The Design Science Research Methodology (DSRM) for Self-Assessing Digital Transformation Maturity Index in Indonesia

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***Abstract*—Digital Transformation is an extraordinary development. Organizations do a lot of work being digitalized. But digital transformation is not only about technology. The comprehensive aspects are involved to provide better service and value to the customers. The Self-assessment Digital Transformation tool to measure the level of digital transformation is needed. This study illustrates how to construct artefacts from Design Science (DS) research perspective. A case study of the self-digital maturity measurement was used to describe the implementation of Design Science Research Methodology (DSRM). DSRM was chosen in the methodology because of the completeness of the stages in the creation of artifacts, especially from the perspective of Information Systems. The DSRM presented here incorporates the principles, practices, and procedures necessary to conduct research. As a preliminary study, the results of this study provide insight for academics and practitioners in designing artefacts with the DSRM approach. This methodology offers how to solve the problem by delivering the artefact as the user needs. This study adds a reference to the development of DS research in the Information System science discipline which is still limited.**

Keywords—Design Science Research methodology, Digital Transformation, Digital Maturity Index

I. INTRODUCTION

Design science research methodology (DSRM) emphasizes the design and construction of artifacts, such as systems, applications, methods, etc., that contribute to the field of IS in organizations [1], [2]. Its distinctive characteristics provide credibility as the basis for a potential DSR genre [2]. The focus of this method is on artifact development. The design of DSRM is strongly influenced by design research, such as March and Smith[3], [4] and Walls [5], each of which focuses on building physical information systems. The resulting DSRM departs from the premise that the designed artifact is likely to be a system or object to support system development, i.e., methods, algorithms, data theory, etc. Several researchers have attempted to provide some guidelines for defining DS research [6]. Work in engineering [7][8] [9][10], Computer Science [10] [11], and IS [12], [13] [6] [3] [4] [5][14] have attempted to collect and disseminate appropriate reference literature [15], [16]; characterize the purpose; distinguish it from theory building and test research, in particular, and from other research paradigms; explain its essential elements; and claim its legitimacy. However, so far this literature has not explicitly focused on developing a methodology for conducting DS research and presenting it [1]. This study presents each stage in the DSRM's framework in information systems. Several studies discussing the role of design science are still limited. This paper fills the limitations of the discussion of artefact development through the DSRM approach which is presented in full at each stage, including: Explicated problems, Define Requirements, Design and Develop, Demonstrate Artifacts, Evaluate Artifacts, and their sub-activities. The case study of self-digital maturity measurement was selected to illustrate the implementation of DSRM. The selection of case studies is based on the limitations of independent measurement of the maturity index. At the same time, organizations need to know the maturity status of DX in their organizations any time. The rapid development of technology has had a tremendous impact on the industry. Proper adaptation to the use of technology makes the industry able to compete even superior. Conversely, the mismatch of technology disclosure makes the industry no longer able to compete and does not even survive the competition. [17].

Meanwhile, the industry is a sector that contributes greatly to a country's economy. Industry readiness in technology is one of the barometers of adapting to technological developments. The presence of Industry 4.0 has great potential in developing the industrial sector[18]. Industry 4.0 fundamentally brings together the digital and physical worlds and offers new opportunities to collect and use information. [19]. It has the potential to increase efficiency and drive innovation on a large scale. Digital transformation is not always technology[20], [21]. Economic-social complexity is an integral part of the problem of Digital Transformation. The difficulty of investing in devices reviewed from a cost point of view becomes a fairly reasonable reason as the cause of the

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digital divide. [22] [23] [24][25], [26]. Likewise, efforts to gain access such as broadband that is not cheap. [27] [28] [29] [30] [31] [32] [33], low awareness of the importance of technology [34][35] [23], and the challenges of integrating technology in the value chain [22] [36][25], [37] becoming the problem for developing countries. However, it is not necessarily able to thoroughly assess the readiness for Digital Transformation. In Indonesia, there is a measurement of industrial readiness in the face of the industrial revolution 4.0. The Ministry of Industry of Indonesia (2018) introduced the Industrial Level Readiness 4.0 measurement called INDI 4.0 or Indonesia Industry 4.0 Readiness Index [38]. This model measures the readiness of industry to welcome the industrial revolution 4.0. The measurement dimensions consist of Management and Organization, People and Culture, Products and Services, Technology and Factory Operations [38]. There are several digital maturity measures that are further discussed in the literature chapter. The digital maturity measurement model has diverse dimensions.

TABLE I. SEVERAL DIGITAL MATURITY INDEX

Model Maturity Index	***PWC***[39], [40]	***Deloitte / TM***[41]	MIT/ Capgemini[42] Subhead	Forrestor's [43]
Dimension	• Digital business model and customer access • Digitization of products and service offerings • Digitization and integration of vertical and horizontal value chains • Data and analytics as core capabilities • Agile IT architecture • Compliance, security, law, and taxes • Organizations, employees, and digital culture	Customer Technology Strategy Operation Organization & Culture	Strategic Assets Internal operations Digital Capabilities (Digital Vision, Governance, Engagement)	Culture Technology Organization Insight

Many maturity models focus on evaluating and judging based on different levels of evolutionary maturity. While some models use status-based levels that describe the level of digital penetration in their internal processes, others use specific archetypes of the company such as agility, customer focus, and strategy. [44]. The adoption of a multidimensional digital maturity model is required to get a complete picture of the success of Digital Transformation. Digital maturity measurement is needed to determine the position of an organization's digital transformation (Teichert, 2019) through various dimensions that affect Digital maturity. Therefore, the identification of digital problems and the status of digital maturity in real terms from time to time independently is needed to support the success of digital transformation optimally. [45] [46].

This paper uses the Design Science Approach methodology (DSRM) ([47] to produce an artifact in the form of Self-Assessment Digital Transformation Maturity Index services for developing countries, especially Indonesia. This paper aims to present DSRM as a methodology for developing technical applications and the design, development, evaluation, and implementation of measurement of digital transformation in organizations. This paper is divided into several chapters. In the first part, the problem is briefly described. The following section is a literature review that describes the DSR method. In chapter 3, the method of working on the paper is presented and detailed in chapter 4. Furthermore, discussions and conclusions are presented at the end of writing. The designed methodology effectively fulfills the objectives of each Design Science activity and adds references to the development of Design Science Research in IS science disciplines.

II. LITERATURE REVIEW

A. Design Science Research

Design science [48] is the scientific study and creation of artifacts developed and used by people to solve practical problems of the public interest. DSRM is generally used to design new services, such as artifact applications [49]. Artifacts are objects made by humans with the intent to be used in solving a practical problem. Artifacts can be of four types, as described by Gregor and Hevner [6], [50]: Construction; Models; Methods; or agency. The artifact must present two essential characteristics: purposefulness and novelty. According to Paul Johannesson et al. [47], a method framework for DSRM includes five main activities: problem investigation and definition of requirements and artifacts' design and development and demonstration and evaluation Explicate problem, investigates, and analyzes practical problems [47], [51].

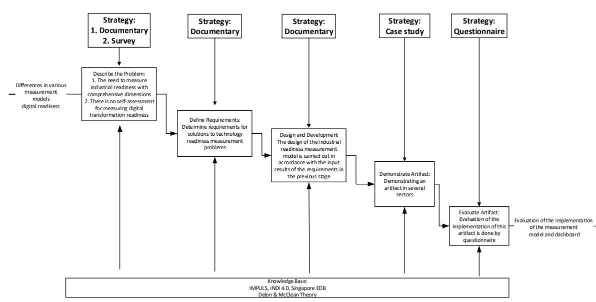


Fig. 1. Research methods step of Digital Maturity Index Dashboard

The issue needs to be formulated precisely and justified by showing that it is essential for some practices. The problem must be of public interest, i.e., significant to one local practice and some global practices. Furthermore, the underlying cause of the problem can be identified and analyzed [52]. The next activity is the Define Requirement Activity. The Define Requirement activity outlines the solution to the described problem (explicated problem) in the form of artifacts. It brings up requirements, which can be seen as transforming the problem into demands on the proposed artifact. Requirements will be defined not only for functionality but also for structure and environment. Artifact Design and Development activities create artifacts that address the described issues and meet the specified requirements. Designing an artifact includes determining its function as well as its structure. The Demonstrate artifact activity is also called "proof of concept", explaining the use of artifacts developed to the user to prove the feasibility of the artifact being built. Demonstrations will show that artifacts can solve a problem. Artifact Evaluation activities determine how well artifacts meet requirements and solve problems. DSRM activities can be done iteratively and

move back and forth between all activities according to research needs. Therefore, these five activities in the design science framework do not have to be sequential. The relationship between one activity and another activity as an input-output relationship.

B. *Self Assessment Digital Maturity Index*

The presence of Digital Transformation is an important phenomenon for organizations. The revolution to accelerate business processes, models, and business practices by utilizing technology adoption opportunities is a digital transformation practice[53]. According to Dion Hinchcliffe [44], the digital transformation framework is an ongoing cycle of growth, refinement, and change underpinned by critical pillars of cultural change, skills building, executive leadership, and business model redesign, strategic goals, and roadmaps. While the business model focuses on scientific research and management practices, companies deploy new technologies and ideas with the help of business models [46]. Model maturity explains how organizations build transformation strategies and what steps organizations take for those transformations [54]. In the academic literature, there is a way of measuring digital maturity through revenue generated by digital offerings in products and services. However, the indicator describes only a few aspects of digital transformation. It is not enough to have a broader view of a digital maturity model.

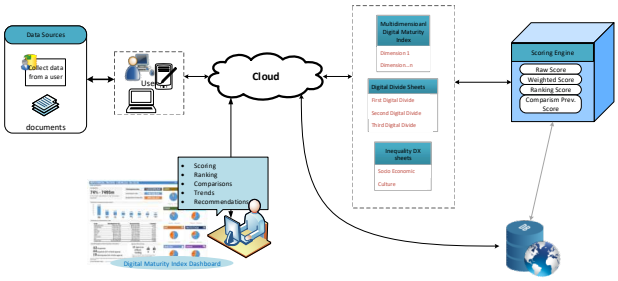
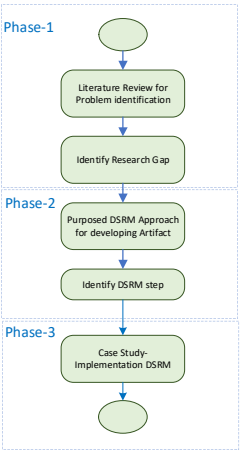


Fig. 2. Technical Diagram self-assessment Digital Maturity Index

Therefore, companies need digital maturity models with multidimensionality. When facing digital transformation, companies in the digital age need to implement comprehensive methodologies such as digital strategy, digital capabilities, IT development, collaboration, transparency, and agility [55]. There are various models of digital maturity with various dimensions in different countries. This dimension includes aspects of transformation management, digitization of internal operations, digital products and service offerings, and digital customer interaction. Several models of digital maturity with their dimensions and maturity levels are presented in Table 1. Meanwhile, various issues must be addressed by organizations in implementing Digital Transformation. Some of these issues include [18], [44], [56]: Inadequate internal skills, integration of new technologies[57], Strategic change, and Short-term outlook challenges. In summary, these issues are mapped out on the digital divide. This research focuses on applying design science research methodology to produce an artifact in the form of digital maturity measurement services independently. The results of this study also answer the needs of management and society in general. It further finds out the position of readiness for digital transformation through activities that have been carried out or planned by the company to support digital transformation. The measurement of digital maturity independently that exists today is very limited, for example, strengthening independent digital life in taxation and particularly discussing taxes. In addition, multidimensional coverage is needed to accommodate a broader understanding of the concept of digital maturity models, as described earlier. Comparison analysis of various digital maturity models is needed as part of the Explicated Problem stage process that will be explained in the next chapter.

III. METHOD



The stages of the research method in this study were carried out in 3 steps. The first step discusses the literature review to identify research problems. The research problems outlined in the research gap have been discussed in the previous chapter. The limited research that discusses the construction of artifacts through the DSRM approach is the main motivation for carrying out the research.

Fig. 3. Research Method Step

The next step discusses the stages of artifact creation and ends with the implementation of the DSRM approach in the case study of making Self-Assessment for Digital Maturity artifacts. The stages of the research method are presented in the fig. 3.

IV. RESULT

This research uses the *Design Science Research Methodology* (DSRM) approach by accommodating its framework [47]. There are five activities in the framework: Explicated Problem, Define Requirements, Design and Develop, Demonstrate artifact, and Evaluation. The research steps for each activity are presented in fig.1.

A. *Research activities based on the DSRM framework*

The initial activity in this study was explicated problems. Input from this stage on problems related to digital maturity index measurement. Strategies for the Explicated Problem with literature or documentary studies and surveys on the service user industry. In this study, service users covered various sectors that support digital transformation, such as banking, education, and health. The output of the Explicated Problem becomes the input on the Define Requirements activity. At this stage, the planned strategy is enough literature study to support the procurement of systems or applications – self-assessment digital maturity index. User interviews are conducted to explore in-depth the needs of users. Furthermore, the Define Requirement activity results become inputs for Design and Develop activities. The literature review strategy is used at this stage, while the theory used to measure user acceptance of technology is Delon & McClean's theory [58]. Comparison of various pre-existing models carried out to obtain digital transformation measurement services in organizations. The results of this stage of developing artifacts become input for demonstrating services in the industry.

Strategy case studies are applied to the demonstration stage. It is through this demonstration activity that evaluation activities can be carried out. The approach used is a Questionnaire.

B. DSRM implementation in e-self assessment Digital Maturity Index case study

A series of case studies are presented on each DSRM activity to illustrate how the methodology is used when implementing the e-self assessment digital maturity Index service, [47]. In projects that support digital transformation in the industry, the development of e-self assessment digital maturity index services is needed. This service measures the organization's readiness for digital transformation, technology adaptation status, digital barrier identification, and recommendations for optimizing digital transformation through ranking scores on each dimension of Digital transformation. Digital Transformation, especially in developing countries, cannot be separated from the Digital divide. Therefore, this consideration of digital inequality needs to be considered in measuring the success of digital transformation and future organizational strategies. A different set of research methods is selected for each methodological activity to perform the necessary work tasks (fig. 1). Artifact's digital maturity index service is planned to be Web-based. The technical of diagrams is presented in fig. 2. Users of this application can access the application as safely as possible with password protection. Furthermore, users can input data according to the criteria requested by the application. These criteria are translations of dimensions and indicators obtained from the Digital Maturity Index comparison analysis results. Finally, the system will display a ranking score and strategy recommendations to optimize digital implementation. The app is built on a web basis.

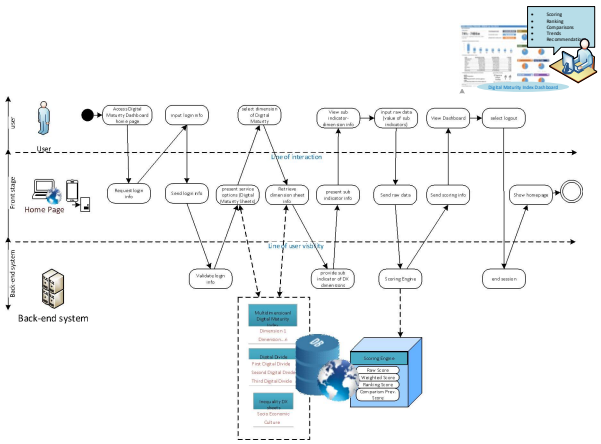


Fig. 4. Service Experience Blueprint of Artifact Dashboard

The user runs the application by inputting organizational data. The system will process and assess the digital maturity index based on each indicator. The application will provide output in the form of digital Maturity Index values and information on improving aspects of Digital Transformation support based on their dimensions. Users can access various devices and input data according to the items requested on the system. The system carries out a scoring processor by accommodating the dimensions of Digital Transformation, Digital Inequality, and other inequality factors. Furthermore, the scoring system will assess the level of the digital maturity index presented on the dashboard. At this design and development artifact stage, mapping each activity on the dashboard is described with the Service Experience Blueprint (SEB) approach. The SEB method[59] was developed specifically for designing multi-interface service experiences. SEB builds on existing methods, combining contributions from service management and software engineering to create unifying approaches to address the infusion of technology into services. SEB enables the integrated design of multi-interface services, leveraging the advantages of each channel to enhance the overall customer experience. SEB at each activity stage on the dashboard is presented in fig.4.

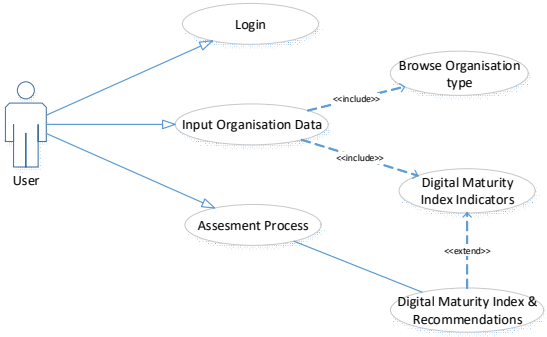


Fig. 5. Use Case Diagram Self Assessment Digital Maturity Index

SEB activity in the dashboard application begins with user identification through the login page. After the system carries out successful user verification, the system will display the input location for each indicator and sub-indicator. The score calculation engine will process user input and display the score results on the dashboard. Interaction design and software engineering methods involving case diagrams and activity diagrams of the integrated modeling language [60], [61], also made useful contributions to designing interaction processes. A use case describes the sequence of actions that the system performs to produce useful results for the user [60] and can be analyzed at a fundamental or concrete level. In summary, the use case section of the system usage diagram is presented in fig. 5. The design and development artifact stage presents details of activities and sub-activities. An in-depth review is needed for future research.

Fig. 6. Dashboard Mockup

The Digital Maturity Index Self-Assessment Service displays the measurement of each dimension's score on the Maturity Index. The dashboard service provides score measurement information on each dimension, fig. 6. Detailed presentation of data on each dimension makes it easy for users to have a specific dimension focused on improving digital transformation success.

V. DISCUSSION

Nowadays, technology is not only used as a tool but has become a necessity. Every organization requires proper disclosure of the use of technology. Knowledge of the level of digital maturity over time is required. Digital Transformation is a continuous cycle supported by the main pillars of the organization [44], as described in the previous chapter, is an effort to maintain the organization's sustainability in the technological era. The digital maturity measurement determines the position of the organization's digital transformation [54] on various dimensions that affect digital maturity. Models use numerical scores that can be expressed in percentages or absolute numbers. Therefore, identifying digital problems and the status of digital maturity in real terms from time to time independently is needed to support the success of optimal digital transformation [45]. However, this solution has hardly been translated into digital maturity measurement services for end-users, such as enterprises. In general, the problems identified are 2, namely: the problem comes from the fact that various existing digital maturity measurement models have various dimensions. Measurement using various models of digital maturity alternately is certainly ineffective and time-consuming. In addition, the differences in the digital divide and factors that influence it, such as socio-economic and culture, need to be considered in the digital maturity model. Furthermore, the level of digital maturity needs to be known in real terms over time easily. However, independent digital maturity measurement services are still limited [62]. Therefore, a digital transformation self-assessment service is needed that can be used independently by the company. Thus, the status of digital readiness and digital problems can be identified immediately. In building a digital readiness measurement service artifact, it is necessary to look at the entire service creation and development process from the point of view of all stakeholders and users. The DSRM developing self-assessment service artifacts digital transformation maturity model is used in this study. DSRM provides a solid scientific methodology where different people and professionals can come together and share their perspectives on how a new service, application, or product should be developed. This demonstration of independent digital maturity measurement services was conducted in several industrial sectors, such as banking, health, and education. The involvement of various industrial sectors in the implementation of the artifact demonstration stage is expected to provide a comprehensive evaluation for service improvement in the future. The artifact in this study is an instantiation. The researcher aims to make the artifact results a service, therefore, the participation of practitioners is carried out from the beginning of the research. Thus, the involvement of end-users in the demonstration stage, using their input from the service evaluation, became the strategy adopted in this study. The DSRM in this study has accommodated the entire service implementation cycle, from the design stage to the sustainability stage. All processes in the DSRM framework are presented at the artifact self-assessment stage of the Digital Transformation Maturity Index.

VI. CONCLUSION

Digital transformation research continues to grow. Various digital readiness measurement models are proposed to help management know the extent to which the organization's Digital transformation has been achieved. An easily accessible digital readiness measurement tool with processing maturity level calculations in the form of artifact instantiation is required. Various methods are used in making artifacts, one of which is DSRM as a methodology that is often used from an Information Systems perspective. However, research on the discussion of DSRM is still limited, therefore this research fills the gap in the DSRM approach in building artifacts. The stages of DSRM are reviewed with case studies of artifacts for measuring digital maturity. As a preliminary study, the results of this study provide insight for academics and practitioners in designing artifacts with the DSRM approach. Future research is needed to reveal each stage of artefact development in more detail and expand cross-sectoral case studies.

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