
Level 0: Incomplete	0.00	0.20
Level 1: Performed	0.21	0.80
Level 2: Managed	0.81	1.60
Level 3: Established	1.61	2.40
Level 4: Predictable	2.41	3.20
Level 5: Optimizing	3.21	4.00

The proposed maturity development parameters, including MM construction [80,81], are presented in Figure 7. The proposed MM scope is a development of the existing MM by meeting the requirements discussed in the previous section. The sphere of maturity has a general characteristic that can be used across sectors. The basis of digital maturity model development not only discusses technology but also aspects of management. The MM model design focuses on the process of maturity, objects and people involving multidimensional aspects. Such focus is so that MM can be accepted in various sectors [1,5]. DX-SAMM design processes are theory-driven by thoroughly considering literature reviews from academics and practitioners. The application method applied to MM is a self-assessment with a product design in the form of an assessment device, but in this paper, textual and functioning description is presented through the calculation of the assessment and classification of maturity levels.

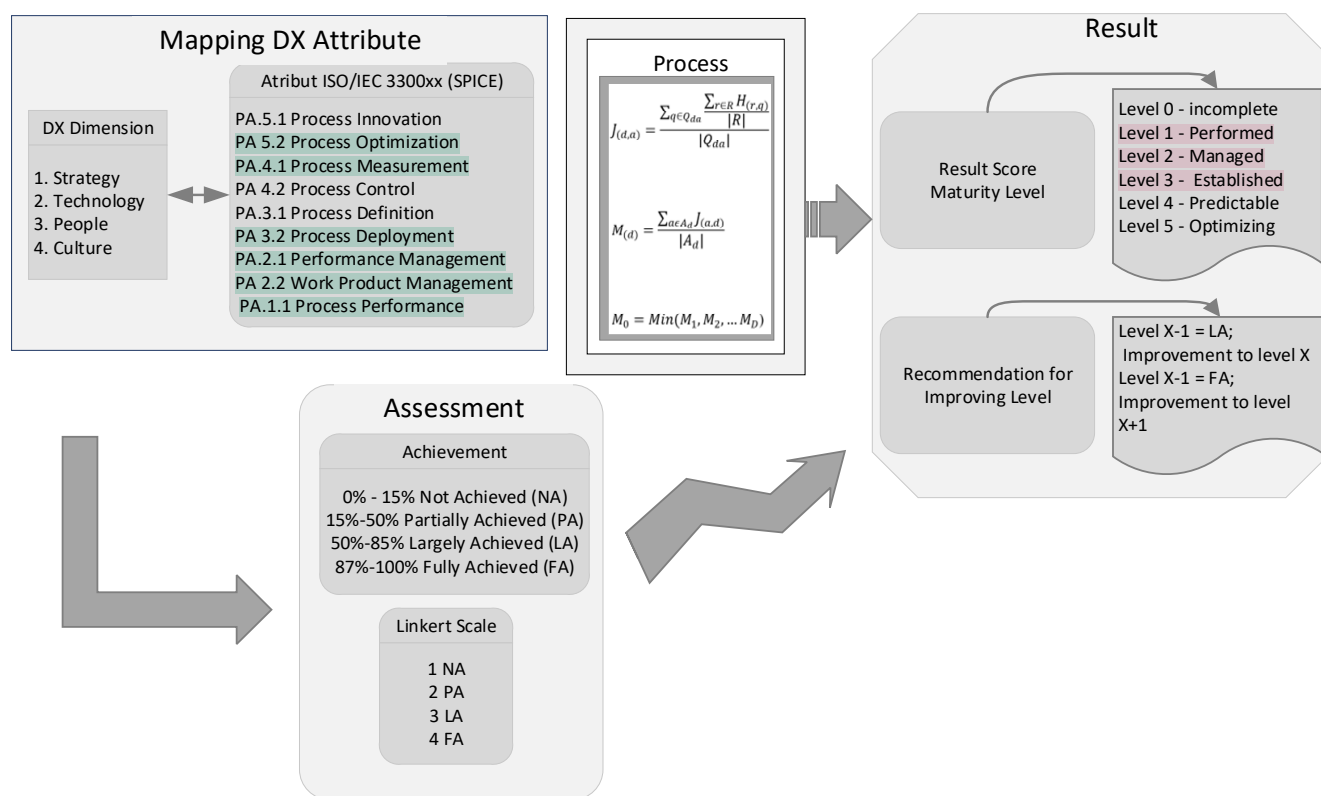


Figure 6. DX-SAMM Assessment Process.

Phase	Decision Parameter	Characteristic			
Define Scope	Focus/ breadth	General Issue		Specific Issue	
	Novelty	Emerging	Pacing	Disruptive	Mature
	Audience	Management-Oriented	Technology-Oriented		Both
Design Model	Maturity definition	Process-focussed	Object-Focussed	People-focussed	Combination
	Goal Function	One-dimensional		Multi-dimensional	
	Design Process	Theory-driven	Practitioner-based		Combination
	Design Product	Textual description of form	Textual description of form and functioning		Instantiation (assessment tool)
	Application method	Self-assessment	Third-party assisted		Certified Professionals
Evaluation	Evaluation Method	Naturalistic		Artificial	

Figure 7. Construction of DX-SAMM Maturity Development.

Product Design in the form of Instantiation (assessment tool) is discussed next. The DX-SAMM application method is based on Self-Assessment, making it easier for organizations to independently assess DX achievement. The evaluation of maturity is artificial through case studies of two different organizations.

4.5. Implementation of Case Studies

The DX-SAMM trial was implemented by two organizations. The first case study was conducted in an educational organization with approximately 700 employees. The organization is a private higher education organization that has existed for over 30 years. The digital transformation process is planned by the organization by adding a special

organizational structure related to digital transformation. It is located in a big city, allowing internet connectivity barriers to be overcome. The term “Edu-case” is used in the first case study. The interviews were conducted with three people: the operation manager, IT manager and marketing manager. The second case study was conducted in a ride-hailing organization with approximately 200 employees. This start-up organization has been around for five years and has been using digital technology since its inception. Organizations continue to transform digitally by leveraging information systems instead of human labor. Even though the organization is located on the outskirts of the city, the use of digital technology has been widely applied in every activity. Therefore, the term “ride hailing-case” was used in the second case study. Interviews were conducted with three people: the operations manager, the planning and development manager and the IT manager. In general, the interviews were conducted to provide an understanding of how to fill out the DX maturity assessment. The assessment was carried out with the achievement of the process, namely, F.A., L.A., P.A. and N.A, as defined in the section on the DX maturity level assessment process. Filling in the achievement of the process objectively is important to do; this is to avoid bias and subjectivity in the achievement score. Therefore, filling in the achievement of the DX process needs to be carried out by the DX team or organizational HR, which understand the organization’s digital transformation well.

5. Results and Discussion

Digital Transformation is a series of activities that are interrelated with the goal of achieving organizational transformation towards digitalization. The results of this study indicate that technology is not the most important dimension in digital transformation. This is in line with the opinion of Tabrizi et al. (2019) [50] that DX is not just about technology. The results of this study differ from several previous studies on technological advantages [16,51,52], which are the main drivers of digital transformation. The technological dimension in this study confirms the research of academic studies [1,36,51,67,75] and practitioners [35,52,82,83]—technology is an inseparable part of the digital.

The most important dimensions that support the success of DX are organization and structure and strategy. This finding also confirms previous findings that successful digital transformation requires an alignment of strategy and governance [1,35,36] and organization [62,67,75]. The dimensions of employees and business processes are the last dimensions that support the success of digital transformation. There is a slight difference from the findings of previous studies indicating that the success of transformation is determined by employees [16,75], customers [36,51], the transformation process [1,74,79,84] and culture [37,67]. In this case, employees, as transformation implementers, determine how the digital transformation implementation strategy is formulated.

The supporting dimensions of digital transformation that have been found in the previous chapter are then applied to a case study of measuring digital maturity.

5.1. Case Study 1

The assessment results in the case study-1 “Education” are presented in Figure 8 by displaying the results of the “Education-case” maturity mapping for the seven dimensions of DX-SAMM. In general, the maturity level is at the 2—managed level, with a score of 1.65. The organization has initiated to change toward Digital Transformation. It has begun to digitize existing business processes through technology. Operational activities have used digital infrastructure, and relationships with third parties have been carried out using technology.

The blue circle in Figure 8 shows the maturity scores on each dimension in the first case study. Based on the assessment, the Culture and Employee dimensions are at the lowest maturity achievement. Employees’ willingness and awareness regarding the adaption to technology impact the success of DX achievement. The added value of technology cannot be fully utilized if the level of trust in technology is low. DX-XAMM provides strategy recommendations for organizations through low-achievement assessments of

related dimensions based on ISO/IEC—SICE assessments to increase maturity levels. In the SPACE assessment, achievements under LA cannot be categorized as reaching the level above it. Some aspects that need improvement include improving employee skills through continuous training, increasing social collaboration and changing the external integration of the electronic data exchange with public partners and financial institutions through technology.

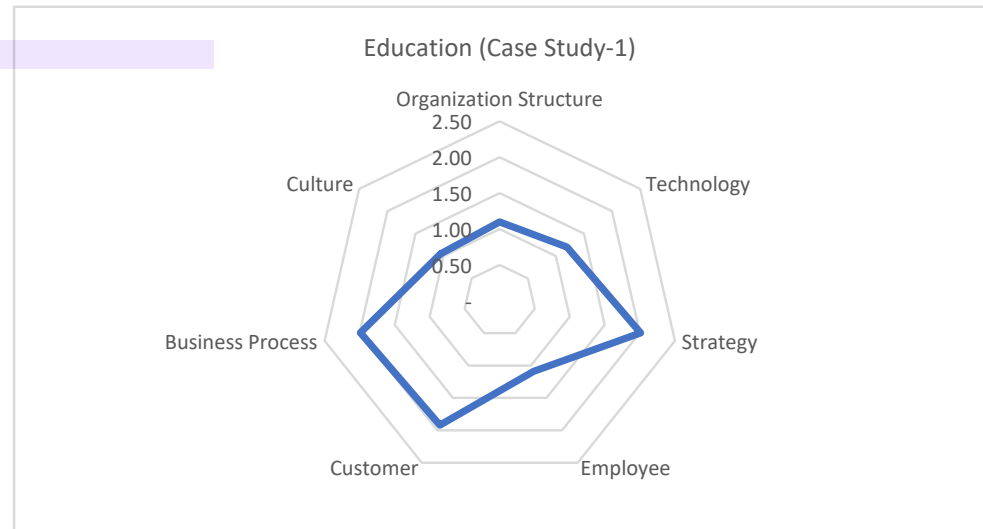


Figure 8. Maturity Level (Case 1).

5.2. Case Study 2

The DX-SAMM assessment results for the Ride Hailing case-2 study are at the 4—predictable level (Figure 9). The orange circle in Figure 9 shows the maturity scores on each dimension in the second case study. In general, digital transition activities have been carried out consistently in accordance with established standards. The integration of business processes has been carried out digitally, the use of technological infrastructure has been continuous and relationships with third parties have been managed digitally.



Figure 9. Maturity Level (Case 2).

Human resources already have an awareness of the importance of technology, which can be seen from the optimal use of technology and security that guarantees the increase in employee confidence in the technology. Real-time data analysis with quantitative techniques is used to make decisions and determine the organizational strategy. The measurement of the digital transition process is routinely carried out and monitored. Despite having reached a high level of DX maturity, DX-SAMM provides recommendations for improvement at the next maturity level through achievement calculations based on ISO/IEC Assessment—SPICE. Increased customer involvement in creating services is necessary. The use of customer personalization data has not been processed optimally; thus, improving the ability to maintain competitive sustainability is essential.

5.3. Cross-Case Study Comparison

One of the foundations for assessing DX success is through DX maturity ratings in organizations. There are differences between the two case studies (education and ride-hailing) in their transformation journey and ambition to achieve DX. A comparison between the two case studies in this study is presented in Figure 10. It vividly shows the difference in the DX maturity achievement graph for the Ride-Hailing case study on all aspects of the dimension compared to the Education case study. The gap between these two case studies is wider in employees (Table 6). Based on the HR assessment in the Ride-Hailing case study, it is more prepared and aware to adapt to technological changes. The role of human resources allows the organization to carry out the vision outlined in the strategy. Human resource readiness and awareness support the achievement of maturity in other aspects such as technology implementation, transformation processes and other dimensions, as well as the seven dimensions of DX-SAMM which are interrelated and integrated.

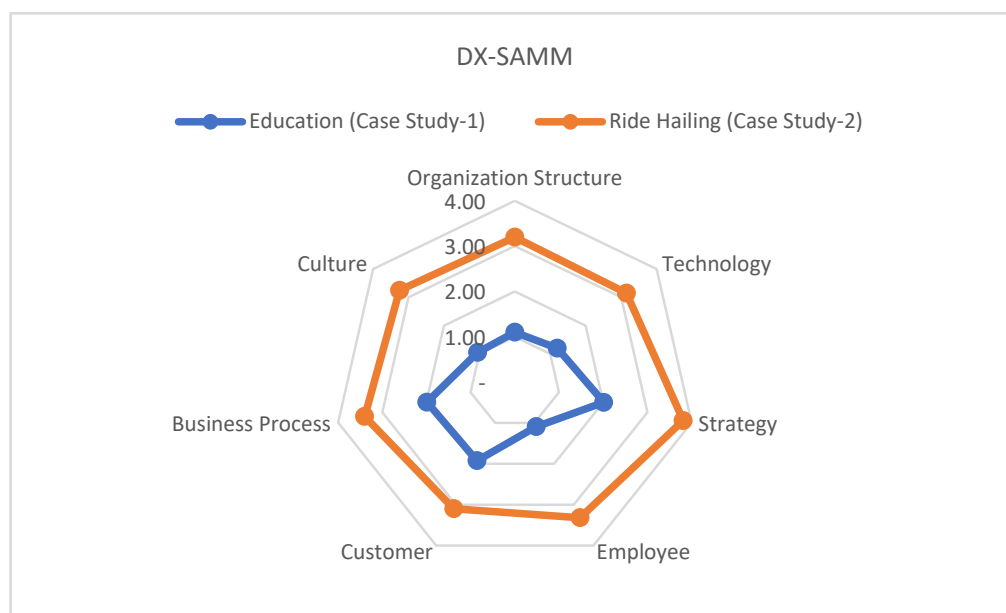


Figure 10. Cross-case Maturity Level Comparison.

In the case-1 study, although the strategy is more mature than other dimensions, the low awareness and readiness of HR impact the organization's digital transformation process. Worker engagement, motivation and participation in strategic change in an organization are the keys to DX's success [36]. The next cross-case maturity gap is the Culture dimension. Organizations that adopt technology have not achieved the expected success of Digital Transformation [67,78]. Technology cannot provide meaningful benefits if the organizational culture is not yet confident. Therefore, the readiness to accept and use technology is low [42]. Culture can be both an obstacle and a reinforcement of DX's success. Cultural maturity is characterized by the willingness of employees to change

and communicate openly in increasing knowledge, which in turn makes it easier for the organization to reach a level of maturity.

Table 6. Maturity Gaps Across Case Studies.

Dimension	Education (Case Study-1)	Ride Hailing (Case Study-2)	Gap
Organization Structure	1.10	3.20	2.10
Technology	1.20	3.15	1.95
Strategy	2.01	3.81	1.80
Employee	1.09	3.32	2.23
Customer	1.92	3.10	1.18
Business Process	1.99	3.40	1.41
Culture	1.05	3.25	2.20
Maturity	1.05	3.10	2.05

6. Conclusions

This study involved 44 maturity models, all of which had not fully met the specified maturity model criteria [1,38,58]. These models were applied in all sectors, published in scientific papers as an indicator of an academic approach, described the supporting components of maturity analysis and were easy to implement with the availability of tools. There was no MM with a comprehensive approach that applies in all sectors. Additionally, many of the existing models had not provided complete details about the model for the application or provided an action plan to allow for increased maturity stages. To fill the gap, this study proposed DX-SAMM with a holistic approach that applies to all sectors. A comparative analysis of existing maturity models was carried out to ensure that the proposed domains could be used in all sectors. The Extended Framework of Digital Maturity was presented with seven dimensions and 20 contents. The proposed dimensions have met the criteria of 40% of the use of dimensions from all existing MMs [5], namely, Organization Structure, Technology, Strategy, Employee, Customer, Transformation process and Culture. Assessment at the maturity level is based on established assessment references, namely, ISO/IEC assessment or SPICE. Supporting descriptions, maturity analysis and assessment calculations based on ISO/IEC assessment standards (PA, LA, FA, NA) were presented in detail. The application method applied to DX-SAMM was self-assessment with a product design in the form of an assessment device. In this paper, a textual and functioning description was presented through the calculation of the assessment and classification of maturity levels. The implementation of DX-SAMM was verified by two different case studies of the organization. The assessment results showed that DX-SAMM could identify the organization's level of maturity while providing a reference for opportunities to increase the level of maturity. Case Studies in educational organizations recognized the importance of digital engagement and human resource readiness to transform. Culture was the biggest challenge for change in organizations. Meanwhile, the "Ride-Hailing" case study has been at the level of maturity and understands that DX is an endless process capable of maintaining continuous improvement. This research makes a scientific contribution by filling the gaps in measuring digital maturity, which accommodates various dimensions of supporting digital transformation as a whole [1,5] and can be easily accessed by users [38]. Previous maturity models varied; they are not always as easily accessible, involve payments or have third-party mentoring. Measuring the maturity level of implementing Digital Transformation requires organizations to know the level of transformation as a guide for future strategy development. Therefore, the contribution of further research is to provide practical implications for increasing maturity levels as well as easing monitoring and evaluating digital maturity in real time. By knowing the current level of digital maturity, organizations can formulate the right strategy to adapt and transform to all changes, particularly digital

transformation. The accuracy of the organization in adapting and responding to changes helps the sustainability of the organization, even making it possible to obtain potential opportunities [18–20]. In addition, organizations can avoid disruptive impacts and risks due to delays in the adaptation to digital transformation [6,10–12]. The measurement of digital maturity produced in this study has general characteristics that can be utilized to identify digital transformation achievements.

Although this research makes many scientific and practical contributions and fills a research gap in digital maturity measurement, it has several limitations. The limitations of this research are the limitations of the case study. The case studies in this study are only two different sectors. A comparison of the implementation of digital maturity measurements in several different sectors and the same sectors is needed to increase the validity of measurements in the future.

In addition, as is characteristic of maturity measurement models in general, detailed and in-depth adjustments for each sector need attention. This is due to differences in the specific characteristics of each sector. The addition of literature by involving a wider range of reference sources can add a wealth of insights regarding digital transformation, which will continue to develop in the future.

Author Contributions: Conceptualization, T.H. and A.P.S.; methodology, N.A.R.; validation, T.H., N.A.R. and A.P.S.; writing—original draft preparation, T.H.; writing—review and editing, T.H.; visualization, N.A.R.; supervision, N.A.R. and A.P.S.; project administration, T.H.; funding acquisition, N.A.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Institut Teknologi Sepuluh Nopember Surabaya (ITS) with Grant Number: 996/PKS/ITS/2022, and the APC was funded by ITS.

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to thank Institut Teknologi Sepuluh Nopember for the funding.

Conflicts of Interest: The authors declare no conflict of interest.

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