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Methodology for Diagnosing the Impact of Operations Management Elements in Technical and Vocational Education and Training in the Garment Industry

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Abstract
Technical and vocational education and training (TVET) plays a pivotal role in preparing individuals for the workforce, equipping them with the specific skills demanded by industries. This paper introduces a methodology aimed at diagnosing the primary elements of Operations Management (OM) essential for the development of TVET activities. The proposed methodology is structured into three key stages using institutional documents, focus group and surveys as data collection approaches. Firstly, it involves characterizing the TVET institution under consideration. Secondly, it encompasses the delineation of supporting operations crucial for the development of TVET activities within the chosen case study context. Finally, it offers a methodology for discerning the principal perceptions and expectations of both learners and trainers regarding the supporting technical learning activities. Elements such as planning, preparation, manufacturing processes, and warehouse management emerged with a perceived high impact on supporting these training activities. Conversely, factors such as location and environmental conditions exhibited a comparatively lower perceived impact within the case study.

Keywords
Operations Management, Technical and vocational education and training, Quality training, Garment industry; Education performance, Education management.

Introduction

Work-based learning is an important strategy for increasing the employment potential of a country's population, both adults and youth. More and more countries around the world are recognizing work-based learning as a valuable approach to improving the quality and applicability of education and training. One of the main forms of such learning is technical and vocational education and training (TVET). UNESCO recommended that this type of learning should be linked to institutional learning, which can develop the competencies of individuals in preparation for the professional environment, in addition to developing their understanding of scientific, technological, social, cultural, environmental, economic and other aspects of society (UNESCO, 2015).

TVET plays an important role in the 2030 Agenda through Sustainable Development Goal (SDG) 4, which aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (UN, 2016). TVET contributes to increasing the number of youth and adults with technical and vocational skills, thereby facilitating their access to employment, decent work, and entrepreneurship. Furthermore, TVET contributes to inclusive and sustainable economic growth and competitiveness, social equity and environmental sustainability (UNESCO, 2023). TVET has also been used as a strategy focused on improving the learning process to enhance the quality of work-based learning and align training with labor market demands (Bahl & Dietzen, 2019).

The creation and supervision of successful TVET learning programs require all involved parties to com-

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prehend the evolving process of learning within the workplace, regardless of how it is formed (Fuller & Unwin, 2019). For technical learning, the workplace is of particular importance due to the complexities, realities, and dynamics that can be found when apprentices and trainees face real-world situations. In TVET, not only trainers but also educational administrators and trainers must consider these individual workplace characteristics. One valuable topic that should be addressed and enhanced is the area of operations management (OM). OM is defined as the set of activities that create value by efficiently transforming resources into products and services in an efficient manner (Esmaeili et al., 2024; Heizer et al., 2017; Merigó et al., 2019). It can support the learning process in TVET by combining both the resources of the educational institution and the learning-teaching process in a way that emulates real industry contexts. This approach can be used to achieve quality and excellence in the educational process. This approach can be used to achieve quality and excellence in the educational process.

The Colombian garment and textile sector is a complex ecosystem comprising numerous key players. The government, through the National Apprenticeship Service (SENA), facilitates collaboration between companies, unions, worker associations, universities, and research entities. The "sectoral design, garment and fashion roundtable" has been established with the objective of identifying the challenges currently facing the industry, with a particular focus on training and employability (Agudelo et al., 2018). The roundtable is composed of representatives from a diverse range of institutions, including universities, research entities, and institutions specializing in TVET. Given their close ties to the nation's productive sector, TVET institutions are well-positioned to address the specific training needs that arise (Velásquez et al., 2020). Indeed, there is a robust interconnection between companies and TVET institutions. As the Chamber of Commerce of Bogotá notes (Chamber of Commerce of Bogota et al., 2018), the capacity to generate timely and relevant training processes is directly linked to the development of a country or region's productive capacity.

Several Colombian institutions offer programs related to industrial garment manufacturing. These programs frequently include workshops that closely resemble real-world garment factories, allowing trainees to gain practical experience of production. However, the Bogota (Chamber of Commerce of Bogota, 2015) highlights the challenges faced by many of these institutions, which mirror those of the broader garment sector. These include difficulties in process management, service delivery issues, high costs, low productivity, and inadequate technology.

Although there is an important focus on the development of the trainees' skills, there is not a clear route to integrate OM decisions into TVET. These decisions could help organizations improve their performance. As TVET institutions emulate real workspaces, the application of OM decisions can support the technical activities performed in the learning process.

Considering these issues, the research questions of this paper is what are the OM elements that TVET institutions should integrate to enhance the learning process for both trainees and trainers? To solve the question, this paper aims to design a methodology to diagnose how the OM decision impacts the training process in TVET institutions by using a case study in Medellín, Colombia.

The paper is organized as follows. In the first section, a literature review about the integration of OM decisions and their application in the education sector, with a particular focus on TVET institutions, is presented. Then, in Section 2, the methodology of this research is presented. Section 3 presents the results of the implementation of this methodology, and finally, in Section 4, the conclusions and future research lines are stated.

Literature review

Several studies have focused on the importance of the effective incorporation of different skills for the trainees in TVET, but they have primarily focused on the development of soft skills, technical training, and the use of innovative educational technologies, leaving a gap in how OM principles can be integrated into TVET programs. In this sense, Dogara et al. (2020) reviewed how the educational planning, tutoring and evaluation impact positively on soft skill development among technical college students While their study highlights the value of structured educational practices, it does not delve into how OM principles could be incorporated to enhance the training process itself. Similarly, Shalender et al., (2024) studied the potential of realistically simulating real-world environments by virtual reality in vocational education. The benefits of virtual reality are widely acknowledged by all stakeholders in vocational training, making it a promising technology for widespread adoption. However, this approach remains focused on pedagogical innovation and does not examine how OM frameworks could improve the operational aspects of TVET institutions themselves.

The role of OM in bridging the gap between educational institutions and the workplace is underexplored in TVET. Oviawe (2018) discussed the potential of public-private partnerships models to improve the

skills development and reinforce the TVET by sharing resources between TVET institutions and industries. Oviawe et al., (2017) further emphasized the importance of collaboration between educational institutions and the workplace to offer opportunities to trainees to achieve skills to meet global standards requirements. Though, these studies fall short of addressing how OM tools, could directly contribute to enhancing the operational alignment between TVET programs and industry requirements.

There are different approaches to use OM models across a range of manufacturing sectors. Gutiérrez Pesantes (2009) designed and implemented an integrated operations management model in a clothing company. This model led to a significant improvement in production, efficiency, quality, cost, and productivity indicators, resulting in an increase in the company's profitability.

OM has been used within education sector, though mostly through limited approaches such as gamification and discrete event simulation in teaching OM itself. Liang and Liu (2021) proposed a learning model based on discrete event simulation to teach OM, responding to the demand for educational methods that align with market needs. Although this work highlights the use of OM as a subject in education, it does not explore the integration of OM as a framework for managing educational institutions or training processes themselves. Similarly, Lewis and Maylor (2007) developed a two-phase research study to analyze existing games to teach OM. They found that the emphasis of the different games was focused on the subject to be taught rather than on improving the OM of the educational institutions.

An alternative approach to the topic is presented by Marchioni et al., (2022), who presented a model that used the overall equipment effectiveness (OEE) index applied to the education sector. This data-driven indicator measures the outcomes of OM in higher education institutions, including student retention, performance, and graduation. This use of OM tools in education provides a potential framework for assessing the effectiveness of TVET programs, but the study is focused on higher education rather than vocational institutions, and it does not address the specific operational challenges of TVET institutions. Although TVET has a direct relationship with the real-world companies' processes, there is still a gap between the use of OM tools in TVET institutions to improve their operational efficiency and better align with industry standards.

This study addresses that gap by proposing a methodology for diagnosing key OM elements that can enhance the operational management of TVET programs. By focusing on elements such as planning, preparation, manufacturing processes, and warehouse management, this research builds upon the existing literature on OM in industry and education while exploring its underdeveloped application in the vocational training sector.

Materials & Methods

This paper proposes a three-stage methodology to diagnose key elements of OM requiring attention within technical and vocational training activities for the Colombian garment industry. The methodology was developed and validated through a case study in a garment workshop from the training center CFDCM located in the metropolitan area of Aburra. Figure 1 presents the proposed methodology. To access required data, three tools were used. For characterizing stage, institutional documents were reviewed. For OM activities stage a focus group was used with particular emphasis on the data generated by the interactions among the group members (Bonilla-Jimenez & Escobar, 2017). For assessment stage an intentioned survey was targeted to trainees, trainers, and managers.

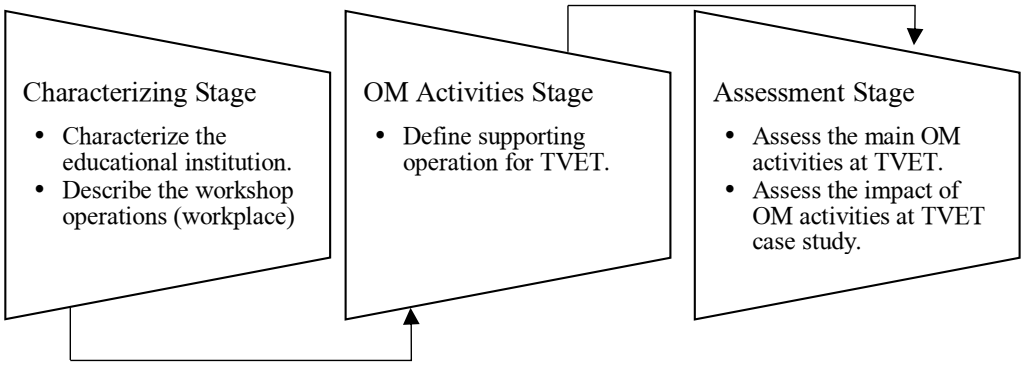

Fig. 1. Methodology for the diagnosis of the impact of operation management elements in TVET

Characterizing stage

This stage aims to collect institutional information about the organization (SENA), its structure, and the training center "Center of Training in Design, Garment and Fashion (CFDCM) in Spanish" ant its workshops where the study is made. Additionally, operational information about the CFDCM is required focusing on the activities to support the TVET. The main idea was to analyze how the institution is organized and identify the workshop operation inside the CFDCM of in terms of its infrastructure, resources, personnel, lines of command, functions, products, and services. As a result, a characterization card for the garment workshop including three components (general workshop information, management assessment and weaknesses, strengths) was defined.

OM activities Stage

This stage aims to analyze the garment workshop as the work/training place where the operations that support the development of TVET activities are carried out. It defines what technical activities support the training process at the specific garment workshop. This stage is carried out by using a focus group through two different approaches, the first one was a semi-structured grouped interview and the second one was a discussion group to validate and consolidate the main OM activities in the CFDCM.

The participants of this focus group were selected according to their experience and personal criteria searching a balance of participants from different roles (non-discriminatory) within the training activities (e.g., trainers, administrators). The following roles and Experience were used to select the focus group participants:

- Operational Knowledge: Participants should be familiar with the operations that support technical training activities and have common experiences in this regard.
- Decision-Making Authority: Participants should have a role in making important decisions related to the operations of the training activities.
- Stakeholder Representation: Participants should be involved in providing services within the training activities (e.g., trainers, administrators).

Personal Qualities:

- Reflective Ability: Participants should be able to reflect on the needs of the population they represent within the training activities.
- Communication Skills: Participants should possess strong communication skills to effectively share their experiences and perspectives within the focus group.
- Teamwork: Participants should be comfortable working collaboratively within the focus group setting.
- Adaptability: Participants should be open to change and willing to consider new approaches to improve the training activities.

The focus group had nine participants, including the general TVET coordinator, three academic coordinators, four trainers, and one administrative assistant. Once the focus group has been formed, the next step is to define the moderator to encourage a diversity of opinions in the group. As moderator of the focus group was the first author of this research.

Finally, we planned the questionnaire and the protocols to develop the different session with the hole group. Two groups of questions were set. One group of questions related to the educational institution and the garment workshop, their resources, processes, and operations. The other set of questions related to get deeper in the services and operations supporting the TVET activities inner the garment center.

The focus group session was conducted according to the research protocol. All participants attended. The moderator facilitated a fluid discussion dynamic that encouraged the expression of diverse perspectives. The two groups of questions were covered in depth, and responses and observations were thoroughly recorded. At the end, the participants' understanding of the topics discussed was confirmed and the collection of the required qualitative data was confirmed.

For analyzing the information from the focus group sessions, we use two phases procedure used by Bonilla-Jimenez and Escobar (2017). The first phase was to code and classify the information by reviewing the transcript of the discussions. The second phase was to analyze the original information together with the transformed conceptual information. Here it is necessary to have a good interpretation, to analyze well the comparisons and the points of view. It is important to distinguish between personal opinions and the consensus reached by the group.

As a result, this stage dives deep into the operations that power TVET activities at the garment workshop. We map out everything from the materials and resources used (inputs) to the training programs delivered (products).

This includes how information flows, who the key players are (suppliers and customers), the management style, relevant policies, quality control measures, and even the layout of machinery and technology.

Assessment Stage

To assess the relevance of the activities that support the technical TVET garment workshop and get a reality check on its, a survey was conducted. This survey provides an initial diagnosis based on the feedback of the workshop's users (who are the user of these train-

ing activities). The following activities were carried out as part of this stage.

- Validity, design, and survey application. We brought together a focus group to discuss the different elements identified in the workshop operations description. This group helped us develop initial questions to diagnose the effectiveness of the workshop's OM. We streamlined the questions by removing duplicates and focusing on those most relevant to the workshop's specific operations, as outlined in OM principles (Heizer et al., 2017).

We transformed open-ended questions into scaled response options (using a Likert scale, where 1 represents the lower level and 5 represents the higher level of the assessment) divided into two groups of questions, the first one related to assess the process performance from the respondent perspective. The second group of questions related to scale different supporting services of workshop to the training process. Finally, with the help of the focus group, we ensured the content validity ratio (CVR) for the survey instrument. This process followed the procedure proposed by Lawshe (1975) (1).

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \tag{1}$$

where, n_e – number of panelists agreeing the category as "essential", N – Total number of panelists

This process supports the survey "content validity", meaning it accurately reflects the workshop's GO aspects we're measuring (Hernández-Sampieri et al., 2018). We designed the final survey using Google Forms. Given that in-depth knowledge of how the workshop works is crucial, a non-probabilistic sample was chosen to survey. This means we targeted trainers, managers, and administrative staff, as they are key users of the workshop.

- Data tabulation and reliability of the instrument: The survey was completed by 30 people from the garment workshop. Participant were 10% managers, 13% administrative (academic coordinators), 6.6% technicians and 70% trainers. The data from the survey was tabulated in Excel.

Subsequently, the reliability of the instrument was verified. This was done by means of the internal consistency measurement procedure, calculating the Cronbach alpha coefficient (2). The result is as follows:

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum v_i}{v_t}\right) \tag{2}$$

where,

α – Alpha de Cronbach
K – number de questions = 25
v_i – Variance of each item de = 15.57
v_t – Total variance = 60.89
Alpha de Cronbach was equal to.

$$\alpha = \frac{25}{25-1}\left(1 - \frac{15.57}{60.89}\right) = 0.78$$

As this value is higher than 0.7, it is possible to determine the instrument is consistent (Lance et al., 2006).

In addition, the value of the Kaiser–Meyer–Olkin (KMO) (Kaiser, 1974) numerical indicator was determined to test the adequacy or suitability of the data for factor analysis.

Results

Characterizing the CFDCM of SENA

SENA is a free government entity that provides technical, technological, and complementary training to empower companies and workers aiming to boosting the national workforce. With SENA's help, businesses can sharpen their competitive edge and achieve better results in the marketplace. But SENA's impact goes beyond individual companies. By investing in training infrastructure across the country, SENA fuels both social and technical development for workers in different regions. This comprehensive vocational training program aligns seamlessly with the national government's goals.

One of the multiple services provided by SENA at the national level is the integral professional training, which is carried out in each of the 117 training centers that are operating in the country. The CFDCM offers training programs in technical, technological, and technological specialization. The training center's infrastructure consists of administrative areas, common areas, support services, conventional and technical training environments, an industrial garment workshop, and 20 satellite workshops in the Aburra Valley Metropolitan area.

The CFDCM boasts a real-world training ground – a garment workshop that mirrors the setup of an actual garment factory –. This space is fully equipped with personnel, machinery, and all the necessary resources to support the garment industry to provide a hands-on learning environment for apprentices and trainers enrolled in industrial garment programs. After analyzing the organizational structure stated by the institutional documentation to characterize the educational institution and their training center, a characterization card for the garment workshop is developed. (Table 1, Table 2, and Table 3) show the characterization cards.

Table 1
Garment workshop general information card

Item	Focus group answer
Workshop goals	To provide services as support to the training activities developed by CFDCM apprentices. To manufacture garments for the "SENA supply SENA" strategy, and SENA self-consumption. To offer technological services for pattern-making, scaling, and computer-assisted tracing areas.
Stakeholders	Apprentices, trainers, managers, administrative staff, contractors, suppliers.
Raw materials and supplies	Different designs, colors, textures, and materials fabrics. Supplies such as threads, yarns, zippers, buttons, packaging bags, fringes, yarns, etc., must also be available.
Garment units	Polo shirts, aprons (male and female), men's shirts, men's and women's jeans, blouses, men's and women's pants, skirts, shorts, overalls, sportswear, institutional uniforms, hospital garments, etc.
Staff	1 academic coordinator, 1 secretary, 3 technical officer, 30 trainers, 1 cutter, 4 maintenance technicians, apprentice/trainees.
Manufacturing modules	The modules are equipped with machinery, equipment, and technology for garments in 3 lines: underwear and sportswear, outerwear, and denim garments. Each module has an average of 25 machines.
Machines	Most of the machines are flatbed, filleting, and coating, but there are special machines such as buttonhole machines, buttoning machines, pressers, multi-needle, elbow seaming, etc. These machines are electronic and electro-pneumatic.
Design capacity	Main workshop: 14 groups / day (25 apprentices per group). Satellite workshops: 40 groups / day (25 apprentices per group)
Training support processes	Planning, procurement, receiving and managing supplies, products designing and developing, Production scheduling and controlling, pattern making and cutting, garment., quality management, outbound logistics, maintaining, continuous improvement.
Training processes	Processes implemented by each trainer to guide the training, such a: preparation, execution, evaluation, corrective actions; applying didactic techniques, session planning, and pedagogical strategies.

Table 2
Management performance measure for the workshop card

Item	Focus group answer
Management performance measure	The academic coordination and administration of the CFDCM have recognized that the effective OM in the workshop can have both positive and negative impacts on various aspects of their performance, including product and service quality, costs, productivity, training activities, and customer satisfaction for both trainees and trainers. However, they admit that they have not yet quantified the extent of these impacts. For instance, they are unaware of the operating cost when services are provided correctly or the quality of training when workshop services, such as maintenance, are satisfactory for internal customers. The academic coordinator and the entire focus group acknowledge that the workshop currently lacks any performance index to measure OM. Therefore, they request, if possible, to formulate a performance index.

Table 3
Strengths and weaknesses of the workshop card

Weaknesses	Strengths
1. There is no process map or organization chart. 2. There is no standardization or control of procedures. 3. There are no permanent people in charge of the workshop operations. 4. The purchasing management process is weak: due to low budget allocation, long contract formalization and execution times. 5. There is no catalog of products and services; the work is based on customer specifications. 6. Late deliveries of materials, in process or finished products. 7. Lack of control and tracking of the support processes for academic activities: maintenance, production control, quality control. 8. High waiting times in the processes of design, cutting, outbound logistics. 9. Users are not aware of the full implication of operations management as a support to training and the benefits. 10. Lack of integration or communication among workshop stakeholders executing the processes. 11. Lack of support from trainers who can contribute to workshop operations. No formal assignment of workloads. 12. The maintenance process lacks personnel for adjustments on special machines. 13. Resistance to change on the part of the shop floor personnel who execute processes. 14. High reprocesses.	1. The workshop employs skilled and knowledgeable individuals who are committed to their work. 2. Processes such as planning, production scheduling and control, purchasing, design and development, layout and cutting, garment-making, maintenance, warehouse, and improvement are well executed. 3. Technological updating and its appropriation in the use according to the productive sector. 4. Workshop personnel possess a high level of knowledge regarding the processes carried out in the workshop. 5. Technical data sheets are well-prepared. 6. Consolidation of the technical office as a strategy for processes and services. 7. Knowledge management has advanced through the technical unit. 8. Workshop operations management has shown progress, although it is not always documented. 9. Permanent updating of the garment sector and operational reality. 10. Continuous improvement is achieved by applying tools such as 5s, visual management, and SMED. 11. The physical space and organization of spare parts and machine shop need to be considered.

OM activities Stage

Whit the CFDCM characterization finalized, a first group of questions were made to the focus group to Define supporting operation for TVET. Figure 2 shows the organizational structure of the CFDCM and the supporting operation activities for TVET. The academic coordination of the CFDCM has three main departments and the supporting operations for TVET are under the technical office responsibility. The main operations are planning, production, schedule, and control, purchasing, raw materials and warehousing, product design and development, pattern-making and cutting, garment manufacturing (sewing), quality control, final product packing and shipping (outbound logistics), maintenance, and continuous improvement.

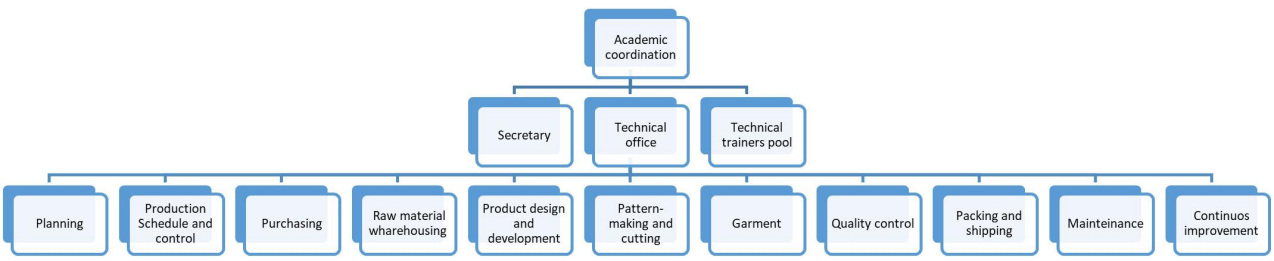

Fig. 2. Organizational structure of the CFDCM

Assessment Stage

To assess the impacts of the different process inner the workshop garment training center, a survey was implemented. The survey was designed to ask for the actual level of performance of each identified key process. We divided the survey questions in two groups. The first group includes questions 1 through 14, which primarily focus on evaluating the operational processes within the workshop. The second group encompasses questions 16 through 27, which address broader aspects of Operation Management, including equipment, logistics, and environmental conditions. In this study, we employed a 90% confidence interval to analyze the survey questions. By calculating the confidence interval for each group, we aimed to assess the reliability and variability of the participants' responses. The results of this analysis are presented in Table 4, providing a statistical framework that underscores the precision of the findings and supports the conclusions drawn from the data. Shaded cells indicate that the highest percentage of responses were considered at this value on the Likert scale.

The value of the Kaiser–Meyer–Olkin numerical indicator for the whole data is 0.35, it can be noted that it takes a low value given that the group of questions considers two internal situations. Therefore, the best interpretation of this value corresponds to that associated with each group of questions. The value of this indicator is 0.67 for the first group and 0.46 for the second. It can be suggested to reconsider the inclusion of items that have an associated KMO lower than 0.40.

For the first group of questions, the focus group identified several critical challenges affecting the operational processes in the workshop. A lack of effective planning for machine and material readiness was a major issue, with delays in the availability of materials, supplies, and personnel, often due to budget constraints. Equipment shortages, inadequate lighting, and poor environmental conditions, particularly heat, further hindered operations. The slow purchasing process caused delays in receiving materials, impacting the training workflow.

Organizational inefficiencies were noted, such as limited schedules and the absence of responsible personnel at key times. There is a need for better inventory management, including a digital system and an expanded warehouse for better material and product organization. Communication gaps were evident in patternmaking and documentation, highlighting the need for better coordination with the technical committee.

Despite these issues, the staff showed a commitment to delivering quality processes when properly resourced. However, the overall effectiveness of these operations is hindered by the inconsistent availability of personnel and resources, emphasizing the need for structural and logistical improvements in planning, maintenance, and quality management.

The focus group findings for the second group of questions, reveal both strengths and areas for improvement. Technologically, the workshop is well-equipped and aligned with the needs of the garment sector, providing apprentices with a solid foundation for training. However, outdated machines remain in the facility, and there is a need for their replacement to ensure efficiency.

The workshop's location, distant from much of Medellín's population, was a noted challenge, with a recommendation for relocation closer to the city center. While the workshop's size is considered appropriate, the participants suggested expansion to accommodate future needs. The layout, though generally suitable, could benefit from a detailed study to optimize space distribution.

Regarding performance, the workshop team demonstrates strong skills and competence, though there are opportunities for further improvement. Environmental factors, including high temperatures and inadequate air conditioning, were significant concerns, as they create discomfort for apprentices and pose potential health risks. Improved lighting was also recommended to enhance working conditions.

The workshop faces staffing shortages, particularly in key operational areas such as quality control, production, maintenance, methods, and timing. Addressing these gaps is essential for improving the overall efficiency and effectiveness of the training program. These findings highlight both the workshop's technological strengths and the need for targeted enhancements in its operational management.

Lastly, the focus group provided valuable insights in response to the question regarding additional aspects to improve the garment workshop's operations management. They emphasized the need for better machinery maintenance, more quality management positions, and additional staff in production control and methods/timing. They also recommended improving logistics, inventory management, and the system for hiring instructors. Documenting processes was highlighted as essential for operational consistency, and participants called for more resources to strengthen management. These improvements would enhance the overall efficiency and effectiveness of operations management in the garment workshop.

Table 4
Summary of survey results

Question	Likert scale							
From your perspective, what is the performance level for the following processes?	***1***	***2***	***3***	***4***	***5***	***Lower bound***	***Upper bound***	***KMO***
1 – Planning	0.0%	0.0%	23.3%	53.3%	23.3%	3.79	4.21	0.53
2 – Preparation	0.0%	0.0%	23.3%	53.3%	23.3%	3.79	4.21	0.28
3 – Procurement	0.0%	36.7%	33.3%	23.3%	6.7%	2.72	3.28	0.44
4 – Warehouse management	0.0%	10.0%	30.0%	46.7%	13.3%	3.38	3.89	0.30
5 – Product design and development	0.0%	3.3%	6.7%	56.7%	33.3%	3.99	4.41	0.13
6 – Production Schedule and control	0.0%	6.7%	50.0%	33.3%	10.0%	3.23	3.70	0.35
7 – Drawing and cutting	0.0%	6.7%	40.0%	36.7%	16.7%	3.38	3.89	0.63
8 – Integration	3.3%	23.3%	13.3%	53.3%	6.7%	3.06	3.68	0.66
9 – Garment Manufacturing	0.0%	6.7%	46.7%	43.3%	3.3%	3.23	3.64	0.66
10 – Quality management	3.3%	50.0%	6.7%	40.0%	0.0%	2.53	3.14	0.36
11 – Outbound logistics	6.7%	40.0%	10.0%	30.0%	13.3%	2.66	3.41	0.52
12 – Machinery and equipment maintenance	0.0%	10.0%	56.7%	26.7%	6.7%	3.07	3.53	0.19
13 – Continuous improvement management	0.0%	13.3%	43.3%	36.7%	6.7%	3.12	3.61	0.49
14 – Overall performance	0.0%	0.0%	53.3%	46.7%	0.0%	3.31	3.62	0.28
15 – Do you consider that any process is missing in the workshop? 1. YES 2. NO	66.7%	33.3%	–	–	–	–	—	–
How do you consider the quality of the following supporting services	***1***	***2***	***3***	***4***	***5***	***Lower bound***	***Upper bound***	***KMO***
16 – The design of the garments or cut pieces (basic and specific exercises)	0.0%	0.0%	30.0%	60.0%	10.0%	3.62	3.98	0.26
17 – The materials and inputs used in the garments	0.0%	0.0%	23.3%	56.7%	20.0%	3.77	4.17	0.28
18 – The garment's manufacturing	0.0%	0.0%	50.0%	43.3%	6.7%	3.38	3.75	0.38
19 – The prices of the garments comparing them with the prices of the market:	0.0%	0.0%	13.3%	60.0%	26.7%	3.94	4.32	0.44
20 – The machinery, equipment, and technology in the workshop	0.0%	0.0%	10.0%	43.3%	46.7%	4.17	4.57	0.36
21 – The geographical location of the main garment workshop in Itagüí, for most of the population	3.3%	33.3%	23.3%	30.0%	10.0%	2.77	3.43	0.46
22 The size of the main garment workshop is:	0.0%	3.3%	6.7%	50.0%	40.0%	4.04	4.49	0.13
23 – The workload inside the workshop and the training modules?	0.0%	0.0%	10.0%	66.7%	23.3%	3.96	4.30	0.18
24 – The performance of the people who provide services in the garment workshop?	0.0%	0.0%	3.3%	63.3%	33.3%	4.14	4.46	0.30
25 – The environmental conditions (temperature, humidity, lighting) of the workshop.	16.7%	43.3%	26.7%	13.3%	0.0%	2.09	2.65	0.60
26 – Do you consider that the quantity of personnel attending to the needs of the workshop is?	3.3%	30.0%	40.0%	23.3%	3.3%	2.66	3.21	0.24
27 – What additional factors should be considered to enhance operations management in the garment workshop, such as machinery, processes, quality, location, distribution, personnel, product design, production planning, supplies, inventory, and logistics?						–	–	–

Discussion

Based on the survey results from CFDCM, the analysis has been done from three different perspectives: workshop processes, products attributes, and other aspects of the OM. These findings contribute to the role of OM in TVET, particularly in the garment industry, by providing a case-specific evaluation of OM elements and highlighting both strengths and areas for improvement.

The overall processes received an intermediate score of 3 on the Likert scale of 1 to 5, with a percentage of 53.3% in response to question 14. This intermediate rating aligns with findings from Oviawe et al. (2017), who also noted challenges in aligning vocational training processes with industry standards, particularly in terms of production scheduling, layout design, and continuous improvement. However, unlike Oviawe et al., our study indicates a more specific gap in the implementation of OM tools like production scheduling and control, layout, and continuous improvement processes within TVET institutions. Moreover, the 66.7% participants felt certain processes were missing highlights an operational oversight that warrants further exploration, especially in comparison to more structured implementations of OM in the private sector, such as Gutiérrez Pesantes (2009), where significant gains were reported through OM integration.

The best score was obtained by five processes, with a score of 4: planning, preparation, warehouse management, product design and development, and integration, with percentages ranging from 46.7% to 56.7%, it demonstrates areas where OM principles have been effectively applied in the workshop. These results reflect Marchioni et al. (2022)'s findings, where higher OM performance indicators correlated with improved outcomes in higher education contexts. However, our study extends this by showing that in a TVET setting, practical aspects such as warehouse management and product design offer opportunities to improve the operational performance of vocational education institutions.

In contrast, purchasing, quality management, and outbound logistics obtained the lowest scores rated with a 2, a low score considering the established scale, with percentages of 36.7%, 50%, and 40%, respectively. Our study contributes uniquely by focusing on the specific context of a TVET institution in the garment industry, revealing that even in a hands-on training environment, the omission of robust logistics and quality management processes can hinder the overall effectiveness of the educational program.

Regarding the attributes of the products generated in the workshop (garments, cut pieces, etc.), the aspects of design, materials, and prices obtained a score of 4, with an average percentage of 59%, indicating that the training in these areas aligns well with industry expectations. The quality of Garment obtained a score of 2 within 50% of participants, considering that apprentices produce the products from their technical training activities that need to improve their quality. These findings reflect a gap in the training's ability to meet high-quality standards, a recurring issue in TVET institutions, as highlighted by Oviawe (2018) in discussions of the need for stronger public-private partnerships to enhance quality outcomes.

Based on question 20 in the survey, the machinery technology aspect of OM received the highest favorability rating, with a score of 90% between scores of 4 and 5. Size, distribution, and performance (questions 22, 23, and 24) were three aspects of OM with high favorability score with percentages ranging from 50% to 63.3%. These high favorability ratings suggest that the CFDCM workshop has effectively integrated OM principles in these areas.

The aspects with the worst scores were location and environmental conditions, which both received a score of 2, with 33.3% and 43.3%, respectively. The comments showed that the location was unfavorable for a large part of the population in Medellin. Another aspect with low scores is the environmental conditions like poor lighting and high temperatures in working/training areas. These factors could be critical but often neglected in vocational settings.

As a final comment from the respondents in question 27, they mentioned that there should be efforts to maintain machinery and equipment effectively, establish quality management positions, and strengthen production control processes, methods, and times. Additionally, there is a need to improve logistics, inventory management, and the system for hiring trainers.

Conclusions

The application of the methodology for diagnosing the impact of operations management elements in TVET in the garment industry has proven to be a tool for comprehensively assessing how these elements influence both learning processes and workshop floor performance. This methodology provides a solid framework for analyzing and understanding how various aspects of operational management, from planning to implementation, directly affect the efficiency, quality and adaptability of training programs and work environments. By allowing for a detailed and accurate assessment, this methodology provides the opportunity

to identify areas for improvement and design effective strategies that drive success in both the educational and industrial arenas, thus promoting sustainable and competitive development in the garment industry.

The implementation of the methodology in the case study allows for a detailed analysis of the operations of the CFDCM and its garment workshop. Some conclusions have been reached that shed light on the functioning and efficiency of the overall system.

The systematic description of CFDCM's operations has allowed us to identify the processes, organizational charts, distributions, activities, resources, and customers involved in the workshop. This detailed characterization includes a technical sheet that highlights three fundamental components. Through the diagnosis of the garment workshop operations, using a specific instrument, and carrying out the collection and interpretation of the results, it has been possible to carry out an exhaustive analysis that has allowed us to draw valuable conclusions.

This observation underlines the importance of these elements in the effective operation of the CFDCM. Regarding the garment workshop, it has been observed that the best-performing processes are planning, readiness, warehouse management, product design, and development, as well as the integration of activities. On the other hand, it has been identified that purchasing, quality, and dispatching processes show less optimal performance compared to the others.

These findings provide a clear view of the areas of strength and opportunities for improvement within CFDCM and its garment workshop, which will serve as a basis for implementing effective strategies to drive efficiency and quality in all operations.

This study also has some limitations related to the specific institution. Since SENA is the largest and most important TVET institution in Colombia, it is possible that the context in other institutions may not be the same and the resources may be less. Replicating this study in other institutions could be more difficult for the administrative staff's willingness. The wide variety of industrial, commercial, and service sectors that require training personnel is another limitation of this study. It is possible that the requirements are different for each sector. These limitations could be addressed in future research by replicating first in other vocational centers for other sectors within the SENA and subsequently in other institutions.

As future research, the design of a model of operation research in TVET institution could help to improve the workshop performance in booth, learning and operational processes. This could be done by integrating the variables decision of OM in the supporting process to the training the apprentice inner the workshop. In this sense, it is important to research on how these OM elements can be better integrated into TVET programs to improve both operational efficiency and educational outcomes.

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References

Agudelo, C., Enciso, S., Correa, R.P., Diaz, Y., Rubio, C., Tejada, N., Merchán, S., Vera, Y., Quiroga, J.C., Borda, S., Ramis, L., Sabater, A., Pedraza, N., Santiago, I.D., and Calad, J. (2018). *Identificación y cierre de Brechas de Capital Humano para el Clúster de Prendas de Vestir de Bogotá-Región.* https://www.undp.org/es/colombia/publicaciones/identificacion-y-cierre-de-brechas-cluster-de-prendas-de-vestir

Bahl, A., and Dietzen, A. (2019). *Work-based Learning as a Pathway to Competence-based Education.* A UNEVOC Network Contribution.

Bonilla-Jimenez, F.I., and Escobar, J. (2017). Focal Groups: a Concetual and Methodological Guide. *Cuadernos Hispanoamericanos de Psicología*, *9*(1), 51–67.

Chamber of Commerce of Bogota; PNUD, and Alcaldía Mayor de Bogotá. (2018). *Identificación y cierre de Brechas de Capital Humano para el Clúster de Prendas de Vestir de Bogotá-Región.* https://bibliotecadigital.ccb.org.co/items/7d77ec2f-399a-4904-818c-9feecc349f06

Chamber of Commerce of Bogota. (2015). *Lanzamiento de Lean Manufacturing para el sector textil – confección.* https://prod.aws.ccb.org.co/Clusteres/Cluster-de-Prendas-de-Vestir/Noticias/2015/Diciembre-2015/Lanzamiento-de-Lean-Manufacturing-para-el-sector-textil-confeccion

Dogara, G., Saud, M. S. Bin, and Kamin, Y. Bin. (2020). Work-Based Learning Conceptual Framework for Effective Incorporation of Soft Skills Among Students of Vocational and Technical Institutions. *IEEE Access*, *8*, 211642–211652. DOI: 10.1109/ACCESS.2020.3040043

Esmaeili, R., Shakerian, M., and Yazdi, M. (2024). *Decision-Making in Project and Operations Management BT.* In Yazdi, M (Ed.); *Progressive Decision-Making Tools and Applications in Project and Operation Management: Approaches, Case Studies, Multi-criteria Decision-Making, Multi-objective Decision-*

Making, Decision under Uncertainity (pp. 21–37). Springer Nature Switzerland. DOI: 10.1007/978-3-031-51719-8_2

Fuller, A., and Unwin, L. (2019). Improving Workplace Capacity as the Prerequisite for Effective Work-based Learning: A Co-production Approach. In A. Bahl, A and Dietzen, A (Eds.), *Work-based Learning as a Pathway to Competence-based Education* (p. 26). A UNEVOC Network Contribution.

Gutiérrez Pesantes, E. (2009). *Diseño y aplicación de un modelo de gestión integrada de operaciones y su influencia en la rentabilidad de una empresa de confecciones [Disertación de Tesis Doctoral]*. Universidad Nacional de Trujillo.

Heizer, J., Render, B., and Munson, C. (2017). *Principles of Operations Management: Sustainability and Supply Chain Management. Pearson*. Pearson.

Hernández-Sampieri, R., Fernández-Collado, C., and Baptista-Lucio, P. (2018). Research methodology. McGraw-Hill Interamericana

Kaiser, H.F.. (1974) An index of factor simplicity. *Psychometrika*, *39*(1) 31–36.

Lance, C.E., Butts, M.M., and Michels, L. C. (2006). The Sources of Four Commonly Reported Cutoff Criteria. *Organizational Research Methods*, *9*(2), 202–220. DOI: 10.1177/1094428105284919

Lawshe, C.H. (1975). A quantitative approach to content validity. *Personnel Psychology*, *28*(4), 563–575.

Lewis, M.A., and Maylor, H.R. (2007). Game playing and operations management education. *International Journal of Production Economics*, *105*(1), 134–149. DOI: 10.1016/j.ijpe.2006.02.009

Liang, H.Y., and Liu, F.Y. (2021). Instructional design based on Discrete-event simulation: provide a humanized and complete experiential learning cycle. *2021 IEEE International Conference on Engineering, Technology and Education*, 883–889.

Marchioni, I., Bustos, H., Brańez, T., and Rios, A. (2022). Institutions of higher education and operations management: towards a conceptual model. *Interciencia*, *47*(12), 536–542.

Merigó, J.M., Muller, C., Modak, N.M., and Laengle, S. (2019). Research in Production and Operations Management: A University-Based Bibliometric Analysis. *Global Journal of Flexible Systems Management*, *20*(1), 1–29. DOI: 10.1007/s40171-018-0201-0

Oviawe, J.I. (2018). Revamping Technical Vocational Education and Training through Public-Private Partnerships for Skill Development. *Makerere Journal of Higher Education*, *10*(1), 73–91. DOI: 10.4314/majohe.v10i1.5

Oviawe, J.I., Uwameiye, R., and Uddin, P.S. (2017). Bridging Skill Gap to Meet Technical, Vocational Education and Training School-Workplace Collaboration in the 21st Century. *International Journal of Vocational Education and Training Research*, *3*(1), 7. DOI: 10.11648/j.ijvetr.20170301.12

Shalender, K., Singla, B., and Sharma, S. (2024). VR in Vocational Educational and Training, Conceptual Framework and Adoption Roadmap. In Malik, R., Sharma, A., Chaudhary, P (Eds), *Transforming Education with Virtual Reality* (pp. 201–209). Wiley. DOI: 10.1002/9781394200498.ch12

UN. (2016). *Goal 4: Ensure inclusive and equitable quality education and promote lifelong opportunities for all – SDG Indicators*. Sustainable Development Goals 0verview. https://mdgs.un.org/sdgs/report/2016/goal-04/

UNESCO. (2015). *Recommendation concerning Technical and Vocational Education and Training (TVET)*. https://unesdoc.unesco.org/ark:/48223/pf0000245178

UNESCO. (2023). *Transformar la educación y formación técnica y profesional (EFTP) para transiciones exitosas y justas: estrategia de la UNESCO 2022-2029*. https://unesdoc.unesco.org/ark:/48223/pf0000386166

Velásquez, S., Giraldo, D., and Botero, L. (2020). Strategic analysis of the environment of the Colombian Sectorial Table of Design, Clothing and Fashion using Delphi methodology and structural analysis estructural. *Revista Espacios*, *41*(22), 119–135.