The Embracement of Design Science Research Methodology in the Development of Digital Transformation Models

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Abstract: - Many organizations should be more confident about adopting different technologies in their business environment. Potential barriers and complexities are the primary explanation for these attitudes. Utilizing appropriate models in technology implementation and evaluation could be a motivation to resolve this distrust and create a state of confidence in transforming towards these technologies. A design science research methodology (DSRM) approach efficiently developed effective digital transformation (DT) models. It includes different phases and follows an iterative approach in developing these models. In this paper, we are presenting two case studies that adopted the DSRM approach in DT. One is to extract a Business model (BM) for initiating DT using a university scientific research information system (SRIS). The other demonstrates new cloud collaboration platforms (CCPs) to create an assessment model for new technologies during pandemics.

Key-Words: - Digital Transformation, Disruptive Technologies, Design Science Research Methodology, Business Models, IT Assessment Models, Cloud Collaboration Platforms, Pandemics.

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1 Introduction

Business needs such as integration and collaboration, storage and manipulation, and research and simulation are currently addressed through Information Technology (IT) systems, [1]. Their key also results in massive changes and substantial advantages in business, [2]. However, many organizations need help adapting these IT systems and succeeding in achieving their Digital Transformation (DT), [3].

A successful DT requires a proper Business Model (BM) design. It involves applying and evaluating technology systems through a BM, [4]. A BM clarifies “the rationale for how an organization creates, delivers, and captures value," [5]. It is an approach to reaching a sustainable business and a platform that connects resources, services, and processes to achieve a competitive advantage, [6]. Creating new business models is part of the significant business improvements that a DT seeks, enhancing customer experience and streamlining operations, [7].

Cutting-edge and disruptive technologies have revealed a new vision for addressing the challenges of the COVID-19 pandemic and other critical conditions. They have unfolded power in managing and constricting the pandemic outbreak and addressing demanding business needs in crises. Developing an assessment model for these technologies during such conditions is still emerging. In addition, prioritizing criteria and determining the significant ones to use in evaluating new technologies during pandemics and disasters still need to be identified.

Building various models concerning DT is iterative and depends on the feedback and data that users provide. A design science research methodology (DSRM) could be practical in developing these model artifacts and considering the human role and competencies in DT, [8]. It also designs and investigates their interaction in a context. Furthermore, it iterates and returns answering knowledge questions to the design problem-solving phase, [9]. A DSRM combines different principles, procedures, and practices that address objectives that confirm consistency with previous literature, provide a formal process model for design science research (DSR), and generate a mental model to present and evaluate DSR in information systems, [10].

This paper applies DSRM to develop two different models using two case studies to support organizations’ DT. One case suggests a BM that could facilitate understanding and implementing new information systems in organizations before initiating DT. The other case presents a pandemic assessment model that supports evaluating the use of new technology systems during crises and pandemics.

2 Digital Transformation

A DT is an approach that causes a crucial shift in a business environment by transferring an organization's main processes into IT solutions, [11]. It also changes conventional business into a smart one. The [3], suggest that IT should be prominent in some of the following dimensions: processes, user experience, markets, relationships, customers, and new organizations.

Different definitions for DT were reviewed by [12]. The definition includes developing new BMs using IT, addressing customers' needs, introducing effective service delivery, and ensuring organizational cultural changes. Their findings suggested that DT is an inclusive approach and a continuous process affected by external drivers such as new technologies. On the other hand, [7], made three observations after thoroughly reviewing DT definitions: First, DT is mainly defined and reviewed with organizations. Second, differences in definitions are related to the types of technologies used and the kind of transformation that is adopted. Third, similarities exist among various definitions. After analyzing these definitions, [7], defined DT as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies".

A DT affects value creation, capture, and delivery in most industrial sections. It is also shown that the DT domain is still evolving, and research in DT is mainly about three topics, [13]: new enabling technologies, shared platforms and ecosystems, and disrupting technologies. New enabling technologies are suggested with the nine pillars of Industry 4.0, such as the Internet of Things (IOTs), cloud technology, and cyber security, [14]. A platform is "any combination of software and hardware with rules, interface, and standards that enable and permit providers of complements to create value and interact with users", [15]. Disruptive technologies are defined as technologies that change the principles of competition by exchanging the measurements of performance that organizations use to compete, [16].

Cloud Collaboration platforms are one of the most significant disruptive technologies that have contributed to DT and changed the work environment rules in this era. Besides their role in enabling better communication and effectively utilizing different areas such as integrated programming and crowdsourcing, they were an urgent demand for online education during the COVID-19 pandemic. CCPs have presented a sustainable approach to online education; they have supported the learning process through the use of cloud computing resources, in addition to their collaborative sharing and creating of documents, [17]. The adoption of CCPs during the pandemic has released a set of challenges, and some analyses of CCPs were performed corresponding to them in terms of access speed, course management, reliability, and communication, [18]. However, no model evaluates these criteria, classifies, or ranks them.

3 Design Science and Research Methodologies

Research methods could be classified concerning process (quantitative and qualitative research), purpose (exploratory, descriptive, and predictive research), logic (deductive or inductive), and outcome (applied or fundamental). These methods are associated with the interpretivism and positivism paradigms, [19]. Positivism is a philosophical system that adopts only experimentation and data of experience, [20]. It uses a structured instrument that describes the relations within phenomena. Positivist research is objective and excludes values, ideologies, and passions, [21]. Deductive research and quantitative methods are examples of positivist research. On the other hand, interpretive research is a paradigm that assumes social reality is not objective or singular; it is formed by social contexts and human experiences, [22]. Inductive research and qualitative methods are utilized in interpretive research.

A significant paradigm that could be implemented with previous approaches, specifically in the information system (IS) field, is the design science paradigm, [23]. Design science research is "a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence", [24]. A DSRM could be introduced through six stages, [10]. These stages are problem identification, objective definition, design and development, demonstration, evaluation, and communication. The previous stages were used in DT case studies and supported the development of models in each case.

Two evaluation perspectives regarding information systems were distinguished in the DSRM, [24]: the ex-post and ex-ante perspectives.

The ex-ante approach is applied before technologies are chosen, implemented, designed, or developed. On the other hand, ex-post is after. The ex-post approach permits evaluation in a real environment using naturalistic evaluation methods. A naturalistic method involves experiments, ethnography, action research, field, and case studies, as has been done in this research.

3.1 Case One: A Digital Transformation Model

In this case, a faculty of scientific research at a university in Jordan was demonstrated as a case study to be part of the DT process. A new internal Scientific Research Information System (SRIS) has been applied to manage faculty research, and Business Model Canvas (BMC) was implemented pre and post-using the SRIS, [25]. The stages of the DSRM process were adapted in this case to derive a Digital Transformation Model (DTM) as follows:

3.1.1 Problem Identification

The main problem is the barriers managers face in adopting new IT systems and succeeding in initiating and launching their DT, in addition to the limited understanding that BMs have shown to the accelerated technological changes. Moreover, the challenges and complexities in shifting to new BMs.

3.1.2 Objective Definition

The objective is to develop a new BM artifact that facilitates DT. It is a qualitative objective that is inferred from the identified problem and presents a solution.

3.1.3 First Iteration – Design and Development, Demonstration, and Evaluation of BMC

This stage includes creating a digital transformation model based on BMC. The BMC combines nine segments that create a business model. The segments are key resources, key activities, key partners, cost structure, value proposition, customer, customer relationships, channels, and revenue. Understanding these segments and their elements is essential to extract and develop the potential new BM that supports DT.

The demonstration stage involves instantiating the BMC of the scientific research faculty pre and post-the adoption of the new SRIS. Instantiation is performed by nominating each segment’s elements of the BMC. These elements support the development of the proposed BM for achieving a DT. A set of suggested question(s) was utilized to extract the elements of each segment of the BMC.

At the evaluation stage, a qualitative approach was applied using focus group and secondary research for both canvases pre and post-implementing the SRIS. The Focus group was conducted with the collaboration of the scientific research board representatives of the faculty. It included verification and validation tests that confirm that elements are correct and right. Correctness meant no additional or missing elements in the canvases. Rightness was checked by their proper existence and position.

3.1.4 Second Iteration – Design and Development, Demonstration, and Evaluation of DTM

After evaluating the two BMCs, a comparison was accomplished between both approaches pre and post-using SRIS. This comparison identified changes in five segments. These segments were considered the fundamental variables of the new model that was suggested to facilitate a DT for an organization. Thus, a new iteration was recommended to design, demonstrate, and evaluate this model using the same case study.

The DT model included variables of key resources, value propositions, customer relationships, and channels. The key resources were the independent variable that initiated DT since the change would not exist without adopting the new IT system, the SRIS. This means that this variable caused the changes of other dependent variables elements, and all components' changes were a response to the SRIS adoption.

After the new model's design was extracted and presented its variables, the demonstration was conducted by confirming that each variable's elements after instantiation were the same post-using SRIS. An empirical investigation followed the demonstration stage to evaluate the new model variables and confirm their elements. This empirical approach was quantitative, using an online survey questionnaire. The questionnaire was formulated using five-point Likert scale questions and distributed to 269 academics in 37 departments using the SRIS. Ninety responses were received from all distributed questionnaires. The questionnaire measures and corresponds to the elements of the variables as follows: Key Resources (3 paragraphs), Value Proposition (7 paragraphs), Key Activities (4 paragraphs), Channels (3 paragraphs), and Customer Relationships (3 paragraphs).

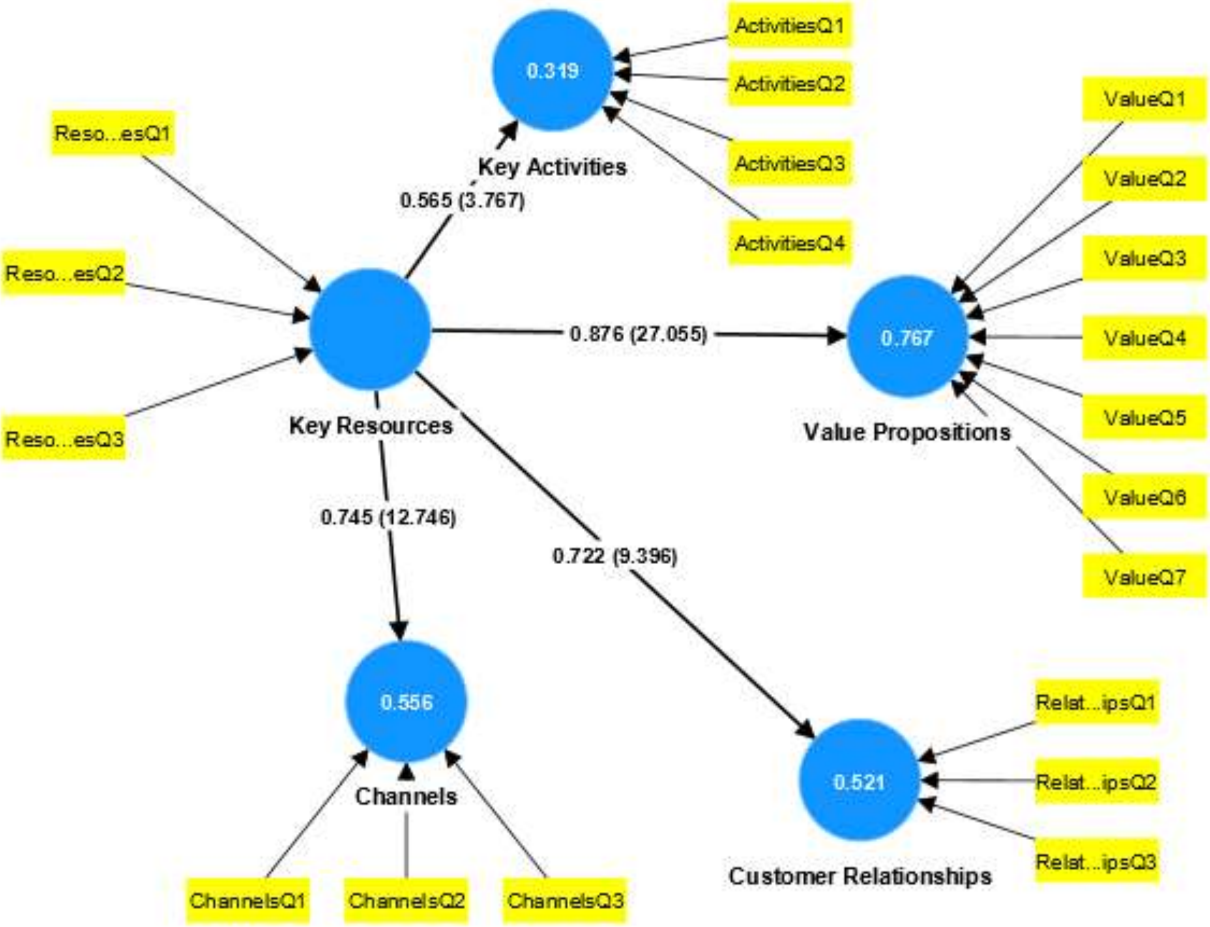

Fig. 1: Assessment of Digital Transformation Structural Model

After analyzing the responses, key findings reported an overall agreement on the new elements of the DTM variables. The value propositions variable has recorded the highest mean, with a maximum score for the social distancing and environment friendliness elements (mean = 4.41, 4.31). 90% of the respondents confirmed that SRIS is the core system for completing the requests of the faculty of scientific research. Also, more than 70 % of the respondents ensure there is no need for individual guidance or follow-up by the faculty staff to resume academic requests after using SRIS. In addition, more than 80% of the respondents believe that services presented by the faculty have become fully automated. Finally, according to the analysis of results using SmartPLS 4, the (R) values showed a significant positive relationship between the key resources variable and the other variables, including value propositions, key activities, customer relationships, and channels (Figure 1).

Table 1 clarifies the R, R square, T, and P values presented in the digital transformation structural model assessment. The main hypothesis H1 was "applying particular BMC segments facilitates the initiation of DT "Sub-hypotheses include, [25]:

- H1-1: The SRIS resource has made a significant difference in Key Activities.
- H1-2: The SRIS resource has made a significant difference in Value Propositions.
- H1-3: The SRIS resource has made a significant difference in Customer Relationships.
- H1-4: The SRIS resource has made a significant difference in Channels.
- Null sub-hypotheses were rejected, and accordingly, we rejected the main sub-hypothesis and accepted the main one, H1.

Table 1. Path Coefficients for DT Structural Model Hypotheses

Dependent Variable	Related Hypothesis	R	R^2	T-Value	P-Value
Key Activities	H_{1-1}	0.565	0.319	3.767	0.000
Value Propositions	H_{1-2}	0.876	0.767	27.055	0.000
Customer Relationships	H_{1-3}	0.722	0.521	9.396	0.000
Channels	H_{1-4}	0.745	0.556	12.746	0.000
a. Predictors: (Constant), Key Resources, Sig <0.05					

3.1.5 Communication

Research communication was achieved by publication and sharing results with academics and professionals through webinars and social media.

3.2 Case Two: A Pandemic Assessment Model of Cloud-based Collaboration Platforms

Disruptive Technologies caused radical changes and led the digital transformation in the industry field. Their role was more comprehensive than organizational aspects such as performance, competitiveness, and effectiveness. It has also expanded into critical times, particularly during the Covid-19 pandemic. Cloud Collaboration Platforms (CCPs) were a significant technology that was crucial and necessary to adopt during the pandemic. An assessment model for this DT technology during pandemics was presented, [26]. The DSRM processes were adapted to derive a Pandemic CCPs' Assessment Model (CCPsAM).

3.2.1 Problem Identification

CCPs have presented a solution to different sectors for monitoring and controlling business needs during the COVID-19 pandemic outbreaks. The educational sector is a vital sector that adopted the CCPs. However, adopting these platforms, especially in the Middle East and a country such as Jordan, was prompt, and no real evaluation plan or model was presented to assess these platforms. In addition, deciding what criteria were significant for evaluation in such a crisis was ambiguous. Accordingly, an assessment model for disruptive technologies (i.e., CCPs) in complex conditions was necessary and proper.

3.2.2 Objective Definition

Our primary objective is to present an evaluation model that supports DT in critical circumstances. It is a qualitative objective that was extracted from the problem and addressed.

3.2.3 First Iteration - Design and Development, Demonstration, and Evaluation of CCPsAM

Three criteria were suggested during the design and development phase for the CCPs assessment model. These criteria were considered essential and based on significant features that were considered an indicator of an information system's appropriate performance and functioning, [27]. The features include running without unpredictable interruptions, supporting tasks that the information system was developed for, and ease of use. The assessment model comprised three corresponding criteria to be demonstrated and evaluated: reliability, usability, and functionality. The precedent criteria were quality characteristics introduced by ISO 9126–1, [28]. They were also presented and measured by a set of sub-criteria or standards. Reliability combines maturity, recoverability, and fault tolerance. Usability is composed of operability, learnability, and understandability. Functionality includes security, accuracy, suitability, and compliance.

After determining the assessment model criteria, the model was demonstrated using a case study of a university in Jordan. A quantitative method was applied using an online survey questionnaire to develop the pandemic assessment model. The model depended on the respondents' rating of the sub-criteria related to the CCPs adopted during the pandemic. The respondents included 46 academics from the IT and engineering departments. The questionnaire was developed using Google Forms and was sent directly by email to all respondents. The sub-criteria were measured through a 3-level rating scale (high, medium, and low). A high level meant a more attention requirement and higher priority when using these platforms during the pandemic.

On the contrary, medium and low levels were given sequentially less priority. After rating the sub-criteria that belong to one of the three main criteria, the respondents were asked to arrange these belonging sub-criteria from high to low priority. They were also allowed to suggest any missing criteria with their rating. After collecting the respondents' answers, data was analyzed using descriptive statistics. Statistics included the mean, maximum, minimum, and standard deviation (Table 2). Findings indicated that security is the most significant standard among functionality sub-criteria. It also has the greatest number of high-scale level ratings among all sub-criteria of the model, with 73.3% of the respondents. Accuracy and suitability were sequentially the second and third most significant standards in functionality criteria.

On the other hand, fault tolerance was the most significant standard of reliability criteria ahead of maturity and recoverability. Finally, understandability was the most significant standard of usability criteria, with a high-scale level of 66.7% of the sample. It also has the most significant number of agreements on priority one rating among all main criteria standards, including security. An overall rating of the key criteria suggested functionality criteria on top with the highest priority to give attention during the pandemic. The rating also indicated that reliability should be the second priority before usability.

Table 2. Descriptive Statistics of all Standards of Main Criteria

Criteria	Min.	Max.	Mean	Std. Deviation
Security	2	3	2.73	0.450
Understandability	2	3	2.67	0.479
Compliance	1	3	2.63	0.556
Learnability	2	3	2.60	0.498
Accuracy	1	3	2.57	0.568
Suitability	1	3	2.57	0.568
Recoverability	1	3	2.53	0.571
Operability	2	3	2.47	0.507
Fault tolerance	1	3	2.47	0.571
Maturity	1	3	2.43	0.568
Interoperability	1	3	2.27	0.583
Note: 1 = Low; 2 = Medium; 3 = High				

3.2.4 Second Iteration - Design and Development of CCPs' Assessment Model

Concerning the previous analysis, we iterate back to the design and development phase to reconstruct the proposed CCPs' Assessment Model during pandemics and crises (Figure 2). The model arranged standards according to their significance based on our findings. It also considers key criteria and their standards rating and ranking by the respondents. The model prioritizes security and understandability since they scored the highest means and number one ranking among other standards. Fault tolerance, accuracy, suitability, and maturity were given the second priority. Eventually, the remaining standards, recoverability, learnability, compliance, interoperability, and operability, were positioned as third priority.

The remaining stages of the second iteration of CCPsAM demonstration and evaluation still need to be applied using the same or any other case studies. Therefore, applying this model while using CCPs in urgent cases and specifically in the educational sector was suggested to evaluate its effectiveness. This could include evaluating users' and IT technicians' satisfaction and performance of CCPs during these critical and time-limited situations.

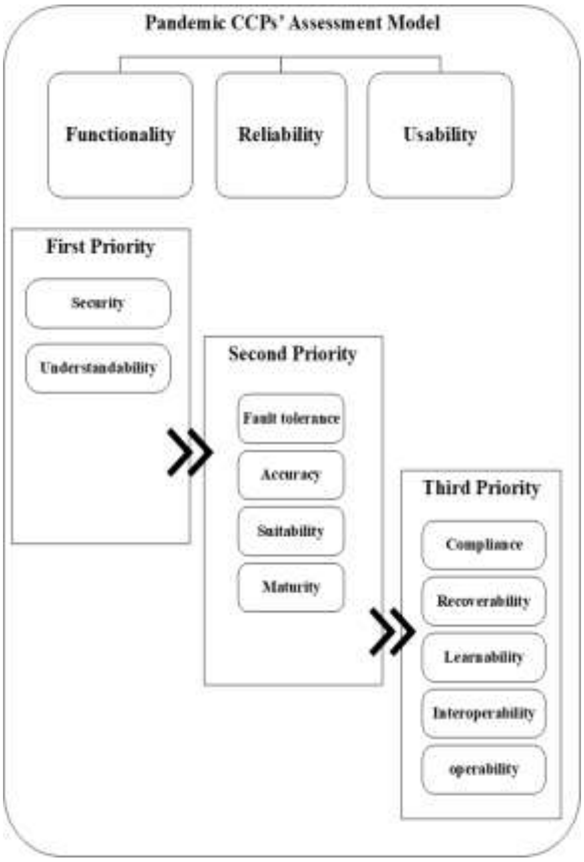

Fig. 2: Pandemic Assessment Model of CCPs

3.2.5 Communication

The new proposed assessment model of CCPs was shared with academics and the educational sector through a conference and publication.

4 Conclusion and Future Work

This paper aimed to highlight the role of DSRM in Digital Transformation. Two cases were presented following the phases of the DSRM process to develop different DT models. The first model objective was facilitating and supporting the initiation and implementation of DT when adopting new technologies in organizations. The model was extracted from the business model canvas segments suggested to accomplish a DT. A case study of a Scientific Research Faculty that has adopted a new scientific research information system at a university in Jordan was utilized to develop and evaluate this model. The findings reported that Key Resources, Value Propositions, Key Activities, Customer Relationships, and Channels are the main segments involved in a DT process. Furthermore, Key Resources are necessary to enable and lead the change in these segments and accomplish a DT process. In conclusion, this model should simplify moving toward DT and predict the position of changes we expect after using new key IT resources.

The second case was an assessment model for DT during the Covid-19 pandemic. Implementing new technologies should promptly evaluate and consider priorities during limited-time actions and pressure organizations run across during critical times and pandemics. Thus, an assessment model was suggested to address such a problem. Different criteria were used in the development of this model. Usability, reliability, and functionality, in addition to their standards or sub-criteria, were the main components that developed the assessment model. Online educational Cloud Collaboration Platforms such as Microsoft Teams and Zoom were used to demonstrate and evaluate these criteria during the COVID-19 pandemic. The criteria and their standards were prioritized in line with their rating and ranking by respondents of an online survey questionnaire. Accordingly, a pandemic assessment model was developed with three levels of priorities that were arranged from the first to the third level concerning their significance. Each level included the standards that were imported from the main criteria. Security and understandability were the most significant standards in this model. This was followed by level two standards that combined fault tolerance, accuracy, suitability, and maturity standards. Finally, the remaining standards in level three were compliance, recoverability, learnability, operability, and interoperability.

Future studies are recommended to engage DSRM in developing new artifacts of BMs involved in the DT process. Further studies should also include the application of the pandemic assessment model of CCPs in the evaluation of new technologies that are used in critical conditions.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The author contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The author has no conflicts of interest to declare.