Global Business and Management Research: An International Journal
Vol. 16, No. 4s (2024)

Research progress and prospects on operational excellence of higher education supply chain in post-pandemic era

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Abstract

Purpose: This study aims to delve into how higher education supply chains can achieve operational excellence in the post-pandemic era. It focuses on the application of supply chain management principles in the education sector and explores strategies and best practices to optimize operational efficiency, resource utilization, and service quality in higher education institutions.

Design/methodology/approach: A systematic literature review methodology was employed. First, relevant journal articles related to educational supply chain management and operational excellence were identified through database searches. These articles were then categorized and analyzed for content. Key findings were summarized based on this analysis, and future research directions were proposed accordingly.

Findings: The findings reveal that while there has been an increase in literature on higher education supply chain management in the post-pandemic era, some gaps still exist. The role of artificial intelligence in optimizing supply chains remains underexplored. Additionally, there is a lack of a universally accepted theoretical framework to explicate the multifaceted dynamics of the post-pandemic education supply chain. The study also highlights the growing importance of themes such as digital adaptability, institutional resilience, and student engagement.

Research limitations/implications: A key limitation is the reliance on secondary data analysis from literature, potentially lacking direct observation and in-depth understanding of practical cases. Future research could focus on specific case studies of higher education institutions, combining quantitative and qualitative methods to build a more comprehensive and practical theoretical framework.

Practical implications: The findings provide guidance for higher education institutions to achieve operational excellence. It is recommended to adopt advanced technologies and

methodologies such as artificial intelligence and lean production to drive internal process optimization, strengthen external collaborations with industry to better align talent development goals, and formulate flexible policies to adapt to environmental changes. Leaders should cultivate an innovation-embracing culture and promote cross-departmental collaboration.

Originality/value: This study systematically reviews the literature on higher education supply chain management in the post-pandemic era, highlighting the importance and research gaps in this emerging field. The insights and recommendations provided offer unique research value for higher education institutions to develop effective supply chain strategies and achieve operational excellence.

Keywords: Higher education supply chain, Operational excellence, Post-pandemic adaptation

Introduction

The COVID-19 pandemic has profoundly disrupted higher education supply chains, exposing their vulnerabilities and urgency for transformation. Educational institutions worldwide had to abruptly shift to online teaching modes, straining resources and demanding rapid reallocations (Li & Lalani, 2020; UNESCO, 2020, Daniel, 2020). This transition unveiled the lack of preparedness in supply chain resilience and agility to cope with public health emergencies (Daniel, 2020; Purcell & Lumbreras, 2021). Moreover, the diverse needs and backgrounds of students posed significant challenges in ensuring equitable access and engagement in remote learning environments (Rizvi et al., 2019).

While existing literature has explored the theoretical underpinnings of educational supply chain management and internal process optimization (Gunasekaran et al., 2004; Habib & Jungthirapanich, 2008, 2010), it falls short in addressing the unique demands of the post-pandemic era. Most studies are rooted in traditional paradigms and lack comprehensive frameworks to enhance supply chain resilience, sustainability, and responsiveness to dynamic market needs (Modgil et al., 2022). Furthermore, the integration of emerging technologies, such as artificial intelligence (AI) and big data analytics, in optimizing post-pandemic educational supply chains remains underexplored (Petrunya & Pasichnyk, 2018).

Therefore, this study aims to conduct a systematic review of the transformation and adaptation of higher education supply chains in the post-pandemic landscape. By synthesizing and critiquing relevant literature, it seeks to identify deficiencies in existing research and propose recommendations for building more efficient, resilient, and sustainably developed educational supply chains. Through this process, the study will highlight the importance of emerging areas like AI, online learning, and digital adaptability, while striving to establish a viable theoretical foundation to guide strategic supply chain decisions and operational excellence in higher education institutions.

Methods

For the study titled “Education supply chain towards operational excellence in post-pandemic era”, a systematic literature review was chosen as the primary research approach. This was done to synthesize and analyze the existing literature on the transformation and adaptation of the education supply chain for operational excellence in the post-pandemic context. Given the broad scope of the topic and the multitude of factors involved, a systematic review provides a comprehensive and structured method to identify, evaluate, and integrate relevant research.

The lens.org database was selected for its extensive coverage of scholarly publications across various disciplines, including education, management, and supply chain research. The time range of 2000 to 2024 was chosen to capture the evolution of supply chain management

concepts, their application in the education sector, and the recent impacts of the COVID-19 pandemic on educational operations.

Research Question Formulation:

Primary Question: How has the education supply chain evolved towards operational excellence in the post-pandemic era?

Sub-Questions:

Q1:What is the present state of the education supply chain?

Q2:What operational challenges have educational institutions faced in post pandemic era ?

Q3:What are the main models and frameworks proposed in the literature for achieving operational excellence in education post-pandemic?

Research process

The research process involved three main stages to progressively refine the scope of the literature search. Stage 1 focused on identifying publications related to supply chain management, irrespective of specific sub-fields. Stage 2 narrowed the search to education supply chain management, with a specific emphasis on higher education. Stage 3 further filtered the results to include publications discussing operational excellence in education.

At each stage, specific keywords were used as search filters, and only journal articles were included to ensure a focus on peer-reviewed, high-quality research. Book chapters were excluded to maintain a consistent and comparable level of rigor across the reviewed literature. The systematic review protocol followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a transparent and replicable process (Page et al., 2021). Relevant data, including publication details, study designs, and key findings, were extracted and organized using a standardized data extraction form.

Data Analysis

After addressing duplicate entries, a manual content analysis was performed to classify the identified publications based on theoretical frameworks and empirical research methodologies employed (Habib & Jungthirapanich, 2008, 2010).

The empirical research section was further divided into quantitative and qualitative studies. Quantitative studies, such as those conducted by Jauhar et al. (2018) and Dewi et al. (2018), provide valuable insights into the efficiency and drivers of supply chain management in higher education through statistical analyses. Qualitative studies, like those by David et al. (2017) and Chansamut (2023), offer rich contextual understanding of phenomena such as student mobility and digital supply chain operations through observational and interview-based approaches.

Upon completion of Stage 1 ,Stage 2, and Stage 3, the subsequent step instituted specific filter criteria. The focus was primarily on:“supply chain management” “education supply chain management”and "operational excellence" as the primary keywords for sourcing articles. We consciously excluded book chapters, emphasizing only journal articles. Preliminary results indicated a vast number of 44,417+ publications across “supply chain management”, approximately 632 papers specifically tackling the nexus between “supply chain management” and “higher education”, and 151 papers on “operational excellence”and “education”. In the management field, there were 7,815 journal articles on “supply chain management”, roughly 241 papers specifically addressing the nexus between “supply chain management” and “higher education”, and 38 papers on “operational excellence” and “education”.

Table 1: Method description

Stage#	All Field	Management Field
Stage 1 Publications from Databases with key word: supply chain management	Step 1: Select Database : supply chain management in lens.org from 2000 to 2024 :197469 publications Step 2: Filter "supply chain management" keyword only Only research articles TOTAL 44417 research articles	Step 1: Select Database : supply chain management in lens.org from 2000 to 2024 :57510 publications Step 2: Filter "supply chain management" keyword only Only research articles TOTAL 7815 Publications
Stage 2 Publications from Databases with key word education supply chain management	Step 1: Select Database : education supply chain management in lens.org from 2000 to 2024 :17244publications Step 2: Filter "education supply chain management" keyword only Only research articles TOTAL 11research articles in information system (3), information systems and management (3), management information systems (3), public health, environmental and occupational health (2) Step 3: Filter again "higher education" + "supply chain management" Only research articles TOTAL 632 research articles	Step 1: Select Database : education supply chain management in lens.org from 2000 to 2024 :3713publications Step 2: Filter "education supply chain management" keyword only Only research articles TOTAL 6 Publications in management information systems (3) and information systems and management(3) Step 3: Filter again "higher education + "supply chain management" Only research articles TOTAL 241 research articles
Stage3 Publications from Databases with key word: education operational excellence	Step 1: Select Database : operational excellence in lens.org from 2000 to 2024 :14314 publications Step 2: Filter education operational excellence in lens.org :4295publications Step 3: Filter again "operational excellence" +" education "keyword only Only research articles TOTAL 151 research articles	Step 1: Select Database : operational excellence in lens.org from 2000 to 2024 :2031publications Step 2: Filter education operational excellence in lens.org :537publications Step 2: Filter "operational excellence" +"education "keyword only Only research articles TOTAL 38 research articles
Stage 4 Check for Duplicates	Step 1: Filter in Zotero	Step 1: Filter in Zotero

Stage 5 Content Analysis	Step 1: manual classification according to the mold :The concept of educational supply chain management surfaced in 2007, aiming to produce talent aligned with industry needs (Habib & Jungthirapanich, 2008, 2010)	Step 1: manual classification according to the mold :The concept of educational supply chain management surfaced in 2007, aiming to produce talent aligned with industry needs (Habib & Jungthirapanich, 2008, 2010)
Stage 6 Discussion	Step 1: Identify key findings Step 2: Answer all research questions Step 3: Identify literature gap & future research	Step 1: Identify Key Findings Analyze the growth in post-pandemic education supply chain literature, focusing on technology integration and online learning trends. Step 2: Answer All Research Questions Address research questions by highlighting trends in digital adaptability, resilience, and student engagement in education. Step 3: Identify Literature Gap & Future Research Pinpoint gaps in theoretical foundations of post-pandemic education supply chains and underexplored areas like artificial intelligence.

On Stage 4, A manual scrutiny was vital at this juncture to address double entries and duplicated works, given the constraints of database filters. All curated publications were integrated into Zotero, a preferred reference management tool. Rigorous efforts were made to negate any redundancy, especially concerning the core themes of the research.

On Stage 5, a manual classification according to the mold :The concept of educational supply chain management surfaced in 2007, aiming to produce talent aligned with industry needs (Habib & Jungthirapanich, 2008, 2010), is used to divide the theoretical research on supply chain management in higher education into two sub-topics:Internal supply chain management in higher education and External supply chain collaboration in higher education. And Empirical Research on Supply Chain Management in Higher Educations is classified to be Quantitative empirical research,Qualitative empirical research and Model and framework building, to answer all the research questions.

On Stage 6, a comprehensive analysis of the compiled research findings was conducted to identify key insights, highlight the current state of educational supply chain studies in the post-pandemic era, and pinpoint gaps and future research directions.

Key observations from this analysis include a limited but growing body of literature specifically exploring post-pandemic operational excellence in education supply chains. The

integration of technology, administration, and pedagogy emerged as a notable emphasis across many studies, reflecting the profound impact of the pandemic on educational processes and operations.

There was a noticeable rise in articles published after 2019, with a focus on topics such as online learning modalities, institutional strategies for adapting to remote education, risk management approaches, and infrastructural adaptations required to support the global shift to virtual learning environments. These studies provided valuable insights into the challenges and evolutions that educational institutions faced during the pandemic, as they grappled with the abrupt transition to remote learning.

However, a significant gap identified was the lack of a universally accepted theoretical foundation that comprehensively explicates the multifaceted dynamics of the post-pandemic education supply chain. This absence suggests an opportunity for future research to develop a robust theoretical framework that can anchor scholarly work in this domain and provide a comprehensive understanding of the intricate interplay between various factors influencing educational supply chains in the post-pandemic landscape.

Additionally, while artificial intelligence (AI) was recognized as a pivotal element in optimizing post-pandemic education supply chains, its exploration in primary academic journals remained underdeveloped. This highlights another potential area for future academic exploration, as AI and related technologies are expected to play an increasingly crucial role in enhancing supply chain resilience, efficiency, and responsiveness in the education sector.

In summary, Stage 6 involved a comprehensive synthesis and critical evaluation of the research findings, identifying key trends, challenges, and opportunities in the realm of post-pandemic education supply chain management. This stage accentuated the necessity for developing a robust theoretical framework to anchor scholarly work in this domain, as well as the importance of in-depth explorations into emerging technologies like artificial intelligence (AI).

Literature Review

The genesis of logistics in the 1950s and its evolution into supply chain management (SCM) by the 1980s has significantly influenced various sectors, including education (Habib & Jungthirapanich, 2008, 2010). Initially focused on operational efficiency in manufacturing, SCM principles have been adapted to service industries like education, addressing unique challenges through customized approaches (Gunasekaran et al., 2004).

Internal Supply Chain Management in Higher Education

The emergence of educational supply chain management in 2007 marked a pivotal shift, aligning educational goals with industry needs (Habib & Jungthirapanich, 2008, 2010). Consequently, internal supply chains within higher education institutions have focused on sustainable practices and performance evaluation, as exemplified by the Integrated Tertiary Educational Supply Chain Management Model (ITESCM) and similar frameworks (Govindaraju, 2016; Mageto et al., 2020).

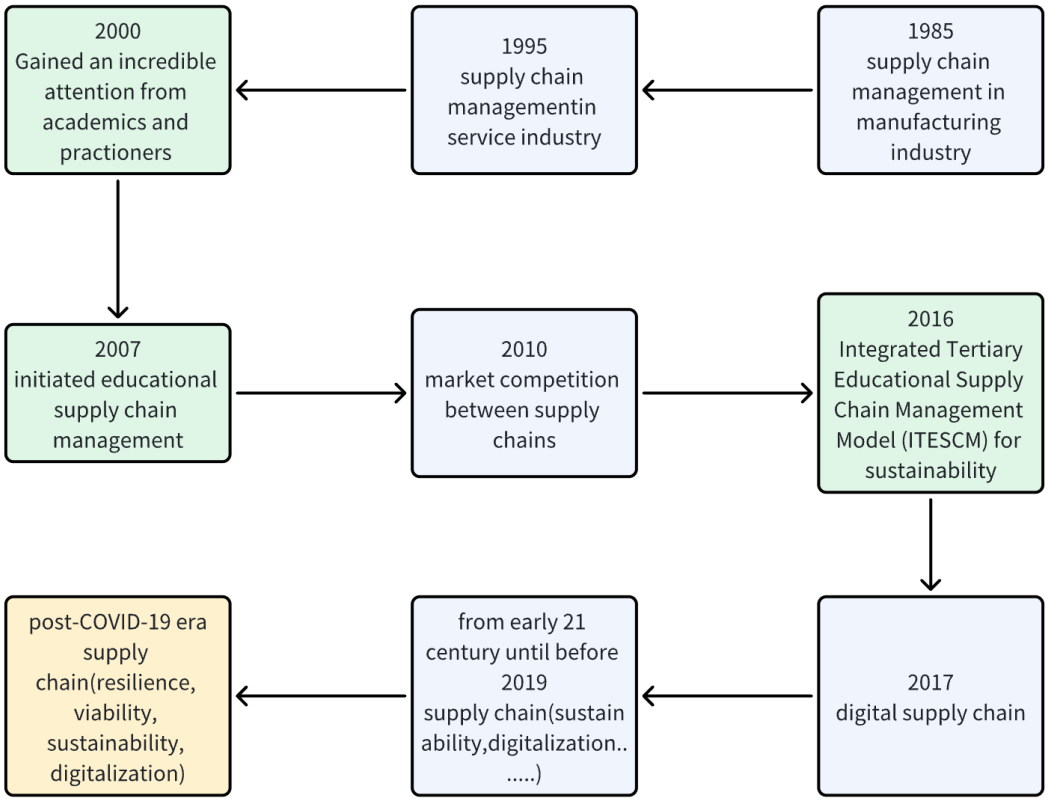

Figure 1: The Evolution of Supply Chain Management. Source. Adapted from Lee et al. (2018)

External Supply Chain Collaboration in Higher Education

External collaborations, a strategy to meet global educational challenges, have involved diverse stakeholders, from material suppliers to end consumers (students and employers). Furthermore, the integration of digital supply chain operations in non-formal education settings and the application of mobile learning models demonstrate innovative adaptations in response to challenges like the COVID-19 pandemic (Chansamut, 2023).

Education Supply Chain Management Framework

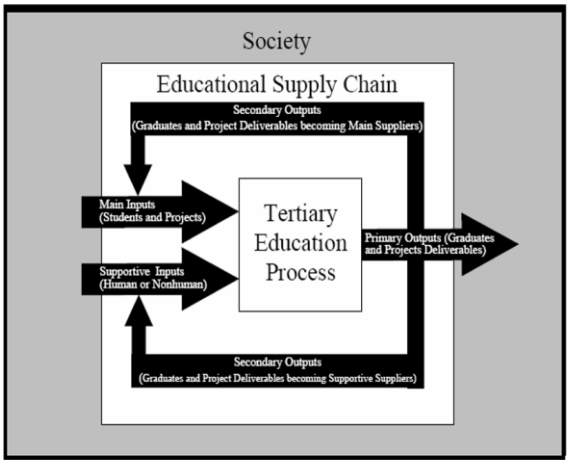

Figure 2 : An integrated framework for research and education supply chain for the universities. (Habib& Jungthirapanich,2008)

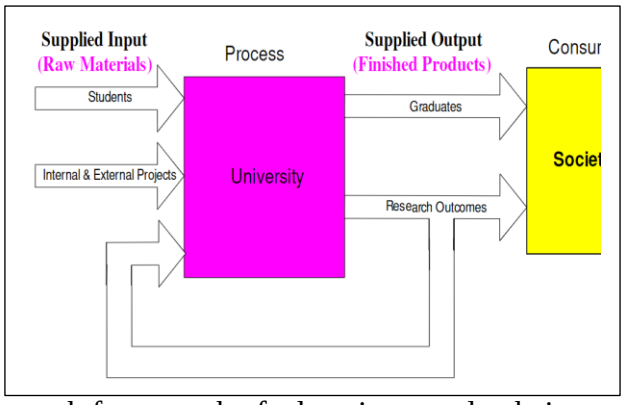

Figure 3: Research framework of education supply chain, research supply chain and educational management for the universities. (Habib& Jungthirapanich,2009).

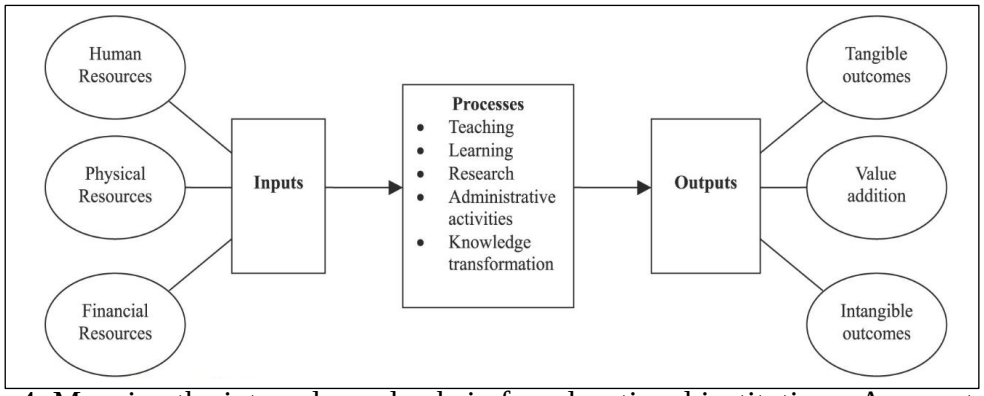

Figure 4: Mapping the internal supply chain for educational institutions. A case study of Kwame Nkrumah University of Science and Technology.(Owusu-Bio, et al.,2015).

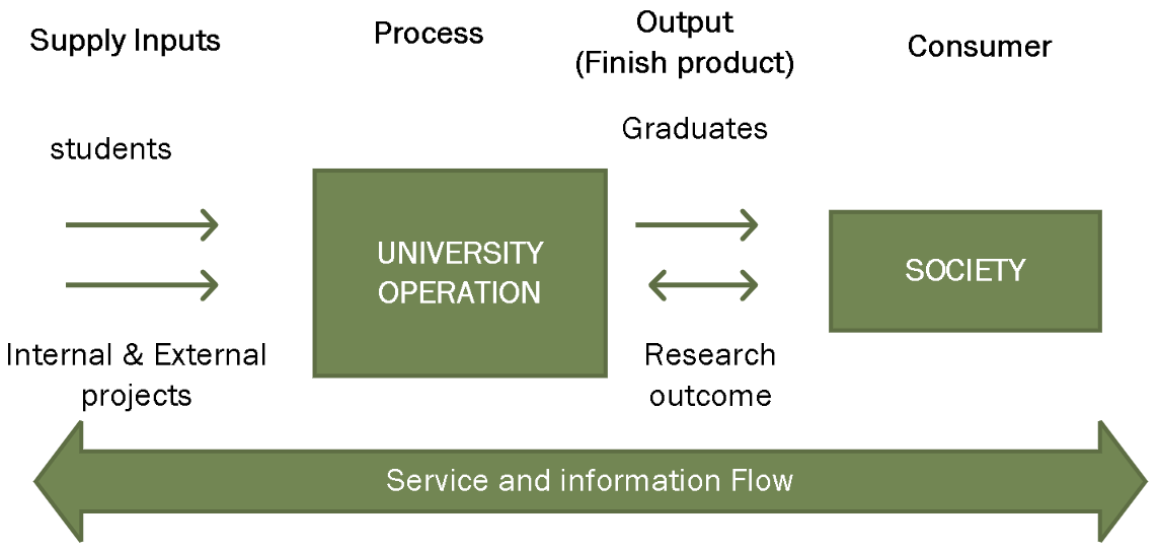

Figure 5: Education supply chain management model to achieve sustainability in private Universities in Malaysia: A review. (Basu et al., 2016)

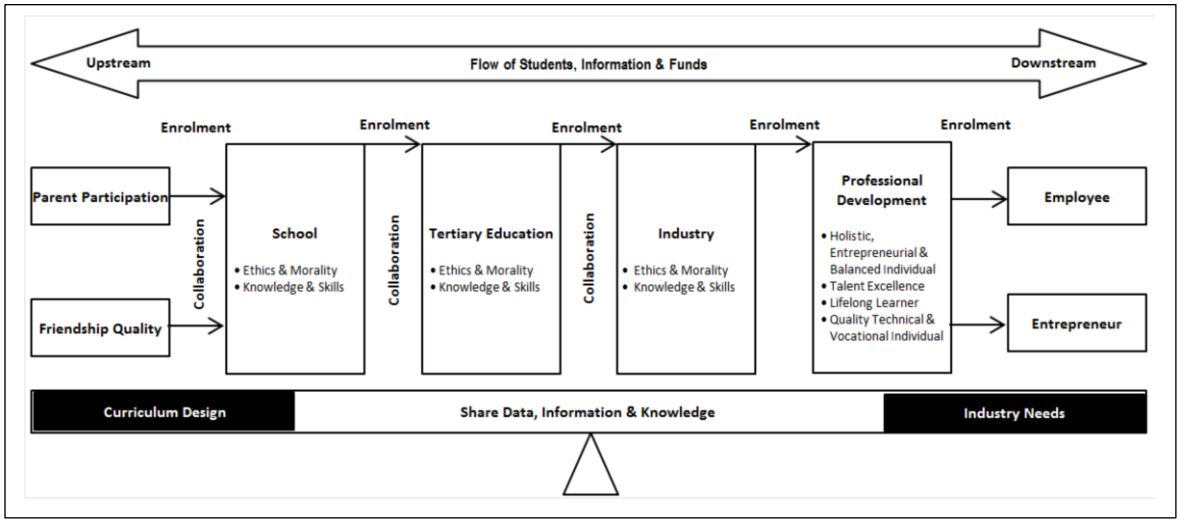

Figure 6: A review of educational supply chain management in Malaysia tertiary education. (Loon et al., 2018)

Figure 2 provides a holistic view of the educational supply chain, with society as the upstream source offering student and project inputs that are transformed through the tertiary education process. This generates primary outputs like graduates and deliverables that not only serve societal needs but also evolve into supportive suppliers, adding value to the cycle. The cyclical nature underscores sustainability, as students become graduates whose contributions feed back into the system.

Figure 3 portrays the education supply chain holistically, with students and projects as input "raw materials" fed into the university as the processing core, outputting "finished products" of graduates and research outcomes that ultimately serve societal needs. This highlights the university's role in transforming societal inputs into valuable human capital and research contributions.

Figure 4 schematically represents the educational process, with human, physical, and financial resource inputs flowing into various teaching, learning, research, administrative, and knowledge transformation processes that ultimately yield tangible outcomes, value addition, and intangible outputs, illustrating the transformation of resources into results through education institutional processes.

Figure 5 outlines a holistic educational supply chain model, with student and project inputs flowing into the university operational core that outputs graduates and research outcomes as finished products directed towards societal consumption, underpinned by continuous service and information flows throughout the chain.

Figure 6 illustrates the educational supply chain management journey from upstream parental influences on curriculum design to students progressing through school and tertiary education emphasizing ethics, morality and skills, with collaboration and flow of students, information and funds, towards industry which also values ethics and skills, allowing for professional development to shape holistic, entrepreneurial and lifelong learning individuals with talent excellence, as well as direct workforce entry, and ultimately entrepreneurs responding to industry needs, representing an end-to-end pathway from initial education to professional and entrepreneurial outcomes.

Moving forward, higher education supply chain frameworks should incorporate new technologies, reinforce social responsibility, and enhance adaptability. Specifically, the adoption of artificial intelligence could enable the intelligentization of teaching management

and processes, optimizing resource allocation and learning analytics (Memarian& Doleck, 2024). In addition, environmental protection and social responsibility should also be integrated into the framework through establishing green campuses and courses, enabling universities to nurture students' environmental awareness; supply chain partners should also strive to reduce environmental impact (Obrecht et al., 2022). Strengthening industry-academia-research partnerships and exchanges by building platforms for collaborative innovation ensures close alignment between educational outputs and industry needs as well as research directions (Meng et al., 2023). The framework should also incorporate elements that promote educational equity, addressing the needs of students from different backgrounds and providing financial aid (Ali et al., 2024). Finally, enhancing the framework's flexibility and dynamism is critical for enabling quick adjustments based on external changes, which is vital for bolstering the supply chain's agility and adaptability (Kazancoglu et al., 2022). In summary, building novel higher education supply chain frameworks calls for integrating new technologies, reinforcing social responsibility, and enhancing adaptability to suit future developments.

Empirical Research on Supply Chain Management in Higher Education

Empirical research on supply chain management (SCM) in higher education is gaining traction as universities face modern challenges, and applying SCM principles, traditionally seen in business, can optimize educational processes. This research area holds potential to revolutionize academic operational efficiency and resource allocation.

Quantitative Empirical Research

In the realm of educational supply chain management, quantitative empirical research has emerged as a pivotal methodology to provide data-driven insights. Jauhar et al. (2018) delved into the efficiency of the Indian Institute of Technology Roorkee from a sustainable educational supply chain management perspective, underscoring the significance of the educational sector in SCM practices. Their study employed statistical analysis to evaluate performance metrics, highlighting areas for improvement and best practices.

Similarly, Dewi et al. (2018) explored the drivers of supply chain management in the Indonesian higher education sector, particularly emphasizing the role of public policies in private partnerships. Their findings, derived from quantitative analyses, highlighted that educational and research suppliers exert a notable influence on the supply chain via university management, with public policies further amplifying this impact. Such empirical evidence is valuable for policymakers and educational leaders to understand the key levers influencing supply chain performance and make informed decisions.

Quantitative studies in this domain often leverage advanced statistical techniques, surveys, and large datasets to identify patterns, correlations, and causal relationships. By employing rigorous methodologies and objective data analysis, these studies contribute to a more comprehensive understanding of the intricate dynamics within higher education supply chains, enabling evidence-based decision-making and strategic planning.

Qualitative Empirical Research

In the context of qualitative empirical research, the internationalization of higher education and digital supply chain operations have demonstrated their significance in educational management. David et al. (2017) delved into student learning mobility among the Arabian Gulf Cooperation Council countries, finding that while learning mobility has been stimulated in the region, it is largely region-driven. Their qualitative approach, involving interviews and observations, provided valuable insights into the contextual factors influencing student mobility, which is a crucial aspect of the educational supply chain.

On the other hand, Chansamut (2023) examined the digital supply chain operation model for non-formal education in rural Thailand, which was deemed highly suitable for the rural non-formal educational setting. Through qualitative methods such as case studies and stakeholder interviews, the study uncovered the unique challenges and opportunities associated with digital supply chain operations in this context, informing best practices and strategies for effective implementation.

Qualitative studies in this field often employ ethnographic techniques, case studies, and in-depth interviews to capture rich, contextual data and gain a nuanced understanding of complex phenomena within educational supply chains. By exploring the lived experiences, perspectives, and behaviors of various stakeholders, these studies offer valuable insights into the socio-cultural, organizational, and technological factors influencing supply chain performance.

Both quantitative and qualitative empirical research methods offer distinct yet complementary perspectives to the understanding of supply chain management in higher education. While quantitative studies provide objective, numerical data and statistical analyses, qualitative studies offer rich contextual insights and a deeper understanding of stakeholder experiences and perceptions. Ultimately, a combination of both approaches can yield a holistic and well-rounded comprehension of the intricate dynamics within educational supply chains, informing effective strategies and decision-making.

Implementation Pathways of Supply Chain Management in Higher Education

The integration of supply chain management (SCM) within higher education has become increasingly vital. The implementation of internal supply chains is transforming university operations, particularly as institutions integrate education and research supply chains with educational management. Habib et al. (2009) and other studies underscore the crucial role of SCM in enhancing operational efficiency and governance in higher education. Additionally, the advent of mobile learning and IoT technologies is revolutionizing traditional educational environments, offering new avenues for real-time monitoring and efficient asset management, as evidenced by the work of Rahman et al. (2021) and Kuandee et al. (2019).

Collaboration between higher education and industry is another critical area of focus. This strategy is essential to align academic offerings with industry demands, ensuring that graduates possess the skills required in the contemporary job market. Examples include Australia's education sector, which has seen a substantial reliance on international students, and Jordan's application of the SCOR model to align graduates' skills with industry needs, as noted by Chowdhury (2022) and Carranza & McKenzie (2024). Such collaborations not only streamline resource allocation but also contribute to the development of curricula that reflect the evolving demands of various industries.

Policy-supported implementation pathways also play a significant role in the effective application of SCM in education. The interplay between public policies and private partnerships, as explored by Dewi et al. (2018), demonstrates the impact of education and research suppliers on SCM, with policy acting as a critical moderating force. Furthermore, the development of frameworks like the Open Education Supply Chain Network, as proposed by Class et al. (2021), highlights the importance of co-creation, agility, and a balanced approach to value creation in education supply chain management. These frameworks and policies underscore the need for a holistic approach, integrating various stakeholders' needs to optimize SCM benefits in the educational sector.

In summary, the successful implementation of SCM in higher education hinges on integrating internal operational efficiencies, fostering collaborative relationships with industry, and developing policy-supported strategies. These efforts collectively contribute to a more robust,

responsive, and efficient educational supply chain, capable of meeting the challenges and opportunities of the modern educational landscape.

Excellence and Improvement

Operational Excellence (OE) represents a comprehensive management philosophy that aims to achieve superior organizational performance through continuous improvement and streamlined operations. This approach integrates sustainable development practices, ensuring organizations thrive economically while upholding social and environmental responsibilities (Camilleri,2017). Key factors like Lean and Six Sigma methodologies play a pivotal role in implementing OE effectively, promoting agility and responsiveness in dynamic business environments (Aguilera & Treviño, 2019). The Fourth Industrial Revolution has expanded the scope of OE, with digital technologies redefining traditional boundaries (Pansare et al.,2024).Lean Production and OE are central paradigms in modern organizations, enhancing operational efficiency and competitiveness. The integration of Lean Six Sigma with Industry 4.0 technologies, as explored by Pongboonchai-Empl (2023), and its application in various sectors from logistics to manufacturing, highlight the evolving nature of these methodologies (Skalli et al., 2023).

Six Sigma's role in OE is particularly noteworthy, especially in navigating the complexities of modern challenges. Muhammad et al. (2022) emphasized the transformative power of Lean and Six Sigma during the COVID-19 pandemic, while Prashar(2021) explored the nuances of OE deployment failures, highlighting the balance between technical and behavioral aspects for successful implementation.

In the post-COVID-19 context, the focus on OE has intensified. The pandemic has underscored the significance of operational excellence methodologies in enhancing customer satisfaction and reducing costs (Trakulsunti et al., 2022). Novel approaches like integrating ISO Management System Standards with the Shingo Model, as introduced by Carvalho et al. (2022), offer insights into assessing an organization's maturity in adopting best practices. The importance of supply chain resilience as an OE strategy, particularly in sectors like agri-food, has been highlighted by Mishra (2022).

In the era of rapid technological advancement, achieving OE is paramount. Artificial Intelligence (AI) and Robotic Process Automation (RPA) emerge as pivotal tools in driving operational management (Tariq et al., 2021). The integration of these technologies with Lean and Six Sigma methodologies offers promising pathways to operational excellence, considering aspects like efficiency, growth, and sustainability (Muhammad et al., 2022).

In summary, OE in higher education and other sectors is an evolving concept, necessitating continuous adaptation to technological advancements and global challenges. The fusion of new technologies and methodologies is key to achieving unparalleled operational excellence, with a focus on lean, sustainability, and resilience.

Discussion

This systematic literature review offers several key takeaways and implications for higher education institutions and researchers. Firstly, the findings underscore the limited but growing body of literature exploring post-pandemic operational excellence in education supply chains. This emergent field demands increased scholarly attention as institutions grapple with the profound impacts of the COVID-19 pandemic on educational operations and processes.

A significant emphasis has emerged on the integration of technology, administration, and pedagogy in post-pandemic supply chain management. The surge in articles after 2019 reflects the global shift to remote learning during the pandemic, highlighting the need for strategies to address challenges such as online learning modalities, institutional adaptations, risk

management, and infrastructural enhancements (Toquero, 2020; Yan et al., 2021). Consequently, higher education supply chains have become increasingly interdisciplinary, necessitating collaborative efforts across various domains.

However, a significant gap identified is the lack of a universally accepted theoretical foundation that comprehensively explicates the multifaceted dynamics of the post-pandemic education supply chain. This absence presents an opportunity for future research to develop a robust theoretical framework that can anchor scholarly work in this domain. Such a framework should encapsulate the intricate interplay between various factors influencing educational supply chains, including technological advancements, socio-economic factors, stakeholder perspectives, and evolving industry needs.

Furthermore, while artificial intelligence (AI) is recognized as a pivotal element in optimizing post-pandemic education supply chains, its exploration in primary academic journals remains underdeveloped. This highlights a potential area for future academic exploration, as AI and related technologies are expected to play an increasingly crucial role in enhancing supply chain resilience, efficiency, and responsiveness (Modgil et al., 2022).

In addition to theoretical development, empirical studies exploring the practical implementation of AI, data analytics, and digital solutions in enhancing supply chain performance would contribute valuable insights. Such research could involve case studies, pilot projects, or large-scale quantitative analyses to evaluate the impact of these technologies on operational efficiency, resource utilization, and stakeholder satisfaction.

Ultimately, the goal should be to create a comprehensive framework that guides higher education institutions in developing robust, sustainable, and resilient supply chain strategies. Such a framework should encompass best practices for resource optimization, risk management, stakeholder collaboration, and continuous improvement, enabling institutions to navigate future disruptions while delivering quality education effectively.

In summary, this systematic review highlights the importance of further research in the education supply chain, particularly in exploring underrepresented areas like artificial intelligence and establishing theoretical foundations to guide future studies. By addressing these critical gaps, research in this domain can empower educational institutions to develop effective strategies, enhance operational excellence, and ensure their long-term competitiveness in an ever-evolving educational landscape.

Conclusion

This research highlights the critical need for establishing a resilient, sustainable, and lean supply chain in the educational sector. Resilience is vital for adaptability in the face of challenges, sustainability focuses on long-term viability and ethical considerations, and lean operations aim at efficiency and waste reduction. To achieve these objectives, educational institutions should consider the following specific strategies:

1: Implementing AI and RPA: The integration of cutting-edge technologies like Artificial Intelligence (AI) and Robotic Process Automation (RPA) is crucial, but their successful implementation depends on cultural alignment within institutions. Educational leaders should foster an environment that embraces technological change while aligning it with institutional values and culture (Tariq et al., 2021). For example, AI could be leveraged for personalized learning experiences, curriculum optimization, and predictive analytics for student success.

2: Fostering Visionary Leadership and Team Cohesion: The role of visionary leadership cannot be overstated in driving innovation and change. Leaders in education should promote a collaborative culture that encourages teamwork and cohesive efforts towards common goals. Cross-functional teams involving faculty, administrators, and technology experts can collectively develop and implement supply chain strategies.

3: Building External Collaborations and Policy-Supported Pathways: Establishing strong collaborations with industry, government, and other educational institutions can enhance the supply chain's effectiveness. For instance, partnerships with technology firms can facilitate the integration of AI in curriculum design or administrative processes. Additionally, leveraging policy-supported pathways can provide the necessary framework and support for these collaborations (Dewi et al., 2018).
4: Adopting Sustainable Practices: Educational institutions should integrate sustainable practices, such as reducing paper use and promoting digital learning tools, contributing to environmental sustainability. Developing green campuses and courses can nurture students' environmental awareness, while supply chain partners should strive to reduce their environmental impact (Obrecht et al., 2022).
5: Cultivating a Lean Mindset: Lean principles and methodologies like Six Sigma should be adopted by streamlining administrative processes, reducing redundancies, and optimizing resource allocation. Systematic reviews highlight the successful application of Lean Six Sigma in higher education institutions, enhancing efficiency and quality across various processes (Cudney et al., 2020).
In summary, the confluence of technological advancements, cultural considerations, visionary leadership, and effective team dynamics is essential for achieving operational excellence in education. The integration of these elements not only enhances the supply chain's resilience and sustainability but also ensures its alignment with the evolving demands of the educational landscape.

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