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Concurrent engineering, product life cycle management using cross-functional teams: A case study

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ABSTRACT

Concurrent engineering (CE) aspires to foster a collaborative environment in which all players work cooperatively to optimize resource use. However, such variables can complicate execution in organizations. This analysis aims to detail creating and implementing a CE model in an Iraqi textile factory. Administrative and quality management procedures were used to collect process data. With the enterprise's culture in mind, a CE model centered on modern product management was created. Two programs were used to validate the proposed model's features. From three to one month, the time is taken to plan and approve inventions was reduced. The method now has a stable architecture due to finding deployment problems, potential operator errors, and bottlenecks. This research used a cross-functional team to accomplish the (CE) goal of shortening the product's life cycle while focusing on the product's quality requirements. Leading organizations understand that large cross-functional teams are critical to rapidly developing creative solutions.

Keywords: Concurrent Engineering, Product Life Cycle, Cross-Functional Teams

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1. Introduction

Rapid industry shifts and competitor diversification are reshaping corporate strategies. To remain competitive and sustain long-term success. the launch and production of new goods with shorter de businesses depend on consumer differentiation livery times and a higher quality/cost ratio [1, 2]. There are several business methods for increasing product quality and decreasing end product prices, but the first step should constantly change. Frank M Gryna, Richard Chim Hai Chua, Joseph A Defeo and José Pantoja Magaña [3] claimed that approximately one-third of the final cost of a product is possibly lost between its manufacture and sale. Waste costs result from continuous or intermittent production process failures such as rework, accidental waste, rejects, exceptions, or irregularities [4, 5]. Since these quality issues will jeopardize an organization's viability and prestige [4, 6], attempts should be taken to improve quality control and manufacturing practices. Specific costs and quality issues can arise in small and medium-sized enterprises (SMEs) due to the conventional job strategy, more commonly referred to as sequential engineering (SE). Each stage of the manufacturing process is developed sequentially in this manner. That is, each step of the series begins only after the preceding one has ended. If a mistake happens during the operation, return to the appropriate stage to rectify the situation [7]. This condition affects the time required to produce a product, the final cost, and the product's quality [8]. A transition from sequential engineering to concurrent engineering (CE) will resolve these issues [9]. E is a methodological approach that aims for the integrated and concurrent nature of products and their associated systems, such as production and service [10]. The objective is to streamline the product or manufacturing process by multi-disciplinary coordination and consider consumer needs for field support [11]. From the start, the team considers all factors affecting the development during its life cycle (from conception to termination), including consistency, cost, timeliness, and user requirements [12]. As a result, cycle times for operations are reduced, rework, and mistakes are eliminated, tasks are standardized, services are optimized, and customer loyalty is improved, among other benefits [13, 14]. concurrent engineering has been used in oil and gas schemes and various items ranging from electronics to helicopters and domestic and military equipment [15]. However, few studies have established a straightforward approach for implementing CE in SMEs. Garnica-González et al. [16] indicate that models, procedures, and instruments should be built to promote and systematize processes for resolving current manufacturing company difficulties. Concurrent innovation is examined from the perspective of engineering design in this review. Concurrent engineering strives to eliminate duplication of effort and reinvent goods. So the researcher collaborates (CE) with the product life cycle by using a cross-functional team based on a case study in an Iraqi carpet factory. The study was divided into two sections: the first section included a summary of the literature, and the second section included an application of the beneficial review in a carpet factory. So, in the practical section, the researcher used a checklist to calculate the gap size in the study sample. The main result was the company has a considerable size gap among the statements of the checklist which evaluates the ability of the carpet factory to implicate concurrent Engineering. The primary recommendation was that the factory should use (CE) to eliminate the product life cycle in order to achieve a comparative edge. Concurrent innovation applications have an impact on the future of factory management when they include corporate planning teams in improving, manufacturing, and promoting products in advance of superior merit and at a lower price. Facilitating coordination and co-operation is essential, as is strengthening contact between the different production process members. The aim of this article is to determine the company's ability to minimize the time lag between the discovery of a product concept and its actual implementation if concurrent innovation is used.. For this research, the carpet factory is selected because this factory implements industrial practices, therefore the research problem divided into (2) sections:

1- Does the top management support concurrent engineering as an approach to shorter the product life cycle?
2- Does the cross-functional team could collaborate effectively to attain concurrent engineering results.

2. Literature Review

2.1. Concurrent Engineering

Recently, sustainability has emerged as a critical aspect of modern goods. Sustainability refers to the characteristics of a commodity that exist from conception, growth, manufacture, usage, and maintenance, all the way to the product's end of life (disposal). Sustainability requires a commodity to serve its primary role, i.e., technological role, and its properties in terms of social (including political), environmental, and economic aspects [17, 18]. It is essential because manufacturers' objective is to create and distribute as many goods as possible on the market to maximize profit. Simultaneously, they want to produce goods at the lowest possible expense, regardless of the detrimental effect on the environment caused by the product's manufacturing and consumption. Concurrent engineering is a philosophy that puts together product engineering, process engineering, market research, customers, knowledge experts, quality specialists, and suppliers to create products and processes that exceed consumer requirements [19]. Concurrent Engineering is a method for designing and developing engineering products. Concurrent architecture, also known as simultaneous engineering, is a form of product design and development in which the various phases occur concurrently rather than sequentially. It reduces product production time and time to market, resulting in increased efficiency and cost savings. Concurrent Engineering means provides a collaborative, cooperative, collective and simultaneous engineering working environment. Foster [20] demonstrates how concurrent engineering culminated in the concurrent execution of the operations. Concurrent Engineering is often associated with the creation of cross-functional teams. Concurrent engineering would not add any more time or expense to the design process. It is critical for achieving half-price products and halving the time required for consumer adoption or steady output of eligible products [21]. It uses five central tenets to guide its simultaneous development:

1. a process.
2. a multi-disciplinary team.
3. an integrated design model.
4. a facilitation.

5. a a computer network service.

Putu Dana Karningsih, Dewanti Anggrahini and Muhammad Imam Syafi'i [22] indicate that concurrent engineering based on (8) essential elements, those concepts are identified twofold: Team formation, leadership, and organization theory are given primary importance, while those concerned with the technologies are identified with standard architecture, planning, coordination, and implementation are secondary. Design teams with better integration and coordination are formed with representatives of all the departments concerned [23]. Concurrent engineering is founded on two fundamental concepts. The first is the idea that all facets of a product's life cycle should be closely considered during the early design stages, from functionality to manufacture, installation, testing, maintenance, environmental impact, and finally disposal and recycling. The second principle is that all design processes can take place concurrently [24, 25]. It enables engineers and managers from a variety of backgrounds to work concurrently on product and process design. Concurrent nature has resulted in an increase in product quality and a reduction in the time required to get new goods to market [20]. Figure 1 indicates the design life cycle developed by concurrent engineering.

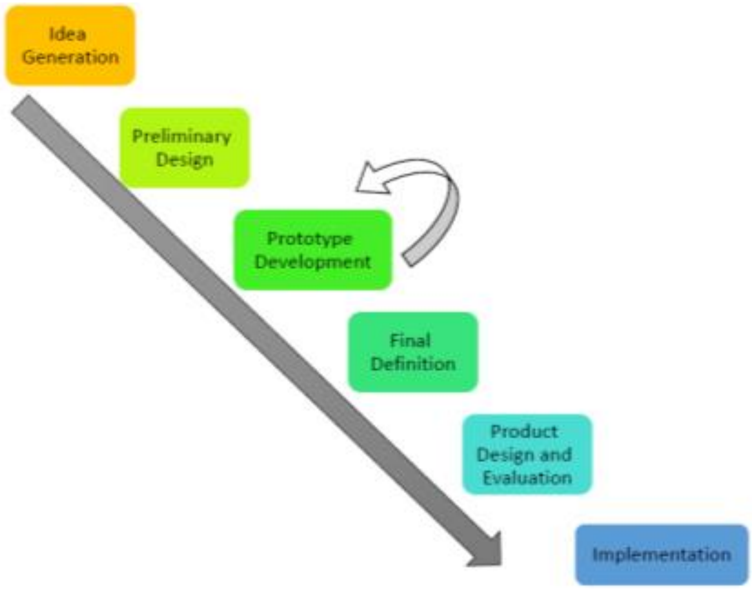

Figure 1. Design life cycle using concurrent Engineering Source: Foster,Thomas, (2010)"Managing Quality), p: 36

Robert P Smith and Steven D Eppinger [26] describe concurrent engineering as a systematic approach to the concurrent design of products and processes such as manufacturing and service.. Concurrent engineering, also known as (integrated product development), is an approach that utilizes a parallel project life cycle. In contrast, Panneerselvam Sivasankaran and Peer Mohamed Shahabudeen [27] They demonstrate that concurrent engineering, also known as parallel or simultaneous engineering, is a relatively recent concept seen as a way of achieving sustainable, world-class manufacturing by the majority of companies. Concurrent engineering is a kind of business process reengineering applied to product development. according to Panneerselvam Sivasankaran and Peer Mohamed Shahabudeen [27], Before introducing concurrent engineering, the following must be used:

- Psychology of the top management.
- Philosophy of the organization.
- Methodology of the activities

In a concurrent engineering climate, teams of specialists from various backgrounds are formally empowered to collaborate to ensure the construction proceeds seamlessly. All members have access to the most up-to-date knowledge. The project management and problem-solving approaches and tools used are critical components of achieving parallelism in modern product design and production. The following sentence describes how each of these components relates to the execution of concurrent engineering.

- Project Methods: Collaboration, achievement tracking, and task definition and follow-up are critical.
- Problem-Solving Approaches: In design and construction programs, methods are used to facilitate and promote the seamless description and solution of interdisciplinary problems.
- Technology: Concurrent innovation uses design technologies that facilitate the influential study, experimentation, and representation of innovative model designs across disciplines. Figure 2 Explains the steps of implementing the (CE).

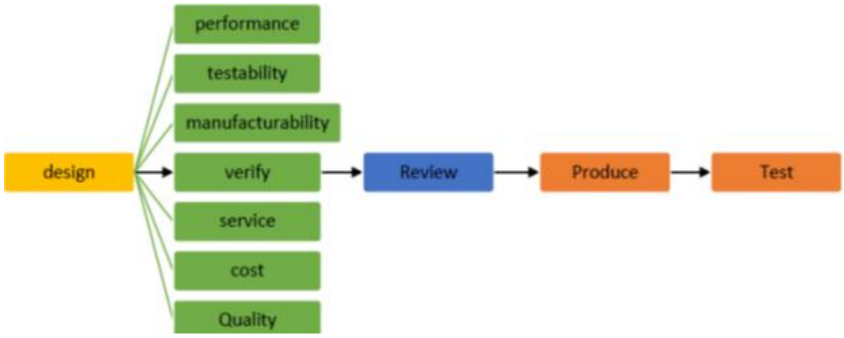

Figure 2. The implementation steps of (CE)Source:Donger et al.; (2017)"Concurrent Engineering: A Review, p: 6

The concurrent possibilities and differences between traditional and concurrent engineering are represented as fundamental aspects and innovations. The main advantages and the main differences between contemporary and traditional engineering are clarified in figure 3.

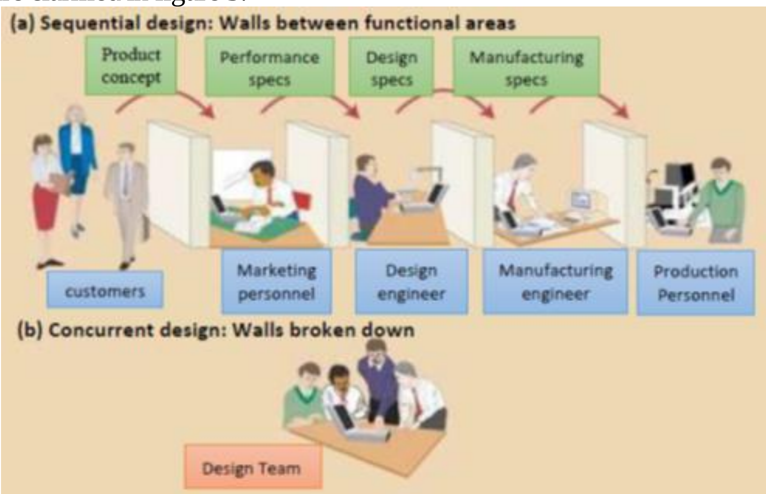

Figure 3. Sequential & Concurrent design Source: Reid & Sanders, (2010),"operations management", p: 60

Figure (3) illustrates the sequential arrangement with walls separating functional zones. The second example depicts a futuristic architecture of dismantled partitions. (CE) refers to cross-disciplinary partnerships and the associated initiative to accomplish universal goals of manufacturing and retailing [28]. According to Panneerselvam Sivasankaran and Peer Mohamed Shahabudeen [27], the following as tools for concurrent engineering.

- Design for Assembly (DFA).
- Design for Manufacturing (DFM).
- Quality function deployment (QFD).
- Effects of Failure Modes and Criticality Analysis (FMECA).
- CAD\CAM\CAE Systems.

Concurrent Engineering necessitates that from the start of a product's conception, manufacturing, and other divisions work together with engineering to ensure, among other aspects, that the product can be assembled effectively until it enters development [29]. As a result, there are seven distinct categories of events that contribute to the achievement of the (CE):

- Establishment of objectives.
- Product development.
- Style.
- Organizing the manufacturing process.
- Manufacturing.
- Production and assembly.
- Distribution.

Figure (4) shows the flow of concurrent engineering activities

Figure 4. The flow of concurrent engineering activities Source: Dongre et al., 2017

But, Maria Kitchoukova and Nelly Staneva [30] show the activities of (CE) by posited the process paralleled with the makeup process, which saves a lot of time, As shown in figure (5).

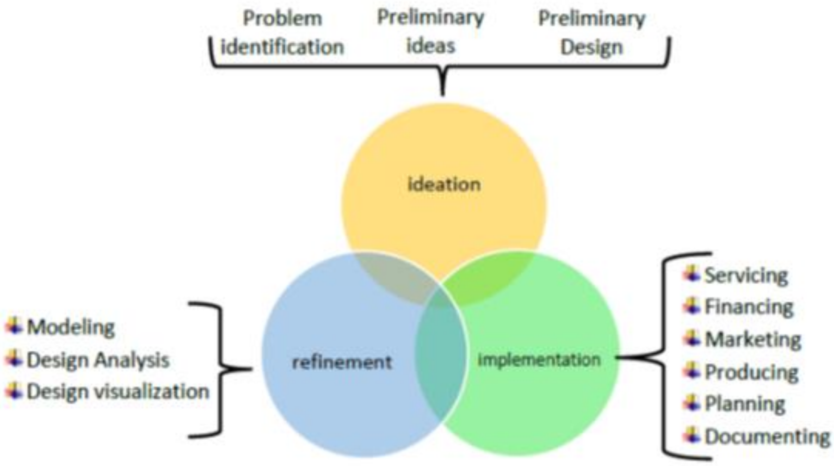

Figure 5. The (CE) of product design Source: Kitchoukova & Staneva, (2014) [30]

George Ellwood Dieter and Linda C Schmidt [31] emphasized the importance of integrating technical design and production staff early in the design process. As a result, both management and new product engines maintain a harmony between the speed and slack needs of the enterprise. Simultaneous Engineering and Concurrent Engineering, on the other hand, are two distinct terms for the same matter. Both contribute to the principle that in order to reduce the duration of a project, multiple projects should be completed concurrently (or partially concurrently), rather than sequentially, and that multidisciplinary teams can collaborate rather than throw items over the wall. The actions of are depicted in Figure 6. (CE).

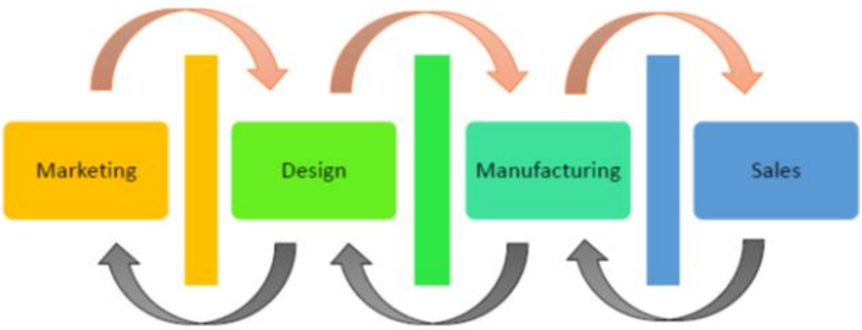

Figure 6. The activities of each department to finish a new product by (CE)

MV Ramana, Laura Berzak Hopkins and Alexander Glaser [32] address design integration as a management method that utilizes multi-disciplinary teams to coordinate all operations from product concept to manufacturing. However, to shorten lead times and costs for new products while maintaining productivity, every firm's new product and service delivery (NPSD) phase is a significant undertaking. [33]. Concurrent engineering helps to remove unneeded modifications and redesigns during the product creation period, resulting in a higher-quality product [34]. The following are the Advantages of (CE):

- It promotes interdisciplinarity.
- Shortens the commodity processing time.
- Expense-effectiveness.
- Improves productivity by assisting during the project's life-cycle.
- Boosts production by halting errors in their paths.
- Has a strategic advantage over rivals.

In contrast, the Disadvantages of concurrent engineering are;

- Management is complex.
- Requires collaboration from both parties; therefore, coordination is crucial.
- Errors are sporadic

2.2. Product Life Cycle Management

Numerous new goods and services have a demand life cycle. When a thing is inserted, it becomes a point of interest [33]. The product life cycle theory is an economic theory that asserts that all of a commodity's goods and labour originate in the region in which it was invented. In certain examples, the agent transforms into an individual that the nation of origin imports. According to Johan Östlin, Erik Sundin and Mats Björkman [35], the product life cycle is a sequence of phases that goods go through over their lifespan, each of which is marked by evolving product demands. Customers should have access to detailed knowledge about the company's goods or services. The term "product life cycle" refers to the time interval between when a product is first delivered to consumers and when it is phased out of the market. The concept is used by management and marketing professionals to optimize advertising, reduce prices, expand into new markets, and update packaging. The process of developing a strategy for supporting and maintaining a product is referred to as (product life cycle management) [36]. James Foster, Joel Greer and Erik Thorbecke [20] illustrate the product life cycle principle by depicting product design, redesign, and related product creation as a process. Hosein Mohammadi, S Saghaian and Parisa Alizadeh [37] state that after introducing a new product, management wishes to gain a reasonable return to compensate for the effort and risk involved in the launch. Thus, the lifecycle of a product's revenue and earnings. It is divided into five distinct phases, as shown in figure: product creation, launch, rise, maturity, and decline (7).

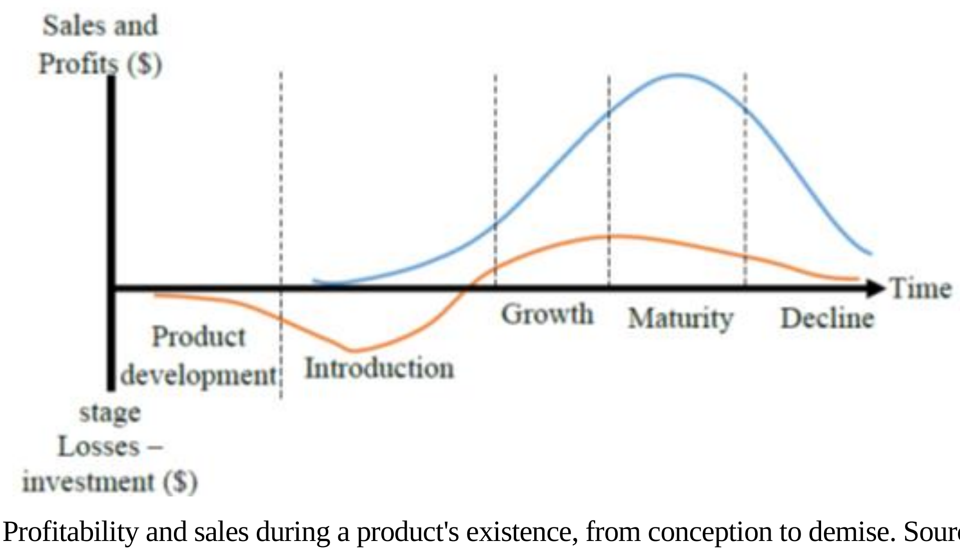

Figure 7. Profitability and sales during a product's existence, from conception to demise. Source: Kotler & Armstrong, [38]

product's life cycle is linked to marketing and management decisions within businesses, and all products move through five key stages [4]. Each stage has its range of costs, opportunities, and risks, and the duration of each stage varies with different goods. As a consequence, the steps of the commodity life cycle can be classified as follows:

1. **Introduction:** this step often involves a significant investment in advertisement and promotion efforts to increase customer awareness of the product and its benefits**.**
2. **Growth:** at this point, the commodity's demand increases, resulting in increased profits. As a result, manufacturing costs fall and profits rise. The origin of the maker of a product increases promotional spending.
3. **Maturity:** at the mature stage, sales will plateau as competition intensifies, necessitating product functionality enhancement to retain market share**.**
4. **Decline:** a commodity faces increased rivalry as other businesses attempt to replicate its success—sometimes by upgrades or price reductions. The product's market share will dwindle, and the product's life will continue to decline**.**
5. **Development:** Also referred to as (the valley of death), the product development cycle involves the accumulation of costs with no associated sales.

Historically, as the product's life cycle progressed, the minor lucrative functions were moved to a lower-cost site. The loop begins with the original product concept, continues with research and development (R & D), and concludes with the product's exit from the market. Each stage is often associated with shifts in the movements of raw materials, manufacturers, components, and delivery to markets as manufacturing (input costs) are optimized to compete effectively [39].

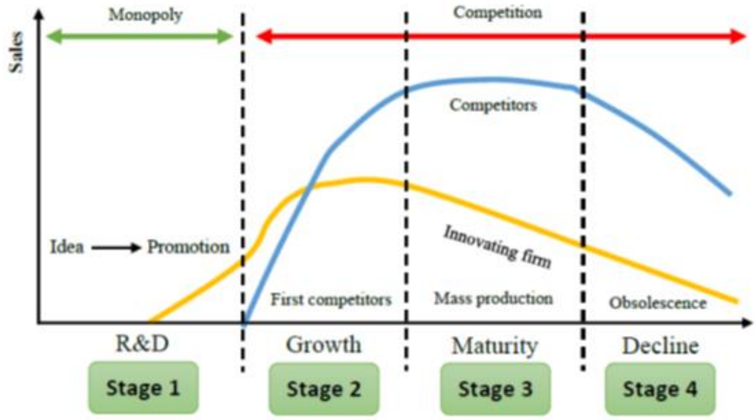

Figure 8. Product life cycle Source: Rodrigue, Jeam, (2020), [39]

Both roles are involved from the outset, often by establishing a new-product production team as soon as design development begins with the product life cycle's first step [40]. Numerous peaceful strategies for organizing and integrating the various phases of a product's life cycle have been created. PLM combines software tools and work processes to solve specific life cycle steps, link disparate functions, and control the whole project. Such tech providers span the entire (PLM) spectrum, while others focus only on a single feature. There are many life-cycle models available in the market. The following steps outline the process of integrating (PLM) into the product life cycle.

- Planning and specifying.
- Developing and analyzing.
- Building is producing and delivering.
- Maintaining and use.

The international product life cycle hypothesis explains the processes in which a product matures and falls as a result of (internationalization). The theory is divided into three stages: -

- New product introduction: At this time, the country's company will develop a new product; the demand for this product will be limited, and as a result, prices will be comparatively poor.

- The Maturity stages: At this point, the commodity producer must consider opening local manufacturing facilities in each developing country to satisfy demand.
- Product standardization and streamlining of manufacturing: At this time, competitive product offerings saturate the market, implying that the initial product's competitive advantage focused on novelty has been lost.

To build the basics of concurrent engineering, the classical way to manage product development processes must be changed. It increased the strain on costs, higher quality requirements, and markets seeking competition necessitate the introduction of innovative technologies for development management.

2.3. The cross-functional teams

A team is a group of people who collaborate, often with little or little supervision, to perform job-related tasks, roles, and activities [41]-[47]. Kijpokin Kasemsap [48] states that a team's composition can influence how well it performs. Specifically, for a positive job community and facilities. The team composition is depicted in Table 1.

Table 1. Team structures

Characteristics	Description	Discrete categories
Interdependence of tasks	The extent to which tasks and outcomes individual's duties depend on the actions of others	• Pooled-no direct interaction • Sequential-assembly-line type task relation • Relationships that are reciprocal and one-on-one • Close cooperation between both parties
Structure of roles	The extent to which • Roles are fundamentally different • Capable of performing independently	• The distinct functional role that cannot be interchanged • Divisional—accomplish every component of the overall mission
Structure of leadership	The pattern or distribution of leadership functions	• Concentrated-single-leadership • Distributed leadership—two or three individuals share the position of leader.
Structure of communication	The flow of communication and information sharing among the team members	• Via a single human, the hub and wheel circulate. • Between team members, a star-free flow exists. • Knowledge flow in a chain-hierarchical fashion
Dispersion of space	The spatial location of team members concerning others	• Physical similarity due to being co-located. • Globally dispersed distributed geographically. • The team's heterogeneous subset co-located.
Team duration	The time span over which the team existed	• Mission execution on an ad hoc basis. • Infinite number of projects for the long run.

A cross-functional team is a collection of individuals with disparate skill sets drawn together by a common purpose. They sometimes form in response to a project that necessitates the skills of several agencies. This form of team necessitates coordination of cooperation and decision-making among the organization's various business functions. PK Ng, GGG Goh and UC Eze [28] characterize cross-functional teams as engineers with disparate and specialized skills that work on various design tasks involving divergent concepts, flair, and potentials. As a result, the most successful operations are now pursuing greater convergence through the use of cross-functional teams. The cross-functional team is broken into two teams which applicating the concurrent engineering:

1. Cross-functional product marketing team: This sort of team consists of representatives from several departments within the organization that are involved in the project. This team can include individuals with experience in repetitive marketing, engineering, software development, electrical construction, or even personnel from another organization.
2. Cross-functional process improvement unit: this team is in charge of designing and establishing the assembly line. To manage a cross-functional team in a straightforward manner, agile management is

needed. However, there are (9) critical leadership qualities that are essential when leading a cross-functional team. These are as follows:

- Superior contact.
- By way of structure.
- Explicitness.
- Mutual comprehension.
- Individualized care.
- Dispute resolution.
- Stable bonds.
- A-Team.
- Adaptability

Concurrent engineering is predicated on cross-functional worker abilities, i.e., the ability of employees to execute a variety of activities on a variety of different devices [10]. Also, Sohee Park, Gary N McLean and Baiyin Yang [49] show that (10) qualities are universal strategic leadership attributes that can motivate and inspire their teams to achieve superior business performance:

Sohee Park, Gary N McLean and Baiyin Yang

- Being receptive.
- Brave.
- Self-disciplined
- Perseverance.
- Motivating.
- Responsive.
- Enlightening.
- Strategic consultants.
- Cooperative.
- ten. A perspective.

Thus, the leadership abilities of those who head parallel engineering teams. Although the need for people skills is probably obvious, the majority of these abilities are natural or developed over time. Are they capable of being educated as needed? Among these abilities are the following.

1. Incorporate different perspectives, especially those of quieter individuals.
2. Resolve disagreements.
3. The developer's abilities.
4. Proceed with little to no jurisdiction.
5. Obtain the required human and other capital. Figure 9 shows how a team leader works and leads the team.

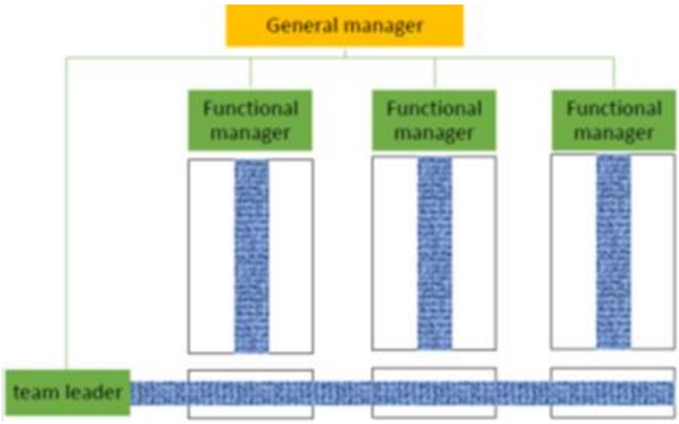

Figure 9. The team leader in a concurrent engineering organization

These cross-functional teams also collaborate on high-level policy initiatives that include many functions [20]. Understanding the team's weak points is the first step in building a cohesive cross-functional team. This pyramid of toxic team traits is based on the five types of team discord:

1. Lack of confidence.

2. Aversion to confrontation.
3. Inadequate dedication.
4. Attempts to evade responsibility.
5. Ignorance of the findings.

Cross-functional teams allow components to communicate and serve as a vehicle for prospect learning [28]. However, a functional group is a permanent collective formed by a corporation to achieve various corporate goals for an infinite period.

3. Methodology

This article is a case study of a general business for woolen industries—specifically, a carpet factory that operates on the SE scheme. Any time the enterprise creates a new product, each department operates independently of the others before the product is sent to the customer. This working method has resulted in high failure rates for goods due to shortages, excessive material usage, unreliable prototypes, a scarcity of raw materials, high price quotations, and project saturation, among other issues. The research shows that such a collaborative process can attain a concurrent engineering approach by building empowerment teams to produce a new product to market faster. The evaluation of the study is based on an analysis of gap size by using the checklist in the factory. The gap size analysis consists of (5) indexes which contained:

1-A list for assessing the employee.
2-A checklist for assessing the automation.
3-A checklist for assessing the collaboration tools.
4-A checklist for assessing empowerment.
5-A checklist for assessing the visual realization.

The (CEO) of the carpet factory stated the problems by helping the researcher analyze statements of the following checklist. The following list is assessing the carpet factory's ability in Iraq to apply concurrent engineering and support the leaders of the company to diagnostic the limitations to attain this approach and solve the problems in the future.

4. Results

Table 2 shows that the gap size reached 62.86%it's too large because of the results of the statement (2) and statement (4). There are no clear roles, documented processes, and standardized training.

Table 2. Results of Employees Assessment

Req.	Items	1	2	3	4	5	6	7
1	The company's new product focus is clear.		*					
2	The appropriate individuals are placed in the proper roles according to their skill set, and all-important new product launch positions are filled.	*						
3	New product-launch processes are documented to enable each team member to execute at a world-class level.	*						
4	Team members have been so well trained on all new product-launch processes to teach a class on the subject.		*					
5	Team members give more than they take. (in other words, team members are not asking for and receiving information more than they offer.)							*
	Weights	1	2	3	4	5	6	7
	Iterations	2	2	0	0	0	0	1
	Weights × iterations	2	4	0	0	0	0	7
	Weighted mean				2.6			
	Match extent				37.14%			
	Size gap				62.86%			

Table 3 indicates that the gap size reached 60%. It's too large because the concurrent engineering approach needs to accelerate the speed of product launches by automating repetitive tasks when it comes to new product development. Using software productivity tools built for flexible systems of production lines, all of these statements are not available in the factory.

Table 3. Results of automation Assessment

Req.	Items	1	2	3	4	5	6	7
1	What do you currently use to document and track new product commercial data from idea to product launch? 1=pen and paper, 2=excel, 4=google sheets, 5=other (i.e., open-source configured and analytics software). 8=PFEP software, 10=PFEP software puts APIs		*					
2	How does data make it from the team member executing the work to product KPIs? 1=functional leads verbalize, 3=program manager collects and presents, 6=all functional leads enter into excel tracking tool, 10=all valid tips enter into the control software tool			*				
3	How and where are product KPIs actuals calculated and tracked? 1=functional leads report, 2=program manager aggregates in excel, 4=leads enter into google sheets, 5=other, 6=leads enter into collaborative software, 10=leads enter directly into PFEP software	*						
4	What do you currently use to document and track new product development and launch tasks? 1=pen and paper, 2=excel, 4=google sheets, 5=other, 6=PFEP software, 10=PFEP software Pius APIs		*					
5	Where are suppler interaction history and notes tracked? 1=not tracked, 2=iemployees' heads/email, 4=pen and paper, 5=other, 6=shared company folder, 8=collaborative software, 10=PFEP software						*	
	Weights	1	2	3	4	5	6	7
	Iterations	1	2	1	0	0	1	0
	Weights × iterations	1	4	3	0	0	6	0
	Weighted mean				2.8			
	Match extent				40%			
	Size gap				60%			

Table 4 explain the gap size, which reached 71.83%, so it's too high versus the match percentage, which came 28.57% that because the extra work and time spent on the process is often the result of inefficient collaboration, such as poor communication, data rework, and having duplicate orders.

Table 4. the results of the collaboration tools assessment

Req.	Question	1	2	3	4	5	6	7
1	1. What is the number of standing weekly meetings (including all functions)? 0=>10, 2=>8, 4=>6, 6=>4, 8=>2, 10= ≤2		*					
2	2. What is the number of reoccurring weekly reports (including all functions)? 0=>10, 2=>8, 4=>6, 6=>4, 8=>2, 10= ≤2				*			
3	3. How many systems are new product data stored in? 0=>10 systems, 2=≤ten systems, 4=≤six systems, 6=≤four systems, 8=≤two systems, 10= 1 system		*					
4	4. How often are new product development and launch information updated and available to the team? 1=not shared, 2=sporadic, 4=monthly, 5=weekly, 6=as requested, 8=daily, 10=real time	*						
5	5. With whom is early new product development information shared? 1=leadership, 2=new product teams, 4=cross-functional teams leads, 6=employees, 8=suppliers, 10=all of the above	*						
	Weights	1	2	3	4	5	6	7
	Iterations	2	2	0	1	0	0	0
	Weights × iterations	2	4	0	4	0	0	0

Req.	Question	1	2	3	4	5	6	7
	Weighted mean				2			
	Match extent				28.57%			
	Size gap				71.83%			

Table 5 indicates that the size of gap 51.43% versus match extent percentage reached 48.57% because the factory only does the specific tasks needed to produce the products to the market to attain the profits faster than the company's competitors. The result is that companies spend far more money and time completing a task internally when they could easily outsource it to a strategic partner to execute at a lower cost.

Table 5. The results of the empowerment assessment

Req.	Items	1	2	3	4	5	6	7
1	All decisions that more junior team members could make have been delegated to them.						*	
2	All tasks that junior team members could do have been delegated to them.						*	
3	The organization incentivized employees, partners, and suppliers in new and different ways. (for example, using performance-based contracts or providing the supply chain team with bonuses/incentives based on profitability.)			*				
4	The organization partners with other companies and suppliers in new and different ways. (for example, they are doing joint research and development.)	*						
5	All activities that an outside partner could more efficiently do have been outsourced.	*						
	Weights	1	2	3	4	5	6	7
	Iterations	2	0	1	0	0	2	0
	Weights × iterations	2	0	3	0	0	12	0
	Weighted mean				3.4			
	Match extent				48.57%			
	Size gap				51.43%			

Table 6 explains that the gap size reached 17.14% versus a lower percentage which recorded 82.86%. That was because the leadership didn't clarify the mission of the company to the employee. Also, there is no explanation for core values, so there is another reason for the size gap that there is no relation between the internal employees and external partners.

Table 6. The results of the vision realization assessment

Req.	Items	1	2	3	4	5	6	7
1	You believe in the company's mission and can verbalize it on demand.					*		
2	You believe in the company's core values and can verbalize them on demand.					*		
3	You believe your work makes an impact in the world.						*	
4	You believe your work contributes to the company's success.						*	
5	Internal employees and external partners (such as consultants, contractors, and suppliers) positively impact new product launches and do not undermine progress.							*
	Weights	1	2	3	4	5	6	7
	Iterations	0	0	0	0	2	2	1
	Weights × iterations	0	0	0	0	10	12	7
	Weighted mean				5.8			
	Match extent				82.86%			
	Size gap				17.14%			

Table 7 shows that the total gap size is 52.65%.

- The checklist of (assess the collaboration tools) recorded the most significant gap size by 71.83%.
- The checklist (assess the employee) was the second in gap size 62.86%.
- The checklist of (assess the automation) was attained a 60% gap size.
- But the fourth gap size was by the checklist assess the empowerment (51.43%).

- The final checklist recorded the smaller gap size (assess the vision realization) was 17.14%.

Table 7. The total gap

	Statements	Gap size
First	Assess the Employee	62.86%
Second	Assess the Automation	60%
Third	Assess the Collaboration Tools	71.83%
Fourth	Assess the Empowerment	51.43%
Fifth	Assess the Vision Realization	17.14%
	Total gap	52.65%
	Match percentage	47.35%

Table 8. The traditional process

	Time (weeks)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Material planning															
Engineering design															
Bill of materials															
Procurement															
Production															
Sell to customer															

Table 9. The concurrent engineering production

	Time (weeks)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Material planning															
Engineering design															
Bill of materials															
Procurement															
Production															
Sell to customer															

The process of concurrent engineering of the carpet factory will embody teams' values of co-operation. Within the overlapping phases of the life cycle will be a series of iterations as following:

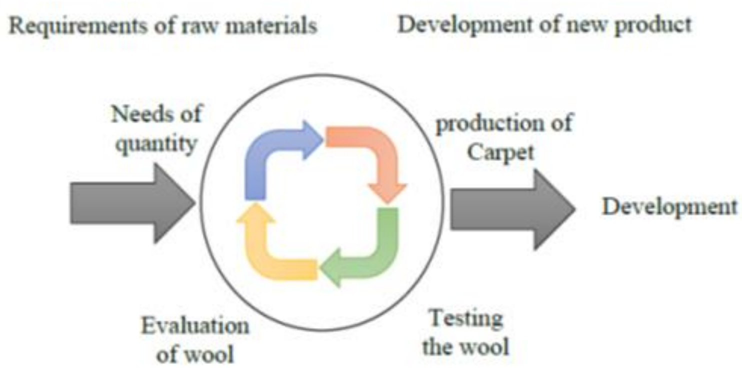

Figure 10. The mechanism of applicating concurrent engineering in the carpet factory

After applying this mechanism, the cross-functional team will play the following important role in developing the new products. All the stages above need to be reviewed by the cross-functional team members who lead the primary role in the concurrent engineering approach.

Table 10. Concurrent engineering model

Investigation production		Design		Process		Production		
Review		Review		Review		Review		

5. Conclusion

Concurrent Engineering is implemented into a model, which eliminates the complexity and drives market efforts. This statement does not imply that no unexpected events or opposition to transition may occur. As is the case for any quality assurance method, deployment intervals are necessary to gain insight and optimize performance. Concurrent Engineering was implemented successfully in the industry because it allowed for customer interaction, which is not popular when designing new products in SMEs. Typically, their involvement is limited to the design stage (due to regulatory requirements) and final product clearance. The main limitation of this study beyond the factory and budgetary is that simultaneous modeling by using the checklist to analyze the gap size was not easy because of the modern concept of concurrent engineering. Concurrent innovation is a rigorous workflow approach that, when used properly, has a positive effect on product quality and the carpet company's goals in Iraq. There are no one-size-fits-all approaches or techniques for each organization or product creation, as shown by the Iraqi carpet company's manufacturing processes. The practice of cross-functional teamwork is the crucial step towards minimizing the gap size in the factory's skills. An empowered team didn't support the product life cycle to attain the product development process. To improve the carpefactory’s competing advantages, the firm must encourage debates and clarifications, enabling knowledge dissemination throughout rapidly. The factory needs to apply concurrent engineering using cross-functional teamwork, which is the essential element of concurrent engineering. The firm's top management should pay particular attention to forming teams and workgroups within the loops of the concurrent product creation phase. The firm needs to identify the conditions, culture, and environment whereby cross-functional teamwork is successfully applied within this organization. Developing successful new products is possible by integrating abilities of both design and manufacturing expertise and deriving the factory capabilities, likeability to create, utilize, and distribute knowledge throughout the process.

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