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Model Development for Measuring Digital Maturity of an Organization

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ABSTRACT

The digital revolution changes the entire business world, organizations are forced to adopt digital technologies to meet the expectations of demanding customers and to sustain in the competitive business world. The Digital Maturity (DM) is the measurement used to assess the degree of adoption and application of digital technologies. As per the literature, the DM is assessed through two capabilities of organizations: digital capabilities and leadership capabilities. This study identified that the DM has another dimension that is digital literacy of employers/employees of the organization. The existing methods of assessing the DM have some theoretical and practical limitations, hence, this study aimed to fill the knowledge gap by developing a conceptual model and a mathematical model to measure the DM. The development of the conceptual model is based on the literature review, and the development of the mathematical model is based on the theory of linear algebra (vector spaces). The newly developed model, named the 3D-Digital Maturity Model (3DDMM), will help organizations to measure their digital capabilities, leadership capabilities, digital literacy, and the DM. It is concluded that the proposed method fills the existing theoretical and practical knowledge gap in measuring DM.

Keywords: Digital Transformation, Digital Maturity, Vector Space

1. INTRODUCTION

1.1 Background of the Study

The third industrial revolution, or Industry 3.0, is the modern industry's first computer era. It is commonly referred to as the 'Digital revolution' or 'Digital Transformation' (Gunal, 2019). Industry 3.0 began in the 20th century through the partial automation of business using simple computers and programmable logic controllers. Today, we are in the fourth industrial revolution, or Industry 4.0, led by the Internet of Things (IoT), Cyber Physical System (CPS), Information and Communications Technology (ICT), Enterprise Architecture (EA), and Enterprise Integration (EI).

The Digital Transformation (DT) is a process of using digital technologies to create new business or modify existing business processes, culture, and customer experiences to meet changing business and market requirements (Schallmo et al., 2017). Digital Maturity (DM) is the measurement used to assess the degree of adoption and application of digital technologies in an organization (Rossmann, 2018).

1.2 Research Problem

The DM of an organization is measured by a set of capabilities of the organization; the success of digitalization depends on digital capabilities and leadership capabilities of the organization (Westerman et al., 2014; Valdez-de-Leon, 2016; Sugathan et al., 2018). The conceptual model of Westerman et al. (2014) was widely accepted and used to measure the DM of the organizations (Rosmann, 2018). The conceptual model of Westerman et al. (2014) uses digital capabilities and leadership capabilities to measure the DM of the organisations. The dimension 'digital capabilities' includes the availability of qualified and experienced people to use the digital technologies but does not consider the importance of digital literacy of other employees. However, recent studies and surveys suggest that the digital transformation of organizations fails due to a lack of knowledge and training of employees (Uchhira, 2021; Rohn, 2022; Heracleous & Gledhill, 2023). Hence, it is necessary to identify the dimensions of DM. Westerman et al. (2014) model categorizes organizations into four quadrants, taking median values of digital capabilities and leadership capabilities as boundaries of the quadrants. Yet medians are sample sensitive, therefore, the position of organizations changes from sample to sample. Also, the method is unable to measure the value of the DM. Hence following research questions were identified.

Research Questions

RQ1: What are the dimensions of DM?

RQ2: How to measure the DM of an organization?

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1.3 Objectives of the study

i. To develop a conceptual model to measure the DM of organizations.

ii. To develop a mathematical model to measure the DM of organizations.

1.4 Significance of the Study

The digital revolution is rapidly changing the boundaries of the industries worldwide; digitalized facilities have become essential in business activities; therefore, organizations are urged to use digitalized facilities in their business processes to survive in the market (Buhalis & Amaranggana, 2015). However, digitalization is a time-consuming and costly process. Hence, organizations need to know their position in digitalization; in other words, they need to know the level of their digital maturity. The existing methods of assessing DM have many limitations; this study aims to develop a conceptual model and a mathematical model for assessing the DM of an organization and make a theoretical contribution. The proposed model helps organizations to measure their DM, compare their DM within the industry and between industries, hence, this study also makes a practical contribution.

2. LITERATURE REVIEW

The literature review is focused on two parts.

2.1 Definitions and Process of Digital Transformation
2.2 Measuring DM of an Organization

2.1 Definitions and Process of Digital Transformation

The DT is defined in many ways: the DT is a process of reinventing a business to digitize operations and formulate extended supply chain relationships (Bowersox et al., 2005). Digitization stands for the complete networking of all sectors of the economy and society, as well as the ability to collect relevant information, and to analyze and translate that information into actions (BMWi, 2015). Schallmo et al. (2017) combine the definitions of many scholars and give a holistic definition: "The DT framework includes the networking of actors such as businesses and customers across all value-added chain segments and the application of new technologies. As such, DT requires skills that involve the extraction and exchange of data as well as the analysis and conversion of that data into actionable information. This information should be used to calculate and evaluate options, to enable decisions and/or initiate activities".

2.1.1 The Process of Digitalization

Schallmo et al. (2017) reviewed the literature of digital transformation in business. The study revealed that the idea of digitalization in business goes back to the 1990s. Initially, digital channels were used only in mass media advertising campaigns, but widespread in

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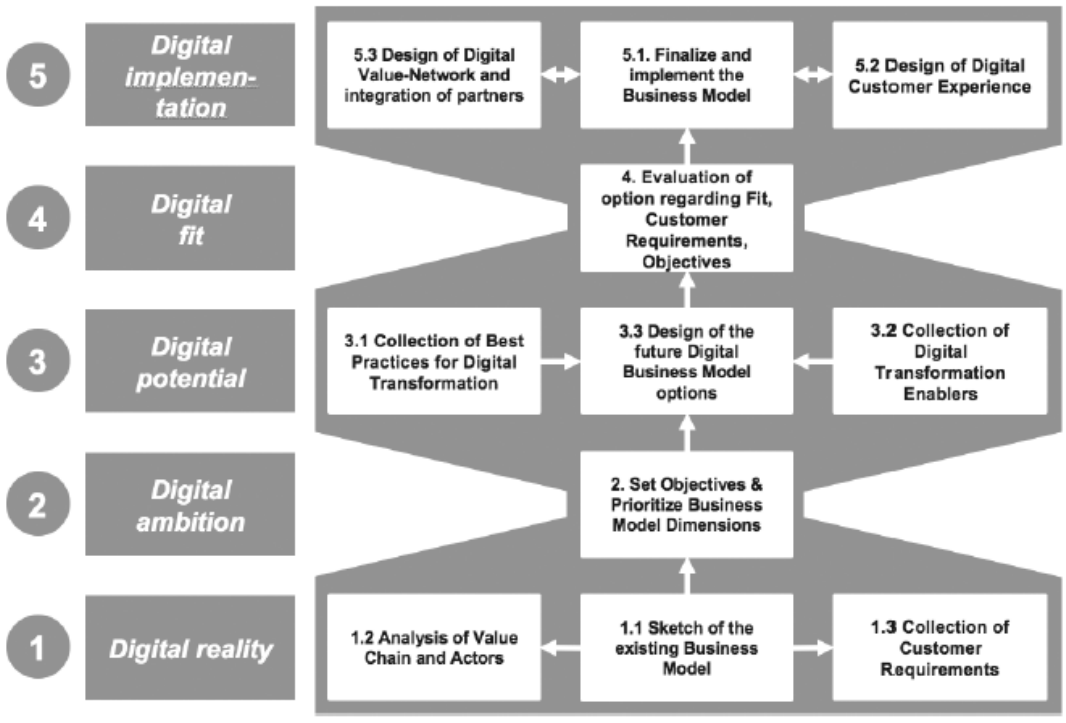
all business activities after 2000. Schallmo et al. (2017) discussed various business models and approaches in business digitalization and presented a roadmap for business digitalization (Figure 1).

Figure 1: Roadmap of DT (Source: Schallmo et. al., 2017)



2.2 Measuring DM of an Organization

Studies have shown that the development of digital capabilities and leadership capabilities leads to higher digital maturity of organizations (Westerman et al., 2014; Sugathan et al., 2018; Rosmann, 2018). The digital capabilities are incorporated into business strategy, technological expertise, business models, and customer experience, whilst leadership capabilities are related to governance, change management, and the culture of the organization. Westerman et al. (2014) developed a conceptual model and an item pool to measure the DM of an organization. They also developed a matrix to compare the DM of organizations (Figure 2).

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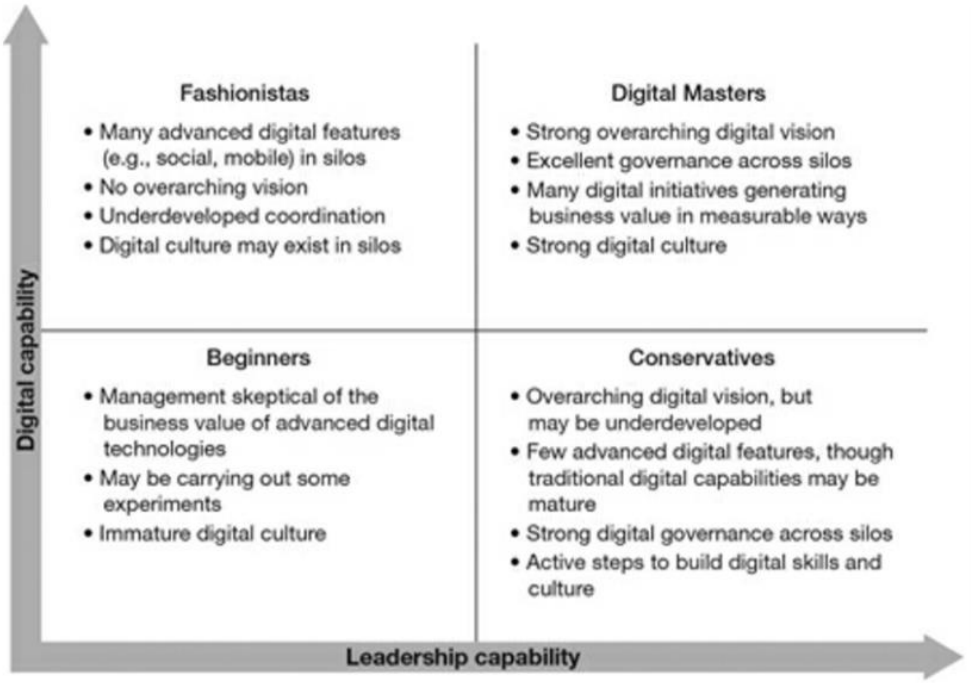
Figure 2: Quadrants of Digital Mastery (Source: Westermann et al., 2014)



The four quadrants are: Beginners, Fashionistas, Conservatives, and Digital Masters. Beginners are at the start of the digital journey; they have low digital capabilities and low leadership capabilities, and some are not certain whether digitalization is suitable for them. Fashionistas have many advanced digital technologies, but they do not have a clear vision about digitalization and have a low level of leadership capabilities. In contrast to the Fashionistas, Conservatives have an overarching vision but do not have sufficient digital capabilities. 'Digital Masters' have acquired necessary digital capabilities; they have a clear digital vision and developed a digital culture within the organization.

Some consultancy companies like KPMG, McKinsey, and Boston Consulting Group have used the conceptual model of Westerman et al. (2014) to develop frameworks to measure the DM, but the implementation of the proposed models was not well-grounded with research (Rossmann, 2018). Hence, Rossmann (2018) conducted a thorough literature review, developed an item pool, and tested the model by collecting data from executives of a sample of companies. Results of the study aligned with the Westerman et al. (2014) framework.

However, internal stakeholders of the organizations refuse to accept the digitalization, as they feel shy to show their incapabilities in digital technologies (Uchhira, 2021; Rohn, 2022). Some studies have shown that the DM of the organization depends on the digital literacy of the management (AlBar & Hoque, 2019; Abbu et al., 2022; Calli et al., 2022).

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Digital Literacy (DL) is the set of basic skills required for working with digital media, information processing, and retrieval (UNESCO, 2011).

DL is measured by five dimensions: Information literacy, Computer or ICT literacy, Media literacy, Communication literacy, and Technology literacy (Bawden, 2008, Son & Robb, 2010, UNWTO, 2011, UNESCO, 2019). Information literacy is the ability to search, retrieve, manipulate, evaluate, synthesize, and create digital content. Computer literacy refers to the ability to operate digital hardware and software. Media literacy is the ability to gather, process, and use information in various forms (textual, sound, image, video). Communication literacy is the ability to communicate one-to-one and one-to-many in traditional and innovative mediums (email, phone calls, and short messages). Technology literacy refers to the ability of using programming languages; create new products, services, and digital technologies (Bawden, 2008; Bunker, 2010; Covello, 2010; Vuorikari et al., 2016).

3. METHODOLOGY

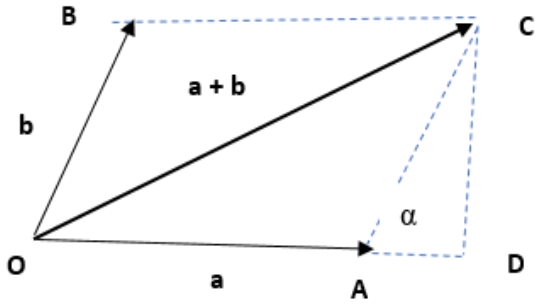
The study is based on the theory of 'Vector Space'. Variables of the study were identified by the literature review (Table 1).

3.1 Vector Space

A vector space consists of a set ***V*** (elements of ***V*** are called vectors), a field ***F*** (elements of ***F*** are called scalars), and two operations: vector addition and scalar multiplication (Oliveira, 2022).Vector spaces are characterized by their dimensions (Hamel dimensions or Algebraic dimensions). The dimension of a vector space is the maximum number of linearly independent vectors. In other words, it is the number of independent directions in the space. A vector has a magnitude (size) and a direction.

Consider two vectors, $\overrightarrow{OA} = \boldsymbol{a}, \overrightarrow{OB} = \boldsymbol{b}$ and the angle between them is α.

Figure 3: Vectors Addition



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By the triangle law of vectors, $\overrightarrow{OA} + \overrightarrow{AC} = \overrightarrow{OC}$

But $\overrightarrow{OB} = \overrightarrow{AC}$, therefore $\overrightarrow{OA} + \overrightarrow{OB} = \overrightarrow{OC}$

By Pythagoras theorem, $(OC)^2 = (OD)^2 + (DC)^2$

$$OD = OA + AD = a + b\cos\alpha$$

$$DC = b\sin\alpha$$

Therefore, $(OC)^2 = (a + b\cos\alpha)^2 + (b\sin\alpha)^2$

$$(OC)^2 = a^2 + b^2\cos^2\alpha + 2ab\cos\alpha + b^2\sin^2\alpha$$

$$(OC)^2 = a^2 + b^2(\cos^2\alpha + \sin^2\alpha) + 2ab\cos\alpha$$

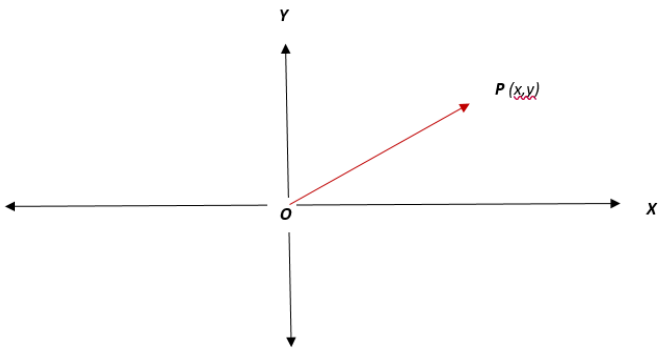
$$(OC)^2 = a^2 + b^2 + 2ab\cos\alpha$$

$$OC = \sqrt{a^2 + b^2 + 2ab\cos\alpha}$$

Hence, the magnitude of the resultant vector of **a** and **b** is $OC = \sqrt{a^2 + b^2 + 2ab\cos\alpha}$

Consider a vector in 2-D vector space, X, Y where $x \in R,\ y \in R$ and $(x, y) \in R \times R$. A vector $\vec{OP}$ in a 2-D vector space has components in two directions, represented as follows.

Figure 4: Two-Dimensional (2-D) Vector Space



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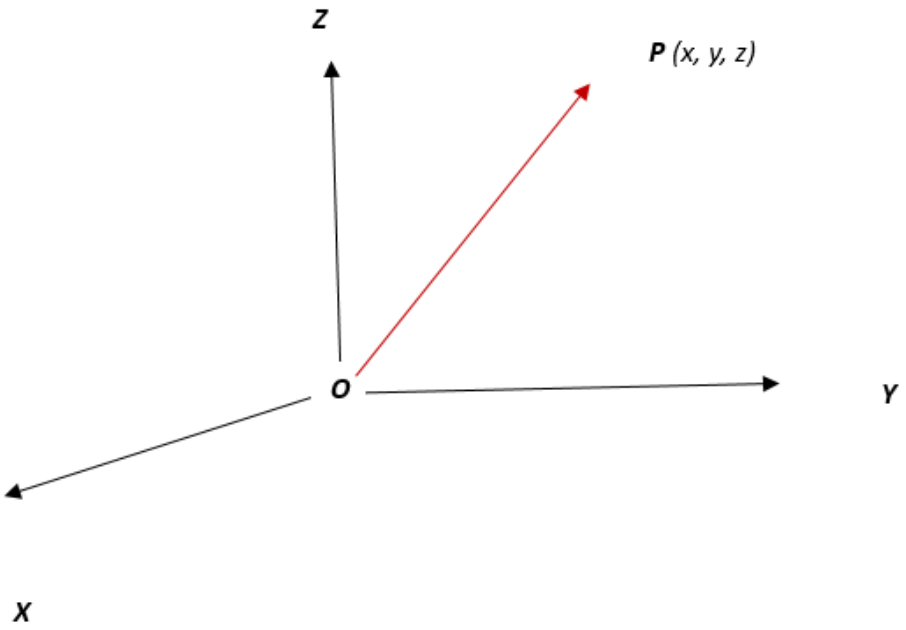
$Let\ P = (x, y), \underline{i}\ \text{and}\ \underline{j}\ \text{are unit vectors along}\ X\ \text{and}\ Y$

Then, $\vec{OP} = x\underline{i} + y\underline{j}$

Magnitude of the vector $\vec{OP} = \sqrt{x^2 + y^2}$

Similarly, a three-dimensional (3-D) vector space has 3 independent directions: *X*, *Y*, and *Z*;

Figure 5: Three-Dimensional (3-D) Vector Space



$Let\ P = (x, y, z), \underline{i}, \underline{j}\ \text{and}\ \underline{k}\ \text{are unit vectors along}\ X, Y\ \text{and}\ Z$

$(x, y, z) \in R^3$

Then, $\vec{OP} = x\underline{i} + y\underline{j} + z\underline{k}$

Magnitude of the vector $\vec{OP} = \sqrt{x^2 + y^2 + z^2}$

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4. RESULTS

Variables for measuring the DM and their dimensions are identified through a literature review, given in Table 1.

Table 1: Summary of Literature Review on Measuring DM

Variable	**Dimensions**	**Literature**
Digital Capabilities of the organization (*X*)	Business strategy, Technological expertise, Business models	Westerman, et al., (2006, 2014), Valdez-de-Leon (2016), Sugathan et al., (2018), Rossmann, (2018)
Leadership Capabilities of the organization (*Y*)	Governance, Change management, Culture	Westerman, et al., (2006, 2014), Sugathan, et al., (2018), Valdez-de-Leon, (2016), Rossmann, (2018)
Digital Literacy of employers/ employees of the organization (*Z*)	Information literacy, Computer or ICT literacy, Media literacy, Communication literacy and Technology literacy	Bawden (2008), Son & Robb (2010), UNWTO (2011), UNESCO (2019), AlBar & Abbu, et al., (2022), Calli, et al., (2022)

We model the DM of an organization as a function of three main variables: Digital capabilities of the organization (*X*), Leadership Capabilities of the organization (*Y*), and Digital Literacy of employers/ employees of the organization (Z). We believe that 'English Literacy' plays a vital role in DL of an individual, hence, that dimension is also included in the development of the conceptual Model given below.

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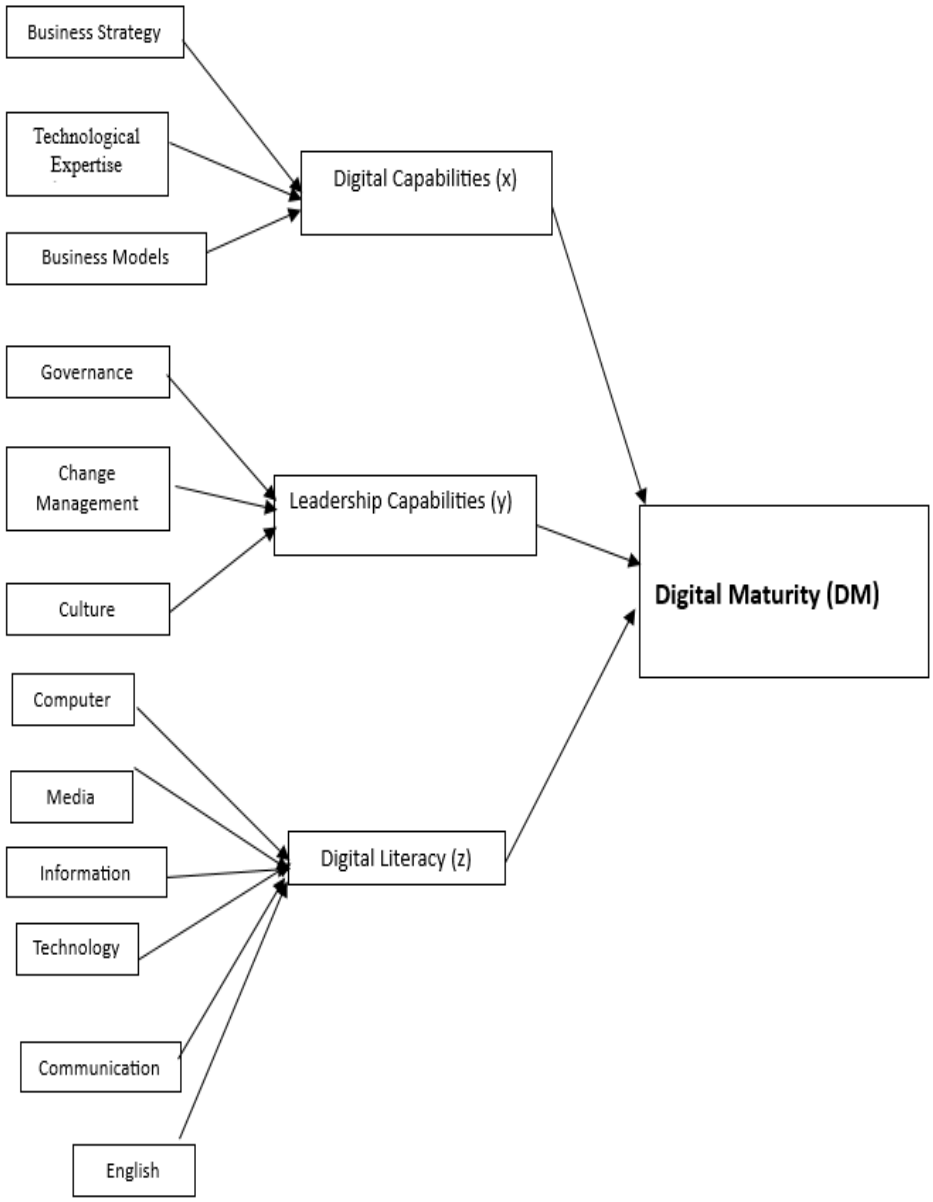
Figure 6: Conceptual Model of DM



Assuming these three dimensions: digital capabilities of the organization, leadership capabilities and DL of employer/ employee are independent, this study models the DM of an organization as independent variables, this study defined them as vectors in 3-dimensional space: Digital capabilities of the organization (*X*), Leadership Capabilities of the organization (*Y*) and Digital Literacy of employers/ employees of the organization (Z).

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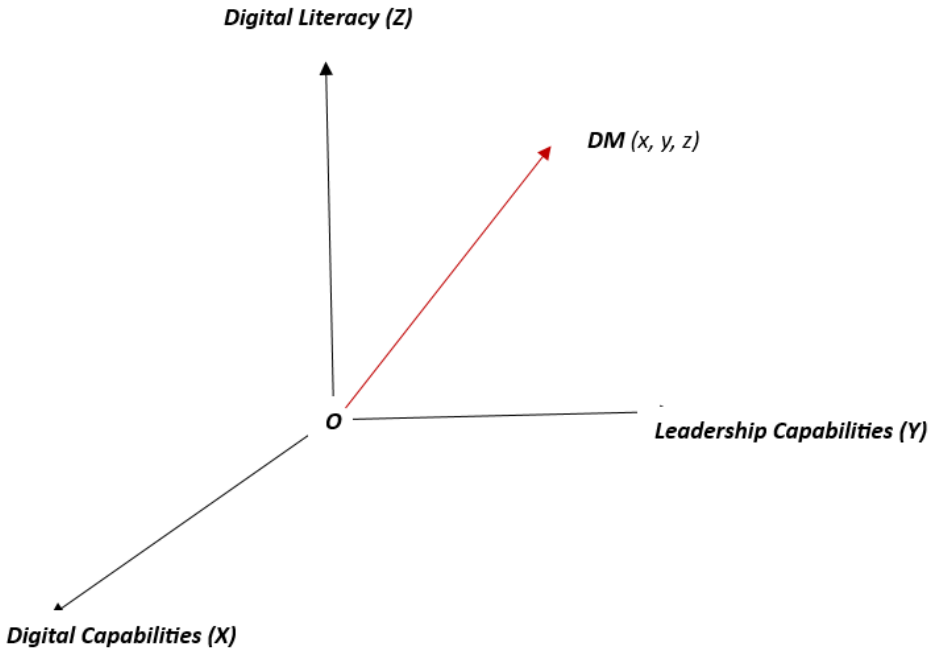
Figure 7: 3-D Digital Maturity Model (3DDMM)



Model assumptions:

1. *X, Y, and Z* are real-valued functions.
2. $x, y, z \in R$ and $(x, y, z) \in R^3$
3. $x, y, z \geq 0$

DM of an organization = $\sqrt{x^2 + y^2 + z^2}$.

This model, named the 3-D digital Maturity Model (3DDMM), can be used to measure the DM of an organization.

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5. CONCLUSION AND RECOMMANDATIONS

Digital transformation changes the entire business world, digital technologies alter customer expectations, and increase the bargaining power, and hence, organizations are forced to digitalize their business. However, digitalization is a time-consuming and costly process, organizations need to measure the level of their digital transformation or digital maturity. The proposed method helps the organizations to understand their position with respect to each capability as well as DM. In general, these variables are time sensitive, which means an organization could acquire more of these capabilities or improve the existing capabilities with the use of digital technologies. This method helps them to monitor their performance over time, for example, on an annual basis, by conducting an in-house survey at a low cost. This also allows the organizations to compare the levels of digital capabilities, leadership capabilities, and digital literacy of the other organizations, within or between industries. The development of 3DDMM has a sound theoretical base. Hence, it is concluded that the 3DDMM is filling the existing knowledge gap of measuring the DM.

This study defined the dimensions of DM as continuous random variables, but DM is a qualitative random variable that can be measured through latent variables. As per the literature, structured questionnaires were used to measure the dimensions of DM, and the item responses were obtained by Likert scales (Rosmann, 2018). However, variables measured by a Likert scale are unlikely to be continuous. In contrast, the Sama Radial Indicator (SRI) of Konarasinghe (2023) converts the qualitative random variables to a continuous scale. Hence, it is recommended to use SRI for measuring digital capabilities, leadership capabilities, and the digital literacy of organizations.

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