Design structure matrix and its applications in innovation management

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Abstract: New product/process development entails technical and managerial complexities, such as coordination among interactions among entities and functions in the supply chain. DSM (Design structure matrix) tools have been successfully used to manage complex projects management tools to simplify the complexity and to offer a visual support to decision-making. Nevertheless, the project management community does not seem to have incorporated DSM, which is often perceived by project managers as being "too technical". To bridge this gap, we perform in this paper a systematic review, which analyzes the publications in the last 10 years about the use of DSM in project, innovation, and product management. The result of this analysis indicates DSM, and its derivations remain an ever-growing tool. Their applications in project management are promising but it is still required to increase the adoption of DSM into the mainstream methods of project management.

Keywords: Design structure matrix (DSM), Project management, Product management.

1 Introduction

Today, companies are confronting extremely complex systems when dealing with products/services and processes (Marques et al., 2021). This complexity compels them to identify solutions that support them to efficiently simulate, model, and visualize the processes, better understand interactions, and manage complex systems (de Paula Ferreira et al., 2020, 2021, 2022). In recent years, the Design Structure Matrix (DSM) has been used more often in innovation management. As a simple visual tool, it helps product managers to better understand the processes and interrelations among stakeholders. It improves decision-making and project planning by estimating time, cost, and resource allocations.

DSM and its derivatives as Multidomain Matrix (MDM) and Domain Mapping Matrix (DMM) have been evolved and used for a long time. However, the tool still offers potential for advancement to improve its application in innovation and product management. Literature provides several reviews on DSM and its uses in diverse industries. Nevertheless, since these studies remain either case-specific or investigate other contexts of use, they are out of the scope of this research.

Xiao and Chen (2010) performed 10 years ago a literature review on the application of DSM in innovation management. The objective of this paper is to update the state of the art in DSM and its application in innovation management, covering the 2011-2022 period. Since innovation management is also impacted by product management and project management (Browning, 2016), we are focused on the application of DSM in innovation management, product management and project management.

The remainder of this study is organized as follows. Section 2 provides a general overview of basic concepts in DSM. Section 3 describes the methodology that has been used to conduct the systematic literature review. Section 4 presents the results of the systematic literature review and section 5 draws some conclusions from the study.

2 DSM Background

2.1 Design Structure Matrix (DSM)

DSM is a network modelling tool that provides a concise, simple, and visual mapping representation of a complex system, depicting the relationships and dependencies among the components. It is used to decompose the systems, products, processes, or organizations into smaller pieces, which helps with managing the complexity (Steward, 1981; Eppinger and Browning, 2012).

DSM is represented by a square matrix, structured in such a way to illustrate the interrelationships among the components of a system, as illustrated in Figure 1. This flexible technique could be used to model a large variety of systems with different architectures. The main advantage of DSM is the graphical display format of the matrix which can represent the architecture of a system in a concise, scalable, intuitive, and readable way (Eppinger and Browning, 2012).

2.2 Various Types of DSM and Applications

There are four main types of DSM architecture models, product, organization, process, and multi-domain. Product and organization are static DSM architectures, meaning that the relationship between the components is not time-based. The

structure always remains the same and there are not many variations in the flow process. The temporal flow models represent processes and multi-domain architecture, as there is a progression in time as it moves from one element to the other. (Xiao and Chen, 2010; Eppinger and Browning, 2012).

Tasks	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
Task 1									
Task 2									
Task 3		X							
Task 4	X		X						
Task 5		X		X					
Task 6							X		
Task 7					X	X		X	
Task 8			X				X		
Task 9							X		

Figure 1. Sample task-based DSM (Shajahan et al., 2019, p. 2).

- Product: represents the components of a product and how it is decomposed into subsystems, components, and functions.
- Organization: represents the interactions among the groups/teams or people and the interactions among different departments.
- Process: represents the flow of the process from the beginning to end, decomposing into sub-processes, tasks, and parameters.
- Multi-Domain: represents multiple types of DSM in a matrix.

Table 1 provides some examples of the application of DSM in engineering and management (Browning, 2016).

Table 1. DSM applications.

DSM Architecture Type	Applications
Product	Portfolio segmentation, product design, design optimization, knowledge management, Resource allocation, etc.
Organization	Managing organizational relationships, clustering organizational structures, work allocation, social network analysis, team assignment optimization, misalignment identification, interorganizational and supplier integration, etc.
Process	Data collection facilitation, managing document flow, dependency analysis in combination with QFD, identification of reworks and defects, overlapping activities, process optimization, network analysis, clustering design.
Multi-Domain	Dependency analysis and architectural patterns in software development, tools and goals architectures in project management, scenario generation, risk analysis in project management, modelling practices in software development, portfolio management, etc.

Innovation management, product management and project management are all time-based activities and evolve over time. As the table reveals, the application of DSM in innovation management is more traceable in the process and multi-domain DSM model architectures which support a temporal flow.

3 Methodology

This study follows the PRISMA (preferred reporting items for systematic review and meta-analysis) methodology that provides guidelines to perform a systematic literature review (Moher et al., 2009). The search protocol used for this study is shown in Table 2. In the identification phase, we found 42 articles on the Web of Science and 50 articles in Compendex.

In the screening phase, after removing the duplicates, 66 articles remained to be further analyzed. Next, we started the eligibility phase by reviewing the title, abstract and keywords. Afterwards, we scanned the remaining articles and retained only papers whose focus is the application of DSM to solve management issues (either product, project, or innovation management). After applying this exclusion criterion, 50 articles were excluded, as they did not fit the scope of the research. Lastly, in the including phase, a total of 16 articles were included in the quantitative and qualitative synthesis.

Table 2. Search protocol.

Data source:	Web of science and Compendex
Search String:	("design structure matrix" or "dependency structure matrix" or "dependency source matrix" or "dependency structure method" or "dependency and structure model" or "dependency structure model") AND ("innovation management" or "project management" or "product management")
Search fields:	Title, Abstract, Keywords.
Period:	From 2011 to 01-04-2022
Language:	English
Document:	All types

4 Systematic review

4.1 Bibliometric analysis

Figure 4 shows the evolution of publications over the last ten years with an upward trend in the number of publications. A keywords frequency analysis was also conducted. The top 5 keywords in the studies and top 3 subject areas according to the Scopus database are presented in Table 3 and 4, respectively.

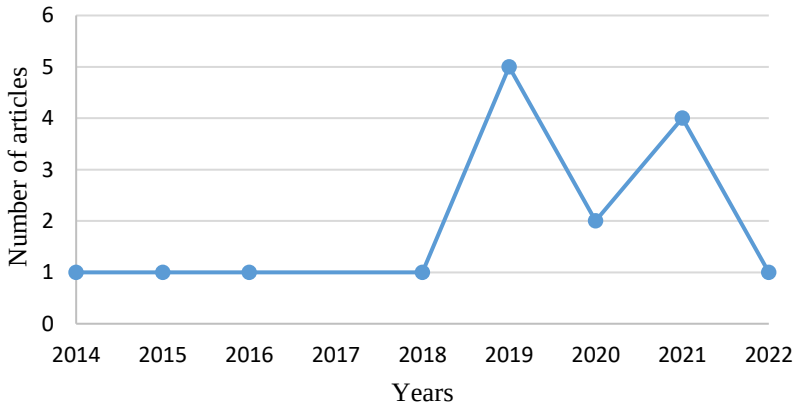

Figure 2. Evolution of publications over the years.

Table 3. Top five keywords.

Keyword	Count
Design structure matrix	15
Project management	12
Dependency structure matrix	9
Product development	9
Product design	6

Table 4. Top three subject areas-based.

Subject area	Count
Engineering	11
Business, Management and Accounting	4
Computer Science	3

Since 2019, the interest of DSM in management in general is increasing, more specifically in "project management" as shown in Table 3. Subject areas are diversifying, Table 4 demonstrates that DSM is not used in engineering projects only, but also in the business world. Table 5 presents a list of the 16 principal research articles based on the application of DSM tools in project management, including a brief description of the studies' main contributions. That supposes various adaptations of DSM in each area, focused on project management, which are presented in the next subsection.

Table 5. Papers using DSM tools in innovation management.

Reference	Method	Main Contribution
Browning (2016)	Literature Review (LR)	Present the evolution of DSM tools and the interactions based on product architecture, process architecture, organization, project management, engineering management, organization science, system engineering, etc. Present multiple extensions and application areas of DSM tools.
Shajahan et al. (2019)	Empirical Study (ES)	Propose the use of DSM tools to reduce complexity in product development and management.
Yang et al. (2014)	ES	Propose a quantitative model using the evolution DSM tools to measure the interaction strength between teams performing overlapped activities.
Chang et al. (2021)	ES	Propose a function product using DSM, MDM, DMM, and clustering method to reduce complexity in product development and management.
Bi et al. (2020)	ES	Propose a model for knowledge transfer using DSM tool.
Yang et al. (2021)	ES	Propose a model to optimize a project organizational network structure.
Mirnezami et al. (2020)	ES	Based on DSM tools, propose an approach to prognosticate project cash flow for project scheduling with overlapping activities.
Shajahan, Subramanyan et al. (2019)	ES	Propose a model using DSM tool and Particle Swarm Optimization (PSO) techniques to identify and manage information exchange and iterations in a project or process.
Yang et al. (2015)	ES	Propose a quantitative model using DSM and MDM to manage coordination complexity in a global development project.
Padala (2022)	ES	Propose a model method using DSM and Axiomatic Design (AD) to better understand and control changes in project management.
Xu et al., (2019)	ES	Propose a procedure to choose the optimal DSM clustering method based on the best perform for a given case.
Yang et al. (2019)	ES	Present an improved Product Development (PD) organizational clustering approach, based on the spectral clustering algorithm that synthesizes social network analysis (SNA) with a DSM model.
Wang et al. (2021)	ES	Propose a clustering method using DSM tools to manage projects from the perspective of risks.
Chama and Bertram (2018)	ES	Introduce a methodology using DSM tools to analyze functional architecture concepts for extremely large complex systems and projects.
Ma et al. (2021)	ES	Propose a method, integrating DSM tools and Critical Chain Project Management (CCPM) methods, as well as a max-plus method, to optimize rework scenarios in a project.
Ramachandran (2019)	LR	Evolution of DSM in project management.

4.2 Applications of DSM

The objective of this study is to identify the use of DSM tools and their evolution on project management. This literature review builds on the works done by Ramachandran (2019) and Browning (2016). Then, an analysis of how this is being used for companies and for exploratory analyses is necessary to reveal the power of this tool to manage a project. Following to the study made by Ramachandran (2019), we know the benefices that can be obtained to manage different types of projects and the uses that can develop with this matrix tool either in simple projects or in a complex project or process. The focus of the study is the interdependence between three different main aspects of product development project such as product, organization, and process (Ramachandran, 2019). The DSM, MDM and DMM frameworks are believed to be valuable in illustrating the relationship between these three aspects in a development project.

In that case, New Product development (NPD) can be defined as a set of activities starting with a demand opportunity in a certain market, followed by development and production, ending with the sale and delivery of a product. NPD is also known as a complex web of interactions and overlapping; as the overlapping is important, to be more efficient; project management is being challenged more and more, pushing managers to better coordinate the communication and interactions between the stakeholders, it needs to be monitoring closely and in the best way possible to not to fail in a project (Shajahan et al., 2019; Yang et al., 2014).

NPD is being suffering lots of challenges last years as the clients are expecting high-quality products deliver in a short time. The companies not only are being challenged by developing complex engineering products but also to better coordinate the interactions and communications between the different stakeholders. Seeing the limitation of traditional project management tools, companies started looking to add more tools to better manage the NPD process.

DSM is being used on NPD, helping to simulate the activities flow process and the interactions and communications between the teams and tasks. The conclusion of the study is positive, and the DSM tool can help to better manage and control the sequence of the process. Due to the visibility that the DSM tool can bring, the NPD process can be improved and better controlled. Also, the overlapping activities can be clustered, and this will help to optimize the structure of a project, reducing the complexity of management, the duration of a project, and for sure the cost. This provides a smart and efficient way to cluster teams in NPD.

To better optimize a process, project, or organization using the DSM tools, clustering is the most common methodology used. As shown in studies, this methodology is the most common and the better used to manage projects, as this can better deal with complex and changes on organizations' management, as this is a more stable methodology and provide more efficiency on managing. Chang et al., 2021 paper constructs a “function-product” domain mapping matrix (DMM), and then constructs a “product-function-team” extended multi-domain matrix (EMDM). This establishes a model for deriving the organizational dependency structure matrix (DSM). Finally, a two-stage entropy clustering model is used to optimize the organization, to reduce the complexity of organization management, enhance the orderliness of the organization, and improve the success rate of product development (Chang et al., 2021).

One main and important aspect that is rarely analyzed and taken into consideration when managing a project is learning and knowledge transfer. When this aspect is well managed, this can help when managing a multi-project, as this will improve the performance on a multi-project. A study (Bi et al., 2020) was done, using DSM tools to analyze the learning and the knowledge transfer in multi-project management, and a model was created, using the clustering methodology. This model can be improved by taking into consideration more aspects, but it gives a positive approach to knowledge transfer in multi-project management (Bi et al., 2020).

Using a clustering method, Yang et al. (2019) presented an innovative method to address two critical issues in PD organizational design: how to quantify structural and attribute similarities between PD teams from a social network perspective, and how to identify clusters based on these similarities. They have provided a framework that enables managers to optimize PD organizational architecture more effectively. They leveraged existing studies on overlapping activities to predict the strength of interaction between PD teams. To facilitate knowledge sharing, they create team attributes similarity based on product and process expertise. This paper was the first research to reframe the actual PD organizational architecture by incorporating similarities in structures and team attributes from an SNA perspective. It integrated the modularity index and the improved S index to find the optimal number of clusters, which they then use with the integrated similarity matrix as inputs to the spectral clustering algorithm to identify clusters.

As a continuation of Yang et al. (2019), Yang et al., (2021) made an interesting study analyzing the impact of building project teams based on a communication network with mutual trust and the positive impact that this can produce on the success of a project. It can also help project managers to better manage projects efficiently and effectively. Using DSM, DMM, and MDS matrix tools allows to illustrate the group structures. Whereas, using the clustering method allows to regroup and minimize the interactions across the groups. The paper investigates the following two questions:

(1) How to build a communication network with mutual trust among Product Development (PD) teams for clustering a PD organization?

(2) How to identify a PD organization’s ‘‘core teams’’ and estimate an appropriate number of clusters?

The paper illustrates how to infer the role-related technical communication dependency between teams using the dependency between components and the mapping relationship between the organization and product.

This clustering helps to reduce the complexity of management. The study showed positive feedback, as the clustering allows the creation of subgroups based on the communication patterns (trust), increasing the facility for managers to better manage complex projects; also, inspiring managers to classify and manage teams based on the trust transferability, reducing critical structure complexity and the interactions of outside the subgroups (Yang et al., 2021). In conclusion, they optimized the network structure through building the group around the core teams.

As well as organization management, fund management is a very important aspect to take into consideration for project managers. It is fundamental to be vigilant often with the cash flow and the cost-saving that can be done during the project. This will determine the success or the failure of the profit of the project.

Mirnezami et al. (2020) did a study, producing positive results for an early stage; it was done by analyzing a new approach developed to prognosticate a project cash flow based on both type-2 fuzzy extensions of DSM for project scheduling with overlapping activities. As a result, when clustering activities using the DSM tool, the structure was optimized, overlapping activities, reducing the project duration, and generating cash flows, giving the managers a clear understanding of uncertainties and project cash requirements. (Mirnezami et al., 2020).

Cash flow is still a very sensitive aspect to take into consideration in project management, the mentioned early study approach is encouraging and brought an initial development in this aspect. However, there are still more factors and resources to consider when modelling a project.

Due to the positive results, the DSM tool is contributing to the NPD process; industries and project managers are using more and more DSM and their evolution to simulate and manage the NPD process, expanding the studies to new approaches and projects.

As previously mentioned, today the industries are challenged more and more by the speed of the changes and growth in the market, it is very important to have the ability to react very fast to the demands and expectations of the clients. This factor pushes the companies to be more competitive on the market and work on a rapid pace to create product development efficient and profitable. At this stage, the role of project managers is determinant and valuable, as they must be creative and use different tools for fast-developing purposes. They must be assertive on the decisions made on a project or new development. A study (Shajahan, Subramanyan, et al., 2019) using the DSM tool to model the process; combined with Particle Swarm Optimisation (PSO) algorithm had shown a successful outcome on decisions made for a NPD process, development time, and cost. It significantly reduced using the mix of both tools. This helps project managers to obtain a better and optimized activity sequence and, consequently, companies to react faster to adjust the NPD process to markets needs. (Shajahan, Subramanyan, et al., 2019).

Yang et al. (2015) propose a study analyzing global product development (GPD) projects, using DSM & MDM tools to conclude that it is possible to reduce coordination complexity on a project with teams distributed across geographical boundaries. The interactions on the teams can be managed to the point of teams sharing strong coordination drivers (which motivate technical information transfer) and coordination barriers (which hinder the process of exchanging information between interacting teams) to be regrouped. This allows companies to put together teams with strong coordination drivers regarding the complexity of the project and the dependency between activities. Regarding the coordination of barriers between teams, they are required to be part of different groups to increase the efficiency of the GPD project. Communication and coordination between the GPD team during the overlapping working hours should be an excellent strategy for project managers to better coordinate barriers and reduce the risks and costs of a project (Yang et al., 2015).

Another main aspect of project management that DSM has proven to add value is in change management. Padala (2022) presents an application case within the construction domain, which is a sector that faces constant changes. These are due to factors such as lack of knowledge, delays in information, interdependencies, involvement of many different stakeholders, among others. To be efficient in such an environment, it is necessary to manage in every stage of the project the communication between every team member, as the point of view can be different and decisions can be made without seeing the next steps of the project, which can be very bad for the project and can cost money. To tackle this complexity, Padala (2022) proposes the use of the DSM tool combined with other matrix model tools like axiomatic design (AD) for identifying changes in the early stages of a project, so to minimize their negative impacts. Padala's (2022) study models the relationship of design parameters for accurate identification of changes, which allow them to be tracked and scheduled to so reduce errors during the implementation of a project.

Yet another area of project management that can benefit from the application of DSM is that concerning visualization of project status (e.g., dashboards). The literature indicates that the combination of existing visualization techniques with matrix model tools can help managers to better understand the relationship between stakeholders and, consequently, better manage the complete project. Graphical methods used to be the most useful techniques for traditional project management (such as CPM, PERT, and CCPM), as those tools can help to understand the structure and complexity of a project, with the complexity of projects faced last years. (Xu et al., 2019; Ma et al., 2021). Companies are being forced to innovate and incorporate other techniques, as those techniques are being a bit difficult to apply for project managers. However, the tools do not help in the identification of unnecessary rework, as they are limited to represent the interactions between the participants in a complex project. The DSM tool helps project managers to not only fully understand the organization of complex projects but also conveniently cluster the activities.

Studies show positive feedback of the combination of DSM and clustering methods (e.g. Loop searching method – LSM, based on graph theory, and the function searching method – FSM), for project management. Xu et al. (2019) propose a method to perform such a combination, so to reduce costs and reduce reworks. This combination can help managers to make smart and better decisions and to manage projects, people, and tasks better. One important recommendation of this

study is to add some preventive activities between different stages of a project, which could prevent future problems and reworks, and which could also help to reduce the complexity of a certain task or activity. (Xu et al., 2019).

A fundamental topic to consider in project management are the risks associated with a project, either risk events or risk factors. One study (Wang et al., 2021) showed analysis using DSM and quality function development (QFD) method to build a matrix with dependencies and relationships between projects and risks. QFD can deduce the strength of dependence between risk events and construct a corresponding DSM matrix of risk events. Finally, the project DSM is optimized and analyzed by the clustering method, and the dependence intensity between the projects is calculated. It clusters them according to the dependencies between the projects. The project set with high-risk correlation is obtained. In the conclusion of this research, managers can group projects with high-risk correlations together to facilitate management. The analysis of risks is an important and relevant topic to be monitored very close to better take decisions and to better manage the high risks associated with the completion of a project (Wang et al., 2021).

Large or complex projects are very hard to manage and to estimate. The analysis of the risks related to a larger project is a game changer to the development of the project. The study by Chama and Bertram (2018) evaluated using the DSM tools, showed the failure of a project in an early stage, identifying on the first stages of the project the failure of important tasks or processes. This helps to conclude that the use of the tool can identify the possible failure and with this information, the errors can be changed or corrected after the project continues to advance stages. The identification of these problems allows to avoid reworks or cost losses (Chama and Bertram, 2018).

Reworks can be a major problem for a project, as this affects the performance of the project, and increase costs, which means, projects are less profitable and delayed. Regular project management tools do not support the analysis of these factors. An empirical study was made by Ma et al. (2021), integrating the DSM tool into the CCPM-max-plus linear (CCPMMPL, critical chain project management method) framework, giving, as a result, positive feedback with a place for improvement to develop a better tool. The model uses a start-to-start relationship of activities instead of the traditional finish-to-start relationship, which also allows overlaps between activities. The mentioned tool can help project managers to absorb rework risks and uncertainties, which will help to better estimate the duration of certain tasks and allow them to have more time to deal with the rework risks during the duration of the project (Ma et al., 2021).

In conclusion, complex projects are a field that is still in exploration to use DSM tools, as the studies found are increasing the use of mentioned matrix-based tools. Obviously, it is, however, required a deeper analysis of the interdependencies between product, process, and organizations with complex projects in the future (Ramachandran, 2019).

4.3 Analysis from literature review

Analyzing the information presented above, when developing a new project or product, the existing management tools represent a promising start for project management with positive impacts after their applications in projects. However, the tools are limited and not powerful enough to cover all the aspects to consider when structuring or modelling a project or process. As Browning (2016) and Ramachandran (2019) already explained, DSM tool provides a new input into the world of project management, and it is employed more by managers to better analyze, visualize, and design projects or processes. As this is bringing constructive feedback and results when managing and mapping projects, this tool is helping to reduce complexity. But there are still lots of applications that can be made in the project management field.

Thanks to our literature review, we can confirm in 2022 that DSM tool is being well used in many different industries and focuses the analysis on different aspects such as risks, costs, cycle times, knowledge transfer, localization, people, task management, interdependencies, interactions, etc. But one of the main common problems shown in the studies analyzed, is the use of DSM tool when managing bigger data projects, as DSM and the known software and algorithms used are not supported enough to handle big data projects. In this case, we know that collecting new data in a project constitutes a complex part and it is difficult to control, manage or sort data in every project we do. The analyzed studies were mostly empirical, there is not much documentation regarding real projects developed using the DSM tools. The data used in the studies are simple, showing positive results, but with the constrain of future investigations and research more extensive for larger projects and data.

So, as Chang et al. (2021) and Wang et al. (2021) recommend, further analysis and developments on algorithms and software to model DSM processes, tasks, projects are required to better analyze larger data projects and to help managers to use DSM tool as a supportive mechanism of management. As Browning indicated in 2016, special emphasis should be put on the knowledge management applications and developments in such cases. Through the selected papers, researchers as Shajahan, Subramanyan et al. (2019), Yang et al. (2014) or Bi et al. (2020) have proposed functional applications in this domain and conclude that DSM and its derivatives can tackle project management issues better than traditional tools. Therefore, these tools must be further used and developed in order to make them more efficient.

As Browning (2016) recommended, the DSM derivative tools (DMM, MDM, AD) are being used in project management like Chang et al. (2021) and Padala (2022) showed. However, it is important to notice that they are in a growing stage. In fact, thanks to these tools, we can go further in project management. But there are still aspects to consider and analyze to conclude that these tools are efficient and effective when managing larger and more complex projects. The complexity of today's projects makes it difficult to design the complete project. It is not easy to include all the stakeholders, tasks, resources, interactions between the elements. The aspect of knowledge, interactions, and risks became very sensitive and difficult to manage. To reduce this complexity and optimize DSM applications, researchers as Chang et al. (2021), Shajahan et al. (2019), Bi et al. (2020), Xu et al. (2019), Wang et al. (2021) and Ramachandran (2019) propose DSM clustering methods which have been validated and currently are recommended to make the clustering effect more stable to deal with complex and changeable organization management or architecture, for instance, the two-stage clustering method (Bi et al., 2020). The clustering method is mostly used when using the DSM tools; this is the most common technique used for managers to divide complex projects into several groups or activities and reduce time cycles, increase revenue, and optimize management complexity in projects, as Wang et al. (2021) mentioned, and Browning (2016) expected. Besides, this methodology allows a network analysis to increase its structure as Yang et al. (2021) demonstrated and Ramachandran supposed in 2019.

According to Shajahan et al. (2019), the complexity is strengthened by managing and scheduling the complex product development projects, with interdependencies between the tasks of complex design projects (Ramachandran, 2019). According to Mirnezami et al. (2020), DSM project schedules delivered satisfactory results in managing overlapping activities, reducing the project duration, and generating cash flow. This article demonstrates the effectiveness of DSM methodologies to assist the project scheduling framework.

Finally, most of the analyzed papers presented satisfactory results on visualizing each interaction in complex development projects and helped to define the interdependence between product, process, and organization (Ramachandran, 2019). Based on Browning and Ramachandran works, our results seem to be encouraging. In fact, all these articles offer functional DSM tools integrating process, product, and organization architectures which provide “an overall view of the interdependencies in a complex development project” as Ramachandran (2019) concluded.

DSM had shown that it's a tool with big potential to manage projects, this tool has shown beneficial results, reductions in complexity management, times, costs, overlapping, risk, knowledge transfer, quality, performance, etc. Further analyses will increase the use of this tool in project management. There is a lot of development that can be made, to better explore DSM tool, different types of interactions, algorithms, software, and, as mentioned, supportive tools to manage complex projects.

5 Conclusion

The speed with which the implementation of projects has been increasing in a short time and with the pressure of being efficient and profitable that is pushing industries to better improve the management of the projects, by monitoring the quality of the processes, the cost, and the development time. Industries are being forced to research and introduce new techniques and tools to meet mentioned requirements. DSM tools and their evolution techniques have been applied last years in many industries with positive success. The cases mentioned in this research had proven the efficiency of the tool and proved that the combination of DSM & MDM with other tools or methods is showing successful results in project management. These methods help managers to visualize projects clearly, to better understand the interaction between the stakeholders, processes, and activities. Also, it showed benefices in cost savings, time-saving, and faster development, accomplishing the market requirements and expectations, considering risks associated with a project.

For the future research, further work is still needed to increase the understanding and adoption of DSM into the mainstream methods of project management especially. DSM has already achieved multiple goals in the areas of engineering design, systems engineering and management/organizational science as Browning demonstrated. However, it seems like broader awareness and understanding would also be beneficial in these sectors. In fact, one of the most important barriers to DSM research and implementation is the complexity of tools and projects. Nevertheless, since Browning’s study in 2016, compared to some other models in operations and technology management, DSM representations have positively received more comprehensive authentication and determination based on an extensive range of applications in various industries, innovative products, projects, organizations, situations, and specific contexts through these last years. Our literature review demonstrates the potential of DSM tools expressed by Browning and Ramachandran, especially between 2014 and 2022. All these examples will enable innovation managers to use derivative DSM tools for project management in a straightforward way.

DSM and its derivatives remain an ever-growing tool which is validated by several researchers. They should be explored and combined with many other tools or processes to assist in the project management field. In particular, the DSM tool can continue to help to analyze projects in many other ways and become more effective. Clustering methodology should be further explored to provide more benefits and be more efficient with less management effort. In that way, an

optimization of the clustering algorithm could be realized to facilitate monitoring and management when there are many items. This paper shows that the use of clustering method can better cope with complex and variable organization management and provides a more direct method to reduce organizational management. Future research may identify the characteristics of clusters and contribute to an understanding of the self-managing mechanisms of organizational networks.

Finally, these studies have shown positive feedback in a developmental stage. This review is not extensive, and some studies may have been left out of the analysis. A more exhaustive review of the literature can be addressed in future studies. Definitively, further studies are required to use DSM and development tools in project management, especially on those following points: improving algorithms (for clustering, for processing, for modelling), system architectures (for simplifying the use of tools) and data sets (to collect more data and use big data). This should be explored deeply to bring better and more effective benefits to innovation managers.

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