Design Strategies for University Educational Supply Chain

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Abstract. The University Educational Institutions are currently perceiving an increase in the demand for their services, which forces them to seek strategies that allow them to have well identified the activities to be carried out at each stage of their processes. This study seeks to identify the strategies, methods, and tools that allow the design of the University Educational Supply Chain, based on a systemic review of the literature. Following as a working method the classification of documents by topic of interest, then the characteristics of the university educational supply chain are analyzed, supply chain design tools applied in different environments are analyzed and the most suitable methods are selected based on established criteria. Feasible to apply in the university educational environment. It is obtained as a result of this work that the Supply Chain Operations Reference Model, the Value Stream Mapping, and Simulation, are supply chain design strategies that are adjusted to the university educational environment and that serve as, help to redesign processes, measure the performance and effectiveness of the services and products offered to students, the labor market and society in general

Keywords: University Educational Institutions · Supply chain · University educational supply chain · Supply chain design

1 Introduction

The study of the supply chain currently represents of interest to managers, leaders, and stakeholders of University Educational Institutions [1,2] who seek to meet the expectations of the labor market and students entering these institutions.

Universities represent the basis for the development of society [3], but they are currently facing phenomena such as the massive increase in the demand for their services, lack of communication between the university education sector and the labor market [4,5] and the scarce funding available to universities to develop their curricula [5,6].

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This situation demands an improvement in the administrative processes and operations of the university education sector [5,7], which leads these institutions to incorporate supply chain approaches in their work strategies [8,9].

This work aims to analyze supply chain strategies, methods, and tools that can be integrated to the university education sector and that contribute to meet the increase in demand for university services, strengthen the communication flow between the labor market and university education institutions and serve as sustainability alternatives for the University Education Supply Chain. The structure of this document is as follows: first, a summary of the articles and journals analyzed is made, according to keywords used in the search system, then the supply chain for university educational institutions is defined, the existing strategies and methodologies for the design of the supply chain are analyzed and finally, the best methods are selected to increase the efficiency and effectiveness in the university educational processes.

2 Literature Review

Understanding the background of studies related to the Supply Chain is an important step that allows you to have a vision of the evolution of these concepts over time. Researchers such as [8] show a timeline, which allows us to visualize how supply chain management has transcended and how its applicability has been both in the manufacturing, service, and education areas. The evolution of the concepts can be seen in Fig. 1.

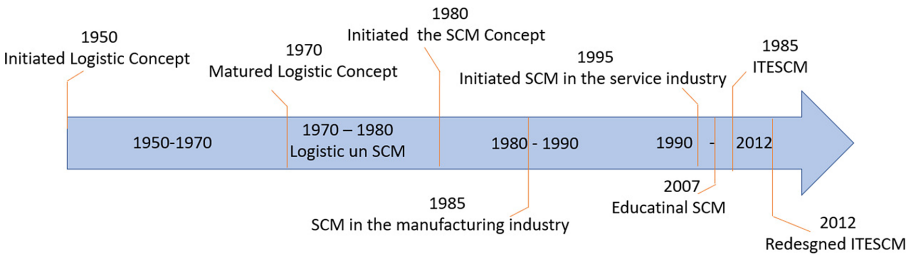

Fig. 1. Evolutionary line of supply chain management. Source: own elaboration with information from [8].

During the1940s and 1950s, logistics was related to the need of the military to acquire, maintain, and transport all its materials and personnel from one facility to another [8]. Then, in the 1960s and 1970s, studies related to physical distribution and logistics began, incorporating in the 1980s the concept of Supply Chain Management due to the need that manufacturing companies saw to incorporate new organizational functions [10,11]. [8] emphasize that the supply chain is characterized by being seen as a unique entity, where strategic decision making at the top level is necessary to manage the chain in its original formulation.

One of the first authors that proposes to apply supply chain tools in University Educational Institutions is [12], who seeks to join theory with practice and proposes a contingency model, which is achieved by applying a questionnaire to employers and students and which allows establishing improvement strategies for the integration between companies, suppliers and clients of University Educational Institutions.

On the other hand, [13] create a model of supply chain management based on strategies that are implemented in the service and manufacturing industry where the structure of the university educational supply chain is defined.

[11] proposes the first largescale empirical study where he defines that the educational supply chain, the research supply chain and educational management are the necessary elements to apply an Integrated University Educational Supply Chain Management Model.

3 Methodology

The methodology proposed in this study consists of a systemic review of the literature that allows to establish criteria for the selection of one or more supply chain design tools that can be adapted to the characteristics of the university educational supply chain and that also allow establish the configuration of the supply chain processes, determine the level of integration between the processes and that contributes to establishing continuous improvement strategies that allow them to be efficient and able to compete in the increasingly global market.

The methodology for selecting the tools consists of three stages which are shown in Fig. 2 and explained below.

Stage I: This stage begins with a planned review of the documents required for the development of this study, which allows for the selection of studies related to the university educational supply chain and supply chain design strategies.

Stage II: Once the different supply chain design strategies have been identified and the peculiarities of the university educational supply chain have been analyzed, selection criteria are established to identify which of the strategies is best adapted to the type of chain to be designed. At this stage, the different scenarios in which the selected design strategies were implemented, the peculiarity of each supply chain studied, as well as the objectives pursued in each study are considered in order to identify those factors that were most repeated and thus determine a common criterion that allows the selection of one or more tools that best fit the case study.

Stage III: In this stage, an analysis of the results obtained from the previous stage is made, where the selected tool is described, based on the coincidence that exists between the criteria selected in the previous stage, thus establishing a frame of reference from the analysis of case studies that allows the understanding of the applicability of the selected tool in the studied environment.

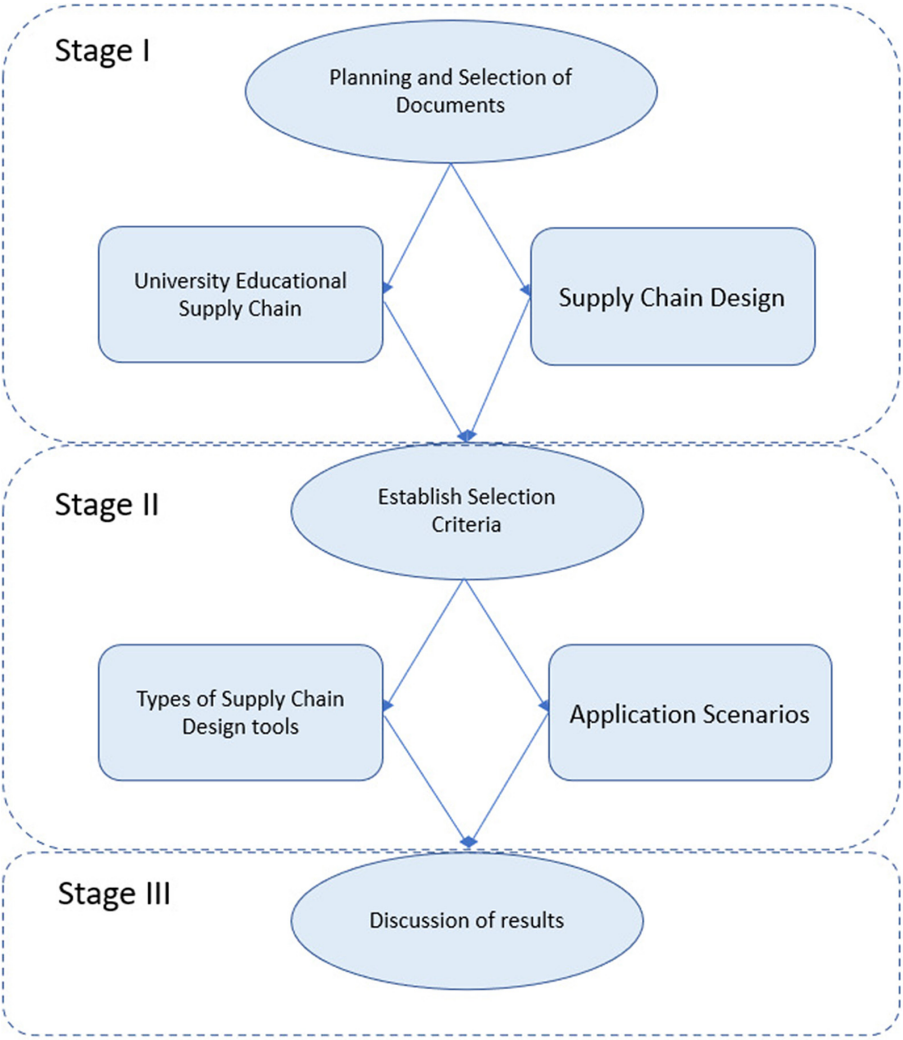

Fig. 2. Methodology for the selection of supply chain design tool criteria. Source: own elaboration.

3.1 Stage I: Planning and Document Review

For the selection of the documents, the following databases were used: Scopus, EBSCO, Web of Science, Elseiver, MIAR, Research Gate, Scielo and Google Scholar. The categories for the search and selection of the documents established were: University Educational Institutions, Supply Chain, Supply Chain in University Educational Institutions, Supply Chain Design and Supply Chain Design Methods and Tools.

A total of 132 articles were selected of which 59 were related to University Educational Institutions, 26 analyzed the general supply chain, 132 analyzed the University Educational Supply Chain, 14 were oriented to the design of the supply chain and 20 of them provided the tools that help in the design of the supply chain. The publication date of these studies is between 2010 and 2018.

The main magazines consulted were Industrial Management and Data Systems; Iberoamerican Business Journal; European Journal of Business and Management; Computers and Industrial Engineering; Competitiveness Review. An International Business Journal; Science, Academic Research and Development; Advances in Decision Sciences; International Journal of Production Research; Industrial Engineering; Management, Technology and Social; Revista Iberoamericana para la Educación; Journal Manufacturing Technology Management; Journal Of Computational Science; International Conference on Industrial Engineering and Operations Management Dhaka; International Journal of Supply Chain Management; Supply Chain Management: An International Journal; Engineering and Development; International Conference on Smart Technologies for Mechanical Engineering; Engineering and Technology; International Journal of Manufacturing Engineering.

From this analysis, it stands out that most of the studies are directed to the analysis of the management and design of the manufacturing supply chain [9,11], only a few analyze this problem in the service industry, where the work of [2,5,8,14] related to the design and management of the supply chain in University Educational Institutions.

Supply Chain in University Educational Institutions. Ensuring development in an increasingly competitive national and international environment implies, for the UIS, considering quality in the teaching and learning processes [3]. For this purpose, the UIS need to adopt supply chain concepts in their own institutions, which contribute to the improvement of productive and service processes, satisfying with quality the expectations of the demanders [2].

The concept of the educational supply chain is a topic that is of interest to many authors [15], since like other supply chains they require the coordination of all their nodes to achieve an aligned flow of information, production and distribution [2].

The University Education Supply Chain is the integrated set of the education supply chain and the research supply chain [8], as shown in Fig. 3. This holistic view of the University Education Supply Chain concept given by [8], shows in a simplified way the twoway sense in which information and service flows, at a single level of supply chain management for universities.

[2], consider that the Educational Supply Chain is characterized by two types of services, one dedicated to teaching, which establishes the direct and indirect services to process inputs; and secondly we have the research services or research projects, considered more expensive and prolonged, requiring a personalized, proactive and reactive supply chain to satisfy the demanders.

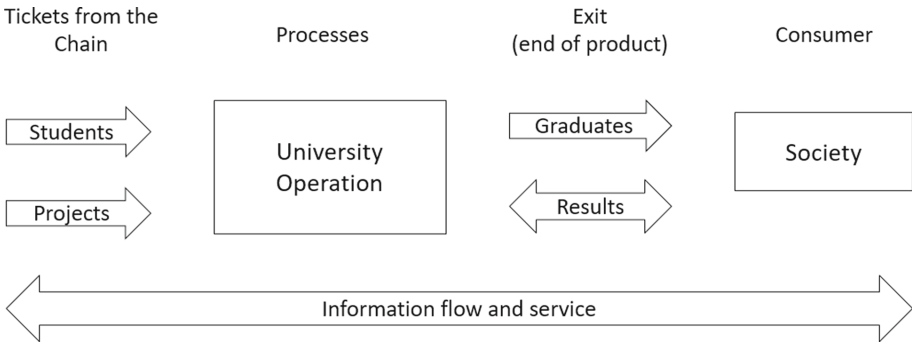

Fig. 3. Holistic view of a University Education Supply Chain. Source: Own elaboration with information of [8].

[16], highlights that the University Education Supply Chain involves schools, colleges of higher education, current students, university staff and employers, who in collaboration with the University Institutions, multilevel and service providers who allow the development of curricula that satisfy the final consumer. Figure 4 shows the twoway flow of the University Education Supply Chain that is achieved through integration between providers, University Institutions and customers.

[2,15] classify the suppliers of the supply chain, according to their entries, considering among them suppliers of teaching services, who become colleges or high schools, universities, faculties within the same university educational institutions, students, family members, organizations that provide scholarships and financial support, suppliers of assets, equipment, and of educational materials such as stationery, technologies, among others [2,15].

[1,11], also establish that project and research providers within the supply chain are selffinanced by the university's own educational institutions and external project providers who provide financial support to universities and research centers.

[9] point out that one of the main objectives of an educational supply chain is to improve the welfare of the final customer, who according to [11] become the students themselves who provide their bodies, minds, belongings, as raw materials needed to obtain graduates and quality research results [11]. On the other hand, [16] considers the labor market, as a client of the University Education Supply Chain, who expect as a result graduates to have the knowledge and skills necessary to perform the work for which they were employed.

To be able to meet market needs and meet customer expectations, University Educational Institutions must have a certain degree of knowledge about the parameters in their supply chains, including suppliers, customers and consumers [9].

The University Educational Institutions must seek the improvement and integration of their processes and services that meet the quality requirements and satisfy the expectations of the demanders, implementing design strategies that

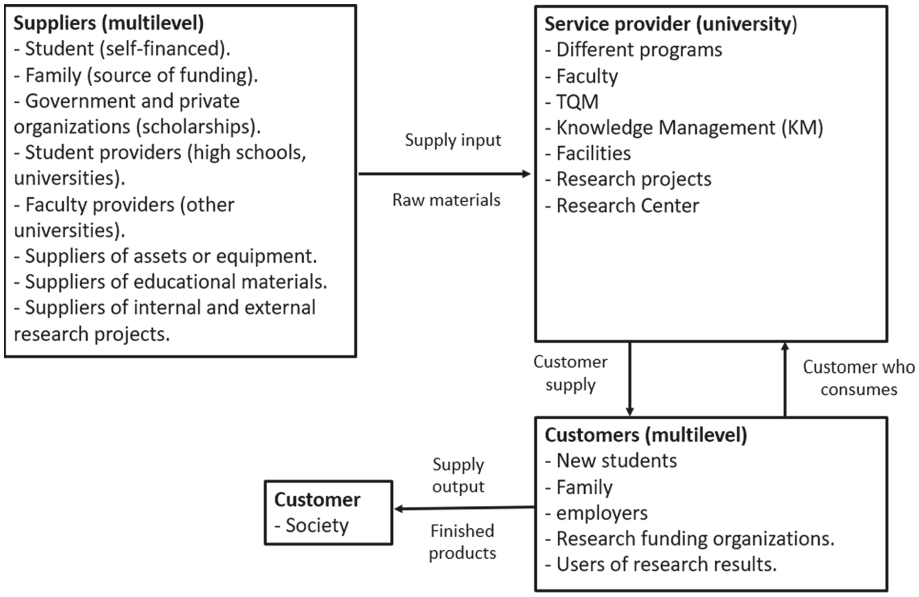

Fig. 4. Integration of information and service flows at each level of the University Education Supply Chain. Source: Own elaboration with information of [16].

allow the university educational institutions to have a much more dynamic and competitive supply chain [2,17].

Through an empirical study conducted at 10 universities in Malaysia, [18] found that CS practices have a high impact on university performance, especially information sharing practices.

Supply Chain Design. Supply chain design is defined as the process of developing, implementing and managing resources, processes and information, which seeks to make the strategic objectives of any institution, company or enterprise achievable over time .

The supply chain design process has been oriented to solve problems related to the location of the facilities, the installed capacity, the current market situation, and the selection of suppliers, among others [20].

The complexity that is perceived in the process of supply chain design is given by the hesitation in selecting the best improvement strategies, the attention of management and the accuracy of cost estimation [20].

[19] suggest that design strategies employed in one supply chain do not generate the same result when applied in another in a different environment. Thus, in the face of the diversity of environments, multiple responses have occurred that contribute to supply chain design techniques and tools [21].

During the development of this work, a total of 14 articles are analyzed that are closely related to supply chain design in different environments. The analysis of these works consisted in identifying the objectives pursued by each study and the supply chain design tools used in each case. Table 1 presents the following analysis.

3.2 Stage II: Establish Selection Criteria

The correct design of the university educational supply chain depends to a great extent on the type of design strategy that is selected for its modeling, so it is necessary to have well established criteria that allow the decision to be made [22].

In the analyzed literature, criteria that different authors have considered for the application of SC design tools can be detected, which are shown in Table 2.

Taking into consideration the criteria that measure the application of CS design tools set out above and considering the need presented by the UESC, the following selection variables are established (Table 3), which allow determining a chain chain design strategy supply for the UEI.

The selected tool is an alternative with flexible characteristics and adaptable to the educational environment, which allows the design of UESC processes, and makes it possible to measure the performance and financial sustainability of the chain, as well as to establish continuous improvement strategies in the whole chain.

3.3 Stage III: Discussion of Results

During the development of this research, CS design methods and tools are identified that can be applied in the EUI due to their flexibility and applicability in different sectors, and that help to redesign the processes in the chain to meet the growing demand for services educational institutions, as well as establishing indicators to measure the performance and quality of the services offered to students, the labor market and society in general.

Among the supply chain design methods that best fit the evaluation criteria established above are the SCOR model, the Value Chain Mapping, and the use of integrated simulation of these two models. Each of these supply chain design tools is described below.

SCOR Model. The Supply Chain Operations Reference Model, or SCOR model, was developed in 1996 by the Supply Chain Council (SCC) to create a standard that enables companies to improve their supply chain operations [23,24].

SCOR can be used to describe anything from simple to complex supply chains, using a common language to describe processes, process performance indicators, improvement practices and technologies [21,25] (Wang, Chan, and Pauleen, 2010; Rashid, and Weston, 2012). Good supply chain management executed under SCOR enables the parties involved to manage, improve their methods and communicate more efficiently and effectively, achieving excellence in the

Table 1. Summary of Supply Chain Design studies and methods. Source: Own Elaboration

Authors	Research objective	Instrument
Rashid Weston (2012)	Create and implement an integrated methodology for the design of complex supply chains	Business model Causal Loop Diagram Simulation
Carvalho et al. (2012)	Improve the resilience of interrupted supply chains by studying alternative scenarios	Simulation
Pardillo-Baez & Gómez-Acosta (2013)	Provide a node design model that contributes to integrated management among the chain's node actors, guaranteeing the required levels of efficiency and effectiveness	Simulation VSM SCOR Model
Prasad, Subbaiah, Rao (2014)	Achieve an integration between competitive and supply chain strategies, based on a supply chain design methodology	Quality function deployment (QFD)
López Manzano et al. (2014)	Improve communication processes and channels in a telecommunications company, based on a redesign of its internal supply chain	Ciclo Deming Modelo DAFO SCOR
Orjuela Castro (2018)	Assess the impact of the type of design of the perishable food supply chain on the balance of logistics flows	Optimization Simulation
Fajardo (2018)	Reduce the delivery time of a company dedicated to the transformation of coated steel sheets in order to meet the delivery deadlines agreed with the client	DMAIC methodology
Carvalho et al. (2010)	Meet the requirements established between the auto parts industry and the automaker, based on a supply chain redesign case study	Data collection and analysis
Hilletofth (2012)	Develop a framework for supply chain design to demonstrate the key benefits and requirements of a differentiated supply chain	Market information gathering
Melnyk et al. (2014)	Understand the three key levels to consider in supply chain design	Case study analysis
Authors	Objectives of the study	Instruments
Masoumik et al. (2014)	Develop a conceptual framework that can shape the components of a sustainable supply chain	Data review and analysis
Pashaei 6 Olhager (2015)	Identify gaps and opportunities for improvement, based on a review of the literature, on the relationship between product architecture and supply chain design	Bibliographic review and analysis
Ivanov et al. (2015)	Analyze recent research on supply chain design with disruption considerations in terms of domino effects	Analyze the literature
Asmussen et al. (2018)	Determine the factors that affect the supply chain design decision making process	Case study analysis

Table 2. Selection criteria of supply chain design instruments. Source: Own Elaboration

Instruments	Selection criteria	Authors
Business model	–It is mainly applicable to complex supply chains –Allows the modeling of the supply chain structure	Rashid, Weston (2012)
Causal loop diagram	–It allows visualizing the behavior of the indicators in the supply chain	Rashid Weston (2012)
Simulation	–Allows you to visualize the behavior of different scenarios in the supply chain –Allows the design of the supply chain network –Contributes to decision-making on improvement strategies –It is flexible and can be applied to all kinds of supply chains	Rashid Weston (2012) Carvalho et al. (2012) Pardillo-Baez & Gómez-Acosta (2013) Orjuela Castro (2018)
Value stream mapping	–Allows the redesign of processes in the supply chain –Allows determining limiting operations –Allows establishing improvement strategies –Flexible and adaptable to any type of supply chain	Pardillo-Baez & Gómez-Acosta (2013)
SCOR model	–Process reengineering –Benchmarking –Measurement of processes –Adaptable to any type of supply chain	Pardillo-Baez & Gómez-Acosta (2013) López Manzano et al. (2014)
Quality function deployment (QFD)	–Allows determining competitive strategies in the supply chain –Allows you to define performance within the supply chain	Prasad Subbaiah, Rao (2014)
Deming cycle	–Allows the establishment of continuous improvement strategies based on the analysis of indicators in the supply chain	López Manzano et al. (2014)
Deming cycle	–Allows the establishment of continuous improvement strategies based on the analysis of indicators in the supply chain	López Manzano et al. (2014)
DAFO analysis	–Analyzes the internal and external environment of the supply chain –Allows the establishment improvement strategies in the supply chain –It is flexible and can be applied to all types supply chains	López Manzano et al. (2014)
Optimization	–Optimizes the development and selection of product, process, services in the supply chain –Allows the alignment of strategy within the supply chain It is flexible and can be applied to all types of supply chains	Orjuela Castro (2018)
DMAIC methodology	–Allows the definition of indicators in the processes of the supply chain –Analyzes and establishes improvement strategy	Fajardo (2018)

Table 3. Selection criteria of supply chain design Instruments. Source: Own elaboration.

	Evaluation criteria				
Instruments	Flexible	Process design	Measurable	Improvement strategy	Number of criteria met
Business model		X			1
Causal loop diagram		X			1
Simulation	X	X		X	3
Value stream mapping	X	X	X	X	4
SCOR model	X	X	X		3
Quality Function Deployment (QFD)			X	X	2
Deming Cycle				X	1
DAFO	X			X	2
Optimization	X	X			2
DMAIC methodology		X		X	2

organizational structure of the value chain and achieving customer satisfaction [24,26,27]. SCOR has several valuable contributions, including its contribution of standardized metrics for measuring supply chain performance [28].

The five main management processes (Fig. 5), by which the SCOR model is governed, are Planning (Plan), Procurement (Source), Manufacturing (Make), Distribution (Deliver) and Return [24].

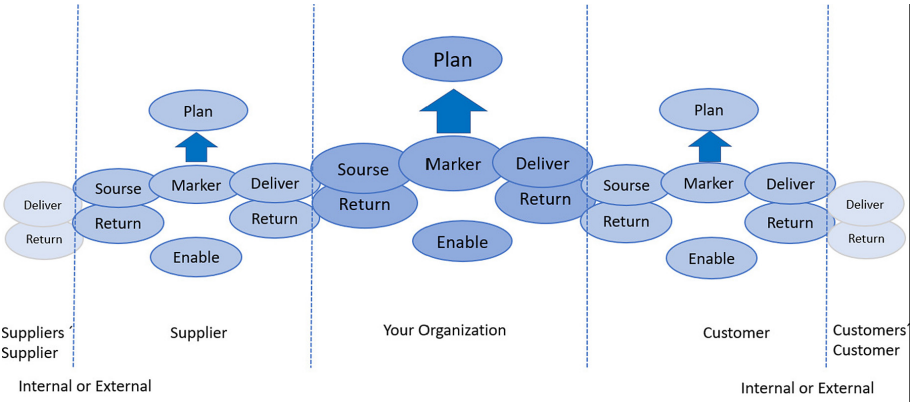

Fig. 5. Structure of the SCOR model. Source: Own elaboration with information of [24].

SCOR includes three levels of detail (Fig. 6), where a) Higher Level. Process Types b) Configuration Level. Categories of Processes and c) Level of Process Elements. Decomposition of the Processes, to these three levels is added a level of implementation which is out of the scope of the scheme, but what is necessary to implement since it allows to define the practices to reach the competitive advantages and thus to adapt to the business conditions [26]. At each of these levels, the supply chain performance indicators are determined, which are divided into five performance attributes: Reliability, Flexibility, Responsiveness, Cost and Assets.

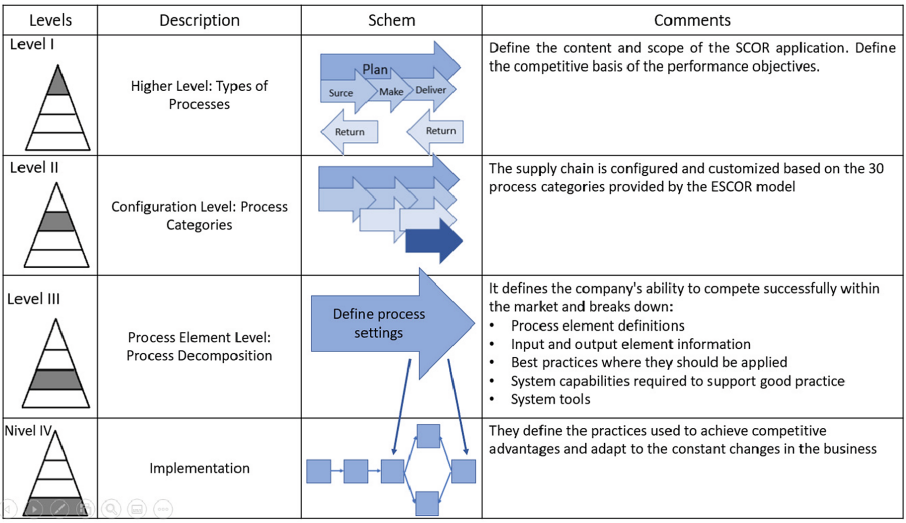

Fig. 6. Levels of the SCOR model. Source: Own elaboration with information of [26].

[26] establish that the application of the SCOR model is beneficial for the companies because it allows a considerable improvement in the processes of the supply chain, it also allows to continue using the technological tools that the company has, being a standard model, with standardized processes, standardized metrics and standardized best practices it is flexible and easy to configure to the particularities that each business, company or institution presents, allowing to integrate their processes, to establish performance indicators and thus to compare their performance with other companies of similar nature.

Some of the limitations of the SCOR model are that it does not attempt to describe each Business Process or Activity, and the model does not contemplate what is related to demand generation processes, product development or research and development. And as for the activities of Human Resources, Training, Systems, Administration and Quality Assurance, SCOR does not contemplate them anymore if they should be considered when applying this model [25].

Value Stream Mapping. Value Stream Mapping (VSM) is a Lean Manufacturing management tool, which allows the visualization of all the processes carried out within an organization, showing the current state of the company, identifying its points of improvement and serving as a contribution for comparison during the implementation of any of the lean manufacturing tools [5]. It supports the redesign of processes, seeking to develop efficient and flexible competitive supply chains [29].

This type of method considers three fundamental pillars: continuous improvement (Kaizen), total quality control and just in time (Just in time), with the objective of making the company, institution or enterprise profitable, competitive and efficient [30].

The VSM model works in manufacturing companies, service companies [31] and even in University Educational Institutions [5], allowing to visualize multiple processes, including the flow of material and information within the institution, as well as the level of integration that exists in them, identifying the source of waste that limits the institutions.

[32] points out that the use of VSM could help improve visibility and develop a risk management system.

[5] proposes to apply this model in university educational institutions, based on the 4 stages of the VSM and a series of steps established in each of them, which are shown in Fig. 7.

The application of this method allows for a visual representation that determines where the limiting operations are located, using symbols, metrics and arrows, which make it possible to show and improve the flow of inventory and information required to produce a product or service that is delivered to a consumer.

On the other hand, [5], highlights that some advantages of applying VSM are

- They help to visualize the global process allowing an integral vision that things really work allowing to see events from the client's point of view,
- They allow to see the losses of a process,
- They allow to link the connections between the material and the information flow and,
- They help the alignment of the organization; that is, giving a starting point for the implementation of an improvement while involving people.
- Manifests a link between the flow of information and material.
- Facilitates a common language for the interpretation of manufacturing processes.

On the other hand, [5] highlights some challenges that institutions present when implementing VSM, among them

- Problems when monitoring processes.
- Ignorance of the model by the staff within the institution.
- Little integration between the processes of the entire supply chain.

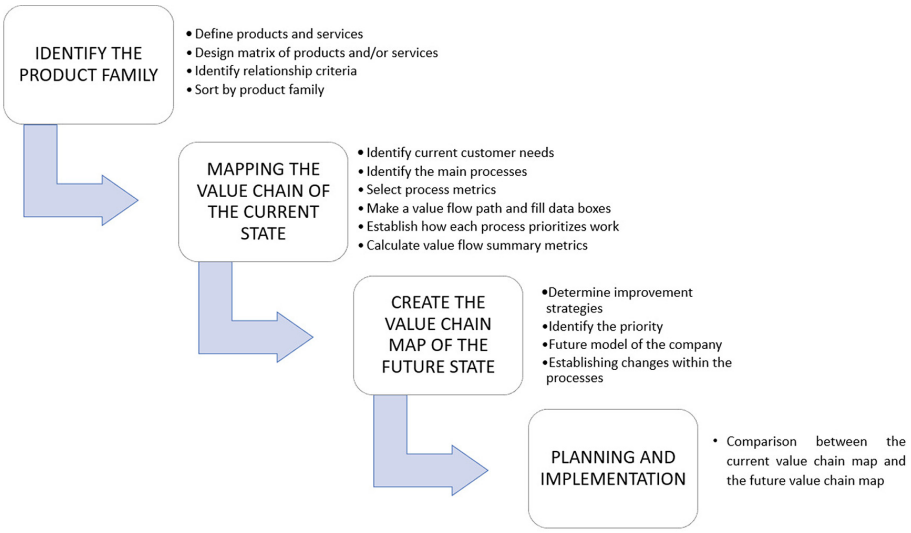

Fig. 7. Value stream mapping model. Source: Own elaboration with information from [5].

- The large number of products and processes that are not yet defined within the institution.
- Wide range of products and production flows that are not yet clearly defined by the institutions.
- Lack of support from top management.

Simulation. Simulation modeling has been widely implemented in many disciplines to replicate and predict behaviors [21], allowing the identification of gaps between actual performance and the current state of the supply chain [33].

Simulation models are often complex in certain cases, since they require coding static and dynamic properties of the systems [21], so it is necessary to have well established the situation being addressed.

According to [34] Simulation is a tool that allows to predict a certain situation in a short period of time, from the consideration of variables that intervene in the modeled scenario, if seeing of support for the election of improvement strategies and for the design of processes in the organizations. In this way, simulation allows to anticipate risks in the supply chains [35].

One of the benefits of simulation is that it is a tool that allows the evaluation of theories and also serves to analyze the organizational situation [36]. [34] considers simulation as a strategy for companies that allows them to reduce the risks that can occur when making a decision in a certain situation in the organization, allowing the reduction of time, costs and helping to visualize the future effects of the implementation of a project [37].

The literature review has shown how the Simulation has been combined with other supply chain design strategies to obtain better results in implementing change and improvement strategies in the organization [21,27,33,37].

Simulation, together with the VSM model, allows us to see in a clearer, faster and more feasible way the limiting operations that affect the current and future state of the value map in the supply chain [37].

On the other hand, it was found in the literature that most of the studies that use simulation in conjunction with the SCOR model focus on solving problems, and apply it fundamentally to the improvement plan process at level 4 of the model, serving as a validation tool for decision making [27].

The truth is that simulation not only makes testing ideas easier, cheaper and faster, but also provides an immediate evaluation of proposed changes in the system [38].

Using simulation models requires appropriate tools such as: SIMUL8 (https://www.simul8.com/), Arena and iThink, among others [21], which provide behavioral analysis capabilities that can predict system results with reference to selected system performance measures

Despite the fact that the application of Simulation allows for a reduction in costs, a decrease in decisionmaking time, and provides greater reliability when selecting improvement strategies, it presents some restrictions such as: the lack of systematization of information, the need to study in detail the relationships between system elements, and the difficulty of integrating and making explicit large models, it facilitates the study of systems, mainly those of smaller sizes and specific phenomena.

4 Conclusions

Although the study of the supply chain is a very frequent topic in industrial and commercial sectors, since it allows to improve the performance of the chain, its application in the educational sector is limited. Several researchers found that there are important opportunities in education systems, such as weak communication between the labor market and universities, lack of funding, and overcrowding. This establishes an interesting avenue of research to analyze educational processes in detail and develop initiatives to redesign their supply chain.

Weak communication between the labor market, students, and the university education supply chain results in a curriculum that is not aligned with the needs of employers, students, and society. Educational institutions require strategies to meet the expectations of their stakeholders.

The literature review also reveals supply chain design strategies that can be applied to University Educational Institutions, among which are considered the Supply Chain Operations Reference Model (SCOR model), the Value Chain Mapping (VSM) and the Simulation.

The implementation of these supply chain design strategies in educational institutions contributes to increase the efficiency and effectiveness of their services and products offered by the different educational institutions.

This study contributes to the knowledge about the use of methods and strategies of university educational supply chain design, a topic that has been little addressed in the literature. Future work could expand to look more deeply at the impact of some of these design models on university educational institutions. This would help to demonstrate that supply chain design strategies contribute to an improvement in their entire supply chain, enabling them to meet the needs of today's market.

References

1. Basu, G., Jeyasingam, J., Habib, M.M.: Education supply chain management model to achieve sustainability in private Universities in Malaysia: a review. Int. J. Supply Chain Manag. **5**(4), 24–37 (2016)
2. Ortega Jiménez, C.H., Eguía Salinas, I.: Demanda y oferta de educación superior: Integración total de la cadena de valor y las cadenas de suministro. Econ. y Adm. **2**(1) 21–50 (2017)
3. Sarrico, C.S., Rosa, M.J.: Supply chain quality management in education. Int. J. Qual. Reliab. Manag. **33**(4), 499–517 (2016)
4. Salazar, E., Capuz, S., De Reza, S., Padilla, J., Salinas, C.: Value stream mapping (VSM) for the process of professional formation. In: 17th International Congress Project Management Engineering, pp. 1387–1399, July 2013
5. Washington, A., Alfaro, D., Jonnathan, L., Rodríguez, S.U.: Tema: Aplicación De Lean VSM (Value Stream Mapping), UNIVERSIDAD ESTATAL DE MILAGRO (2018)
6. OCDE: Panorama de la educación 2019, Centro de México (2019). https://www.oecd.org/centrodemexico/estadisticas/. Accessed 21 Feb 2020
7. Trina Contreras, J.C.: Búsqueda de alternativas para la formación docente en la cuarta revolución industrial en el contexto universitario. Reforma Siglo XXI, vol. 100, pp. 46–49 (2019)
8. Habib, M.M., Hasan, I.: Supply chain management (SCM) - is it value addition towards academia? IOP Conf. Ser. Mater. Sci. Eng. **528**(1), 1–9 (2019)
9. Murali Krishna, M., Subbaiah, V.K.: Supply chain management: the educational organization perspective. ASIAN J. Manag. Res. **3**(1), 277–281 (2012)
10. Habib, M.: An integrated educational supply chain management (ITESCM). Ph.D. dissertation Graduate School of Information Technology, Assumption University of Thailand (2009)
11. Habib, M.: An empirical research of ITESCM (integrated tertiary educational supply chain management) model. In: Management and Services, October 2011
12. Briner, R.B., Denyer, D., Rousseau, D.M.: Evidence-based management: concept cleanup time? Academy of Management Perspective, p. 22, November 1996
13. Cigolini, R., Cozzi, M., Perona, M.: A new framework for supply chain management. Int. J. Oper. Prod. Manag. **24**(1), 7–41 (2004)
14. Owusu-Bio, M.K., Manso, J.F., Adiwokor, E.: Mapping the internal supply chain for educational institutions. A case study of Kwame Nkrumah University of Science and Technology. Eur. J. Bus. Manag. **7**(32), 32–42 (2015). http://www.iiste.org
15. Forero, D.E., Ramos, J.C.: La integración vertical en la cadena de abastecimiento de las instituciones de educación superior en Colombia, Criterio Libr. no. 22, p. 255 (2015)

16. Gopalakrishnan, G.: How to apply academic supply chain management: the case of an international university. Management **20**(1), 207–221 (2015)
17. Fajardo, S.A.D.: Rediseño de la Cadena de Suministro en función del tiempo de entrega, Universidad Autónoma de Nuevo León (2018)
18. Basu, G., Jeyasingam, J., Habib, M.M.: Education supply chain management model to achieve sustainability in private Universities in Malaysia: a review. Int. J. Supply Chain Manag. **5**(4), 24–37 (2017)
19. Melnyk, S.A., Narasimhan, R., DeCampos, H.A.: Supply chain design: issues, challenges, frameworks and solutions. Int. J. Prod. Res. **52**(7), 1887–1896 (2014)
20. Asmussen, J.N., Kristensen, J., Wæhrens, B.V.: Cost estimation accuracy in supply chain design: the role of decision-making complexity and management attention. Int. J. Phys. Distrib. Logist. Manag. **48**(10), 995–1019 (2018)
21. Rashid, S., Weston, R.: Design of an integrated methodology for analytical design of complex supply chains. Adv. Decis. Sci. **2012** (2012)
22. Báez Olvera, M.D.L.Á.: Apoyo a la decisión para el diseño y la planeación integrados de una cadena de suministro. Universidad Autónoma de Nuevo León (2015)
23. Rashid, S., Masood, T., Weston, R.H.: Unified modelling in support of organisation design and change. Proc. Inst. Mech. Eng. **223**, 055–1078 (2009)
24. Stewart, G.: Supply chain operations reference model, pp. 1–976 (2017)
25. Wang, W.Y.C., Chan, H.K., Pauleen, D.J.: Aligning business process reengineering in implementing global supply chain systems by the SCOR model. Int. J. Prod. Res. **48**(19), 5647–5669 (2010)
26. Prakash, S., Sandeep Gunjan, S., Rathore, A.: Supply chain operations reference (SCOR) model: an overview and a structured literature review of its application. In: International Conference on Smart Technologies for Mechanical Engineering, pp. 1–20, October 2013
27. Kersten, W., Saeed, M.A.: A SCOR based analysis of simulation in supply chain management. In: Proceedings - 28th European Conference on Modelling Simulation, ECMS 2014, pp. 461–469 (2014)
28. Bauer, D., Göbl, M.: Flexibility measurement issues in supply chain management. J. Appl. Leadersh. Manag. **5**, 1–14 (2017)
29. Gonzalez, V., Lozano, S.M.F., Sandoval, W.E.G., Villacreses, K.B., Vera, D.S.: Modelo del mapeo del flujo de valor - Value stream mapping (VSM) para la mejora de procesos de producción de empresa de Dulcería-café. In: Proceedings of LACCEI International Multi-conference on Engineering Educational Technology, vol. 2018-July, January 2018
30. Carrera, M.R., Sanchez, J.L.: ean Manufacturing La evidencia de una necesidad (2010)
31. Morlock, F., Meier, H.: Service value stream mapping in industrial product-service system performance management. Procedia CIRP **30**, 457–461 (2015)
32. Busse, C., Schleper, M.C., Weilenmann, J., Wagner, S.M.: Extending the supply chain visibility boundary: utilizing stake-holders for identifying supply chain sustainability risks. Int. J. Phys. Distrib. Logist. Manage. **47**(1), 18–40 (2017)
33. Carvalho, H., Barroso, A.P., MacHado, V.H., Azevedo, S., Cruz-Machado, V.: Supply chain redesign for resilience using simulation. Comput. Ind. Eng. **62**(1), 329–341 (2012)
34. Rivera, J.C.: El uso de la simulación para apoyar la toma de decisiones organizacionales. Rev. Estud. Adm. Empres. **9**(1), 70–84 (2016)
35. Brintrup, A., et al.: Supply chain data analytics for predicting supplier disruptions: a case study in complex asset manufacturing. Int. J. Prod. Res. **58**(11), 3330–3341 (2020)

36. Frantz, T.L., Carley, K.M., Wallace, W.A.: Computational organization theory. Encyclopedia of Operational Research Management Science, pp. 246–252 (2013)
37. Rodríguez-Fernández, Y., Abreu-Ledón, R., Franz, M.: Mapeo del Flujo de Valor para el análisis de sostenibilidad en cadenas de suministro agro-alimentarias. Ing. Ind. **40**(3), 316–328 (2019). [1]
38. Faulkner, W., Templeton, W., Gullett, D.: Visualizing sustainability performance of manufacturing systems using sustainable value stream mapping (SUS-VSM). In: International Conference on Industrial Engineering Operational Management, Istanbul, Turkey (2012)