Platform conceptual model in QFD for generic drug

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Abstract: The objective of this article is twofold: a) to present a seven-steps procedure to build conceptual models and b) to propose a platform conceptual model for developing generic drugs. The procedure for building conceptual models was drawn based on the lessons learned from our eighteen-year long Action Research Program on QFD implementation and the platform conceptual model for generic drugs was obtained from three applications in a government-owned pharmaceutical company. The seven-steps procedure facilitates the process of reasoning, shortens the time spent on conceptual model building and enables the QFD practitioners to use the method to its full extent; whereas, the platform conceptual model makes subsequent new developments easier and faster. Conceptual models as well as platform conceptual models need further testing. We believe this article will help QFD practitioners to go beyond the Quality Matrix, the House of Quality and to make use of the full potential the method offers; in addition, the platform conceptual model derived from this study can serve as a basis for those working with a similar process/ product. The article brings QFD applications to the generic drug pharmaceutical industry, which has an extremely important social impact helping to lower the cost and facilitating the access of the population to health treatment. It also contributes to introduce the concept of platform into QFD conceptual model building.

Keywords: QFD, conceptual model, platform conceptual model, generic drug.

1. Introduction

Comprehensive QFD is subdivided into: 1) Quality Deployment (QD), where the focus is on the deployment of information necessary for achieving the quality of a new product; and 2) Quality Function Deployment, restrict sense (QFDr), where the focus is on the deployment of work necessary for assuring quality. The operational units of QD are: tables, matrices, conceptual models, and standards. Of these, the importance of conceptual model should be highlighted, because it is the representation of the cause-effect "architecture" needed for achieving the quality assurance of a new product. It is through the construction of conceptual model that one comes to identify the tables and the matrices that are needed; also, it is through the information brought out, step by step, by the conceptual model that standards are elaborated before the production begins (CHENG; MELO FILHO, 2007). However, studies have shown that QFD applications have largely been restricted to the first matrix – the quality matrix (CARNEVALLI; MIGUEL, 2008). In addition, in reports where the deployment went beyond the first matrix, there were no descriptions of how the conceptual model had been obtained.

QFD conceptual model usually represents the deployments by which a product can be developed. However, in some of our QFD applications in industry we have realized that it rather represents a platform of products. In this article we take the definition of product platform as the common subsystems, interfaces, and manufacturing processes used within and shared across different individual products (MEYER; DADAL, 2002; McGRATH, 1995; MEYER; LEHNERD, 1997; ROBERTSON; ULRICH, 1998). In the three applications on generic drugs presented in this article, Amoxicillin, Lamivudine and Zidovudine (LZ), and Nevirapine, we introduce the concept of platform into the conceptual model building process, because the similarity of their manufacturing process fulfill the definition of platform.

Very few studies on the development of generic drugs have been published in the world, in spite of their social and economic importance (PRASNIKAR; SKERLJ, 2006). In Brazil, the development of active drug substances is still very limited. However, there is an ever increasing demand for large quantity of generic drugs to supply the Unified Health System (SUS), for free distribution of medicines by the government through hospitals and health units spread around the country (POLICASTRI, 2003). Since the approval of the law of generic drugs (Law 9.787/99) in 1999, there has been a continuous growth in the production and consumption of this type of drug (see Table 1).

In particular, it seems that QFD has not ventured into this type of industry and drugs (CARNEVALLI; MIGUEL, 2008). We see a strong social importance in pharmaceutical development and production of generic drugs, especially as to the free distribution to those who otherwise would have difficulty in obtaining treatment for their diseases. Thus, it is our wish to see more QFD works on products with relevant social impact, and we hope that the conceptual model put forward here will help other similar projects. Therefore, it is our aim to extend QFD applications beyond the first Matrix, to introduce the concept of platform into the process of building QFD conceptual models, and also, to bring experiences of QFD applications into industries where QFD works are rare.

2. Methodology

Our understanding of QFD has been shaped and refined by our studies and implementations in industrial organizations during the last eighteen years through an Action-Research Program (BLUM, 1955; SUSMAN; EVERED, 1978; CHECKLAND, 1981; COUGHLAN; COGHLAN, 2002). This program has resulted in many dissertations and publications (CHENG; MELO FILHO, 2007). In the period of 1993 to 1998, we were fortunate to receive a special assistance by Professor Tadashi Ohfuji of Tamagawa University, who helped us to deepen our understanding of QFD (OHFUJI; ONO; AKAO, 1990). The lessons we learned from our eighteen years long Action Research Program on QFD implementation enabled us to establish a seven steps procedure for building conceptual models.

The expiration of drug patents and the approval of law for generic drugs in Brazil have contributed greatly to enhance government investments on state-owned drug development and production institutions. In the State of Minas Gerais, for instance, financial resources have been made available for building new plants and renew old units at Fundação Ezequiel Dias – FUNED. This institution decided to scale-up three generic drugs, Amoxicillin in capsule, LZ coated tablet and Nevirapine tablet, for production in a new manufacturing unit. In the past, according to the company, the time from pharmaceutical development to production was too long, mainly due to problems related to meeting required specifications of the product during large scale production. To avoid recurrent problems, the company decided to use QFD method to assure the quality of its generic drugs. The intervention was carried out during a period of twelve months. Thus, the platform conceptual model for generic drugs was obtained from three applications in this government-owned pharmaceutical institution. Part of this work has been reported elsewhere (CHENG et al., 2008; CHENG; MELO FILHO, 2008).

A multifunctional team was formed. It involved the areas of Production (Pro), Pharmaceutical Compounding (Pha), Quality Control (QC), Quality Assurance (QA), and Industrial Production Management (ENG). It was expected that this multifunctional team would facilitate the synergy among the actors of the organization and contribute to the early detection of problems, leading, thus, to a successful project. The leader, a supervisor of the liquid line, was given the responsibility of managing the new plant. She and four operators were released from their previous functions to work full-time on this project. Figure 1 represents the structure of work organization and the type of multifunctional team (CLARK; WHEELWRIGHT, 1993).

This structure can be classified as an intersection of functional with light-weight type because, except for the leader and the four operators, the remaining participants were not released from their functional areas to work full-time in the project, and, the leader did not have the power over human and financial resources. The team was divided into four working fronts: a) product, b) control parameters, c) packaging, and d) standards. The team and the area managers received training on QFD method. There were weekly working sessions, divided between the four work fronts, and mediated by the researchers.

3. Intervention

The procedure for building conceptual model we propose is made up of seven steps: 1) to analyze the objectives of the QFD project; 2) to define the deployments in the dimensions

Table 1. Evolution of generic drug production in Brazil. June/2000 - December/2007 (million of units).

Year/month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
2000	-	-	-	-	-	2.55	3.11	4.21	4.84	5.28	3.06	2.46	25.50
2001	2.90	3.43	3.94	5.01	5.59	5.73	7.82	9.59	5.89	8.20	8.26	9.98	76.33
2002	10.72	9.94	9.43	12.02	9.98	9.65	11.67	10.80	12.42	11.72	12.17	11.39	131.92
2003	10.51	9.76	10.50	10.91	11.53	8.91	10.61	11.08	13.31	13.62	10.53	11.35	132.62
2004	11.17	10.11	16.05	15.09	18.95	18.45	19.14	16.48	15.62	17.03	16.98	14.50	189.57
2005	14.19	13.80	18.78	21.10	23.42	24.75	21.04	21.55	18.81	19.27	20.18	20.42	237.31
2006	16.06	19.91	20.58	15.19	26.55	31.87	33.71	32.97	29.41	27.45	29.30	23.07	306.07
2007	27.35	19.95	25.26	26.89	29.81	31.92	30.55	32.35	31.33	31.98	36.47	31.97	355.84

Source: BRASIL (2008).

of quality, cost, technology, and reliability; 3) to visit the production line, or to draw up a possible flow of process when a new line is being planned; 4) to group up items, such as, raw material and processes, in sets; 5) to define cause-effect relationships from client to raw material, in tables; 6) to define the sequence of matrices in the model; and, 7) to draw the conceptual model and to represent extractions (elements to elements) and conversions (numbers to numbers of prioritization). We will refer to these steps in the descriptions of the process the team went through in building the three conceptual models for the three drugs.

3.1. Amoxicillin

The objective of this project was to assure the quality of a new product in the stage of preparation for industrial production (transition from laboratory scale to industrial scale). Therefore, the development team decided that a more elaborated conceptual model was needed, because it was important to establish all necessary contributing factors (step-1). Only the quality dimension was chosen due to the objective of quality assurance (step-2). The new plant was under construction; however, the flowchart of the manufacturing processes was available – it is represented in the bottom part of Figure 3 (step-3). The construction of the conceptual model for this drug was divided in two stages: the first one examined the production process up to the final product capsule, and the second one focused on the packaging process. For the aim of this article, it will suffice to present the first stage. As for the second stage, the reader can refer to Cheng et al. (2008). The team built the production flow in inverted direction, starting from the desired effects - capsule in accordance with the generic drug specification (see Figure 2). It was not necessary to build the Quality Matrix because the product was a generic drug with pre-established technical specifications. After defining the main group of contributing factors, a set of tables was obtained - this is represented in the middle part of Figure 2 (step-4) (step-5). For the definition of the matrices, the team carried out an effect-cause analysis, starting from the table of quality characteristics of final products, in inverted direction of production flow. To establish the sequence of the matrices in the conceptual models, the team followed the same logic by defining, in inverted direction of the production flow, the intersections between the matrices represented in the upper part of Figure 2 (step-6). Finally, the team built the conceptual model represented by Figure 3. Many versions of conceptual model were drawn before reaching the final one (step-7).

The model shown in Figure 3 is divided in two parts. One refers to the continuous process of obtaining Mixture, and the other refers to the discrete process of obtaining Amoxicillin-Capsule in Process (intermediary product-QCIPC) which, after quarantine, is called final product (QCFP). Since the characteristics of the intermediary product capsule are inserted in the quality characteristics of the final product, this table is separated in QCIPC (the triangle QCFP is a table, not a matrix). This distinction was fundamental for establishing cause-effect relationship needed for obtaining the final product, and it facilitated the analysis by the project team.

The team also felt it necessary to collect and analyze other information, thus, auxiliary matrices were constructed as shown in Figure 3. It was important to determine a) the environmental conditions, because these affect the QCIPM and QCIPC; and, b) the storage conditions of capsules (raw materials) and encapsulated amoxicillin, because these may

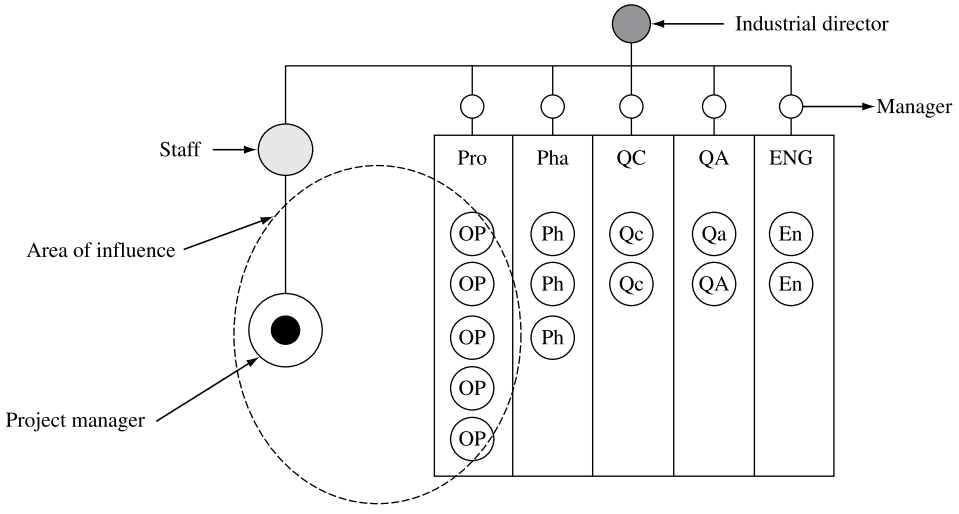
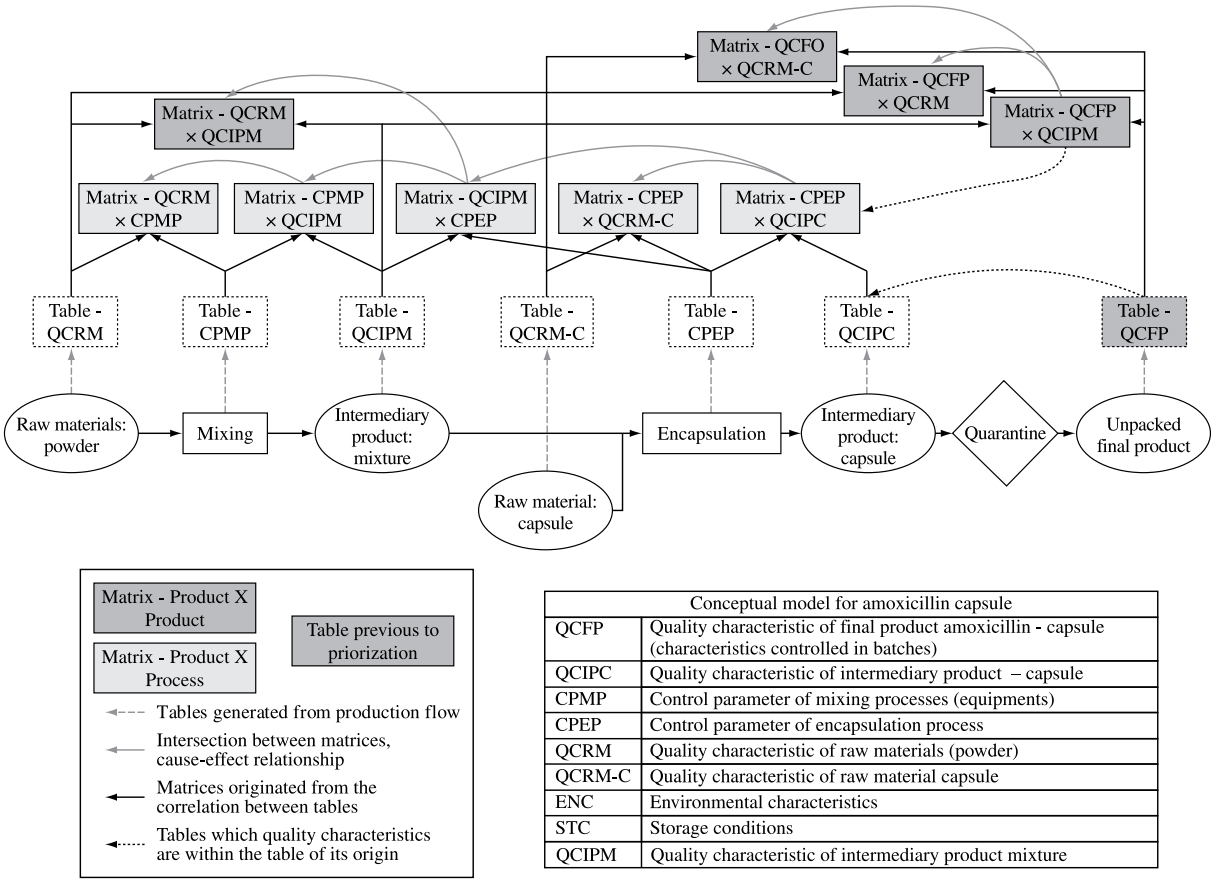


Figure 1. Structure of work organization. Source: NTQI Technical Report – FUNED Project (QUALITY..., 2007).



Conceptual model for amoxicillin capsule	
QCFP	Quality characteristic of final product amoxicillin - capsule (characteristics controlled in batches)
QCIPC	Quality characteristic of intermediary product – capsule
CPMP	Control parameter of mixing processes (equipments)
CPEP	Control parameter of encapsulation process
QCRM	Quality characteristic of raw materials (powder)
QCRM-C	Quality characteristic of raw material capsule
ENC	Environmental characteristics
STC	Storage conditions
QCIPM	Quality characteristic of intermediary product mixture

Figure 2. The construction logic of a conceptual model for amoxicillin-capsule.

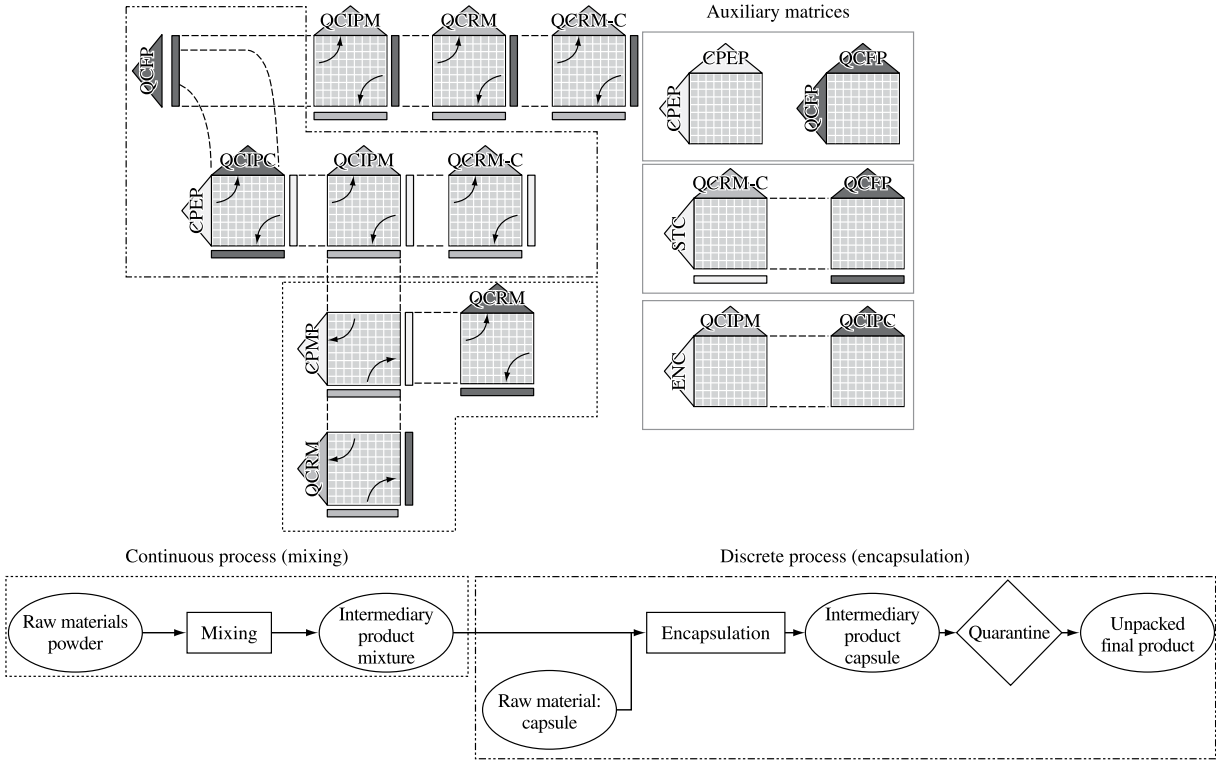


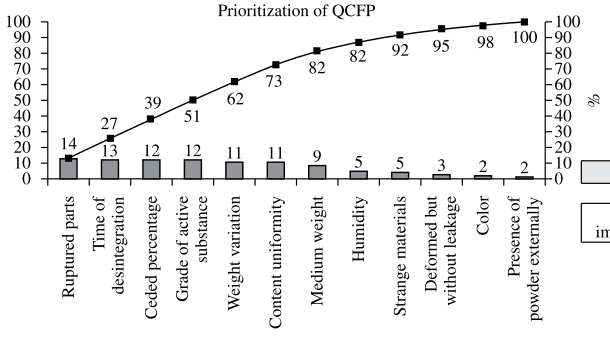
Figure 3. Conceptual model for Amoxicillin-capsule.

be influenced by those conditions. The team elaborated a total of 12 tables and 19 matrices. Figure 4 and Figure 5 show, respectively, examples of table and matrix.

The table of quality characteristics of final product (Figure 4) was elaborated based on Brazilian, North American, European and Japanese pharmacopoeia; and, it was deployed into physical, chemical, and biological characteristics. During working sessions, the biological characteristics were taken out, because they were not measured batch by batch. The team filled up the measure units, the specified values, and the goal for each characteristic (based on generic drug pharmacopoeia). The criteria used for prioritizing the characteristics of final product were: pharmaceutical equivalence, bioequivalence, stability, expected effect in the final consumer, and sensorial satisfaction of consumer (patient). The team attributed weight to each criterion and, then, gave to the parameters the following scores: 5, does influence; 3, may influence; 1, has to be considered; 0, no relationship. In order to facilitate the visualization of the importance attributed to each characteristic, the team drew a Pareto graphic as illustrated in Figure 4. To obtain the QCFP, the team deployed the cause-effect relationship as shown in Figure 5 (see, for example, CPEPxQCIPC). The questions asked were: a) how the control parameters of the encapsulation equipment may interfere with the quality of the intermediary product capsule, and b)what should be the control limits of CPEP for achieving QCIPC. Figure 5 shows this matrix.

The team elaborated a set of production standards: three Quality Assurance Standards (Table of QAS for Capsule, Mixture, and Blister); three Technical Standards for Processes (TSP for Encapsulation, Mixing, and Blistering); and, two Control Flowcharts (CF for Control of Capsule Approval and Blister Approval). See an example of standard in Figure 6.

This work contributed to the early detection of problems related to product, process, and raw material. Two points can be highlighted: a) the specification range of raw material characteristic density, which could have jeopardized the capability of compressing the powder in capsules (final product); b) the quality characteristic humidity of raw material, which upper specification limit was the same as of final product. This specification did not take into



Level 1	Level 2	Level 3	Level 4	Measure unit	Type of inspection	Direction
Physical characteristics	Appearance	Integrity	Deformed but without leakage/ scratched	yes/no	QL	-
			Ruptured parts	yes/no	QL	-
			Strange materials	yes/no	QL	-
		Presence of powder		yes/no	QL	-
		Color		C/NC	QL	-
	Weight	Medium weight		mg	QT	↑↓
		Weight variation		%	QT	↑↓
	Time of desintegration			min	QT	↑
Chemical characteristics	Ceded percentage			% V.R. in minutes	QT	↓
	Grade of active substance			% of value in label	QT	↑↓
	Content uniformity			% of V. R. and DPR	QT	↑↓
	Humidity			%	QT	↑

Projected quality									
Prioritization									
Weight/ importance	3		3	5	1				
	Pharmaceutical equivalence	Bioequivalence	Stability	Bioavailability/therapeutic effect in patient	Sensorial satisfaction in patient	Absolute weight	Relative weight	Specified values - goal	Globe values 1- lot 06050274
	3		1	0	3	15	3%	yes	
	5		5	5	5	60	14%	no	
	3		3	0	3	21	5%	no	
	1		1	0	3	9	2%	no	
	1		1	0	5	11	2%	C	
	5		3	3	0	39	9%	689	604 mg
	5		3	5	1	50	11%	+- 7,5%	–3,20 - +3,10 %
	5		5	5	1	56	13%	<= 45 min	16 min 7 s
	5		5	5	0	55	12%	> 85% (Q+5) V.R. in 90 min	96,34%
	5		5	5	0	55	12%	90% - 120% V.R	99,43%
	5		3	5	0	49	11%	????	100,13% DPR 0,75
	5		3	0	0	24	5%	max 14,5%	12,66%
						444	100%		

Figure 4. Table of QCFP amoxicillin-capsule.

Table of quality characteristic of intermediary product capsule (processes parameters of encapsulator) / Table of control parameters for the operator in encapsulator (equipment).			Level 1	Appearance					Weight		Time of desintegration	Absolute weight	Relative weight (%)		
			Level 2	Deformed without leakage/ scratched	Ruptured parts	Strange materials	Presencer of powder externally	Closure	Medium weight	Weight variation					
			Measure unit				C/NC	C/NC	mg	%	min				
			Type of inspection				QL	QL	QT	QT	QT				
Level 1	Level 2	Measure unit	Direction	C/NC	C/NC	C/NC	C/NC		↓↑	↓↑	↓				
Operations	Control parameters of operator													Type of control	Operation ranges (Max-Min)
Capsule feeding				5	0	1	0	0	0	0	0	0,37	5,4	Manual - Activated by button F1 (the sensor warns that capsules are needed)	
Capsule positing				0	0	0	0	0	0	0	0	0,00	0,0	Mechanical	
Capsule opening	Vacuum pressure	mbar	↓↑	0	0	0	0	0	0	0	0	0,00	0,0	Mechanical	200 mBAR/0,2 BAR ± 10%
	Filter condition (vacuum pumps)	C/NC		0	0	0	0	0	0	0	0	0,00	0,0	Manual	C
Powder feeding	Speed of powder agitator	rpm	↓↑	0	0	0	0	0	1	1	0	0,34	5,0	Automatic - Activated by button F2/F3 and by the sensor of powder from aspirated bowl.	0,86 rpm
Capsule filling	Height of aspirated bowl stand	mm	↓↑	0	1	0	0	0	5	3	0	1,55	22,9	Manual - Fixed by product based on required medium weight	40 - 45 mm of the bowl ruler
	Height of filling head piston	mm	↓↑	0	1	0	0	0	5	5	0	1,93	28,6	Manual - Adjustment of medium weight	0 - 25 mm - Variable by raw material
Compactation	Aspirated bowl sucktion	mbar	↓↑	0	0	0	0	0	0	0	0	0,00	0,0	Mechanical	200 mBAR/0,2 BAR ± 10%
	Height of compactation pins	mm	↓↑	0	1	0	1	5	0	0	?	0,48	7,0	Manual - Adjustment of minimum compactation for forming peg	0 - 25 mm - Variable by raw material
	Height of peg ejection pins	mm	↓↑	0	0	3	1	0	0	0	0	0,28	4,1	Manual - Liberation of pegs for filling up capsules	1 mm outside the jet
Capsule rejection	Capsule rejection pins			0	0	0	0	0	0	0	0	0,00	0,0	Mechanical	
Capsule closure	Height of closure pins	C/NC	↓↑	5	5	0	0	5	0	0	0	1,65	24,3	Manual	C
Capsule ejection	Capsule ejection pins			0	0	0	0	0	0	0	0	0,00	0,0	Mechanical	
Cleaning of matrices	Aspiration pressure	L/min	NA	0	0	0	5	0	0	0	0	0,17	2,5	Mechanical	300 L/min - Manual
												6,77	100,0		
Weight	Absolute weight			15	60	21	9	11	39	50	56	261			
	Relative weight (%)			5,7	23,0	8,0	3,4	4,2	14,9	19,2	21,5	100			
Globe							Some problems								
Specified values - goal											±2%				
Procedures - SOP															

Figure 5. Matrix QCIPCxCPEP.

Quality characteristics			Specification (proportion of non-conformities)	In the beginning of process			When changing PVC bobbin			When changing aluminium bobbin			When there is rupture of PVC			When there is rupture of aluminium			When the machine stops for 10 or over 10 minutes			In the change of shift			In maintenance intervention			When a control parameter of a related equipment is altered			During the process					Related control document
				Form of measurement	Size of sample	Record	Form of measurement	Size of sample	Record	Form of measurement	Size of sample	Record	Form of measurement	Size of sample	Record	Form of measurement	Size of sample	Record	Form of measurement	Size of sample	Record	Form of measurement	Size of sample	Record	Form of measurement	Size of sample	Record	Form of measurement	Size of sample	Record	Frequency	Form of measurement	Size of sample	Record	Who	
Front	Lot number	Correct 1	50 ppm	Visual	1	LVOP																Visual	1	LVOP	Visual	1	LVOP								
		Legible 1	50 ppm	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	30 min	Visual	10	LVOP	Operator	
	Expiration date	Correct 2	50 ppm	Visual	1	LVOP																Visual	1	LVOP	Visual	1	LVOP								
		Legible 2	50 ppm	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	Visual	10	LVOP	30 min	Visual	10	LVOP	Operator	
	Absence of dirt internally		50 ppm																																	
	Presence of all capsules		50 ppm																																	

Figure 6. Table of quality assurance for blister.

account the possibility of humidity absorption during the manufacturing process.

3.2. LZ coated tablet

The building of the conceptual model for LZ coated tablet also followed the seven steps procedure and only positive quality was deployed. Figure 7 shows the construction logic of this conceptual model in flowchart and Figure 8 represents the conceptual model.

This model is divided in four parts: i) continuous process for obtaining Mixture; ii) discrete process for obtaining tablet; iii) continuous process for obtaining suspension; and iv) continuous process for tablet coating (see Figure 8). This division showed to be fundamental for understanding the cause-effect relationship in the production process. In addition to this, it was necessary to obtain and analyze other types of information, thus, similarly to the Amoxicillin project, the team elaborated Auxiliary Matrices. There were a total of 12 tables and 18 matrices. The major contributions of this project were: 1) it brought unity to and transformed into documentation the tacit knowledge about drug development and processing; 2) it facilitated discussion about coating process; and 3) it generated data for building platform conceptual model for solid drug for oral use.

3.3. Nevirapine tablet

The conceptual model building process for Nevirapine also followed the seven steps procedure, but only positive quality dimension was deployed. Figure 9 is a flowchart that shows the construction logic and Figure 10 represents the conceptual model itself. The model is divided in two parts: i) continuous process for obtaining Mixture; ii) discrete process for obtaining tablet. There were a total of 6 tables and 6 matrices.

4. Platform conceptual model

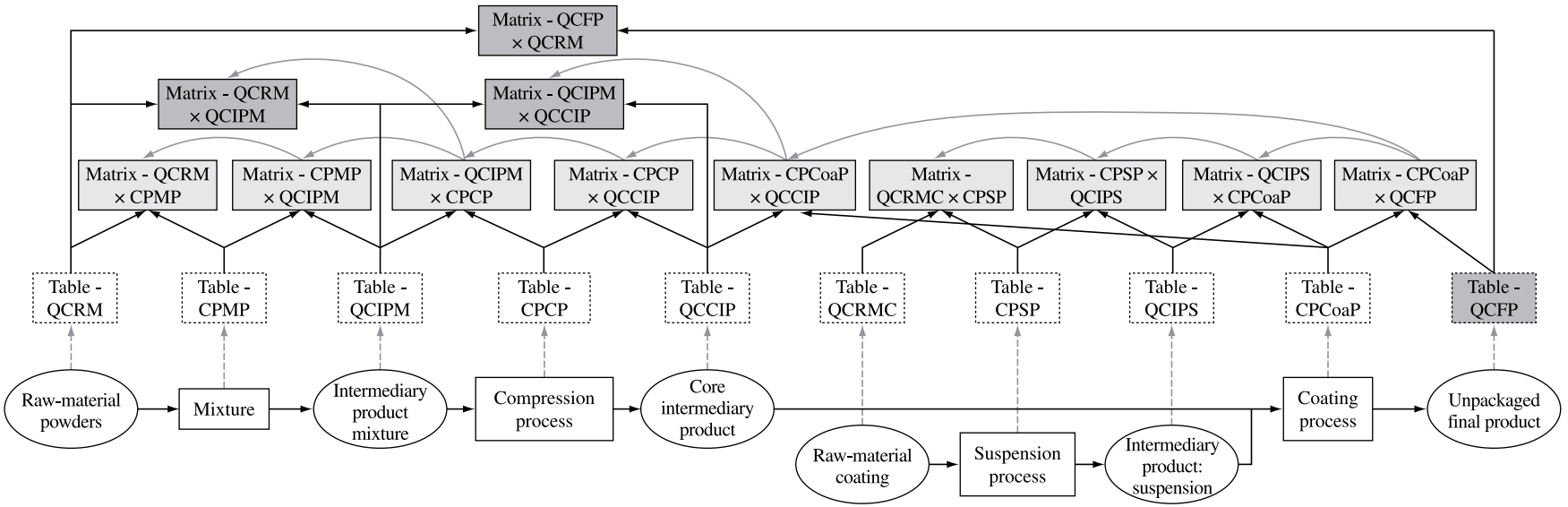
An analysis of the three conceptual models shows that they present a common structure that we name, hereafter, as platform conceptual model for solid generic drug for oral use. It follows the basic production flow, as shown in Figure 11, and contemplates two stages of production process: 1) continuous (mixture) and 2) discrete (encapsulation or compression).

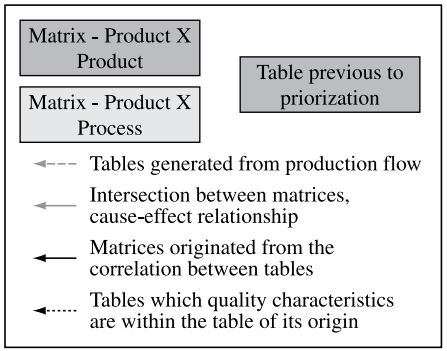
The production flowchart generates a set of tables: QCFP (Table of quality characteristics of final product); QCDIP (Table of quality characteristics of discrete intermediary product); DPCP (Table of discrete process control parameters); QCIPM (Table of quality characteristics of intermediary product mixture); MPCP (Table of mixing process control parameters); QCRM (Table of quality characteristics of raw-materials). Theses tables are present in the three cases. Subsequently, it is possible to establish the cause-effect relationship between the tables that form the matrices and the intersection between the matrices (see Figure 12).

Finally, we drew the platform conceptual model for assuring the product quality in the stage of preparation for production, which is shown in Figure 13.

The construction logic for the platform conceptual model generated from the three case studies is as follows:

- The table of quality characteristics of final product (QCFP) is dismembered into table of quality characteristics of intermediary discrete product (QCIDP), because the first one refers to the product which has its control after the quarantine, whereas the second one covers the product which is controlled during the process.
- In order to meet the quality characteristics of the discrete intermediary product, it is essential to have discrete process control parameters (QCIDPxDPCP).





Conceptual Model for LZ	
QCFP	Quality characteristics of final product (Lamivudine + Zidovudine compressed and coated)
QCCIP	Quality characteristics of core intermediary product – characteristics controlled in batch and in process
QCIPM	Quality characteristics of intermediary product mixture
QCIPS	Quality characteristics of intermediary product suspension
QCRM	Quality characteristics of raw-material
QCRMP	Quality characteristics raw-material powder
QCRMC	Quality characteristics raw-material coating
CPMP	Control parameters of mixing process (equipments)
CPCP	Control parameters of compression process
CPSP	Control parameters of suspension process
CPCoaP	Control parameters of coating process
ENC	Environmental characteristics
STC	Storage conditions

Figure 7. Construction logic of the conceptual model for LZ.

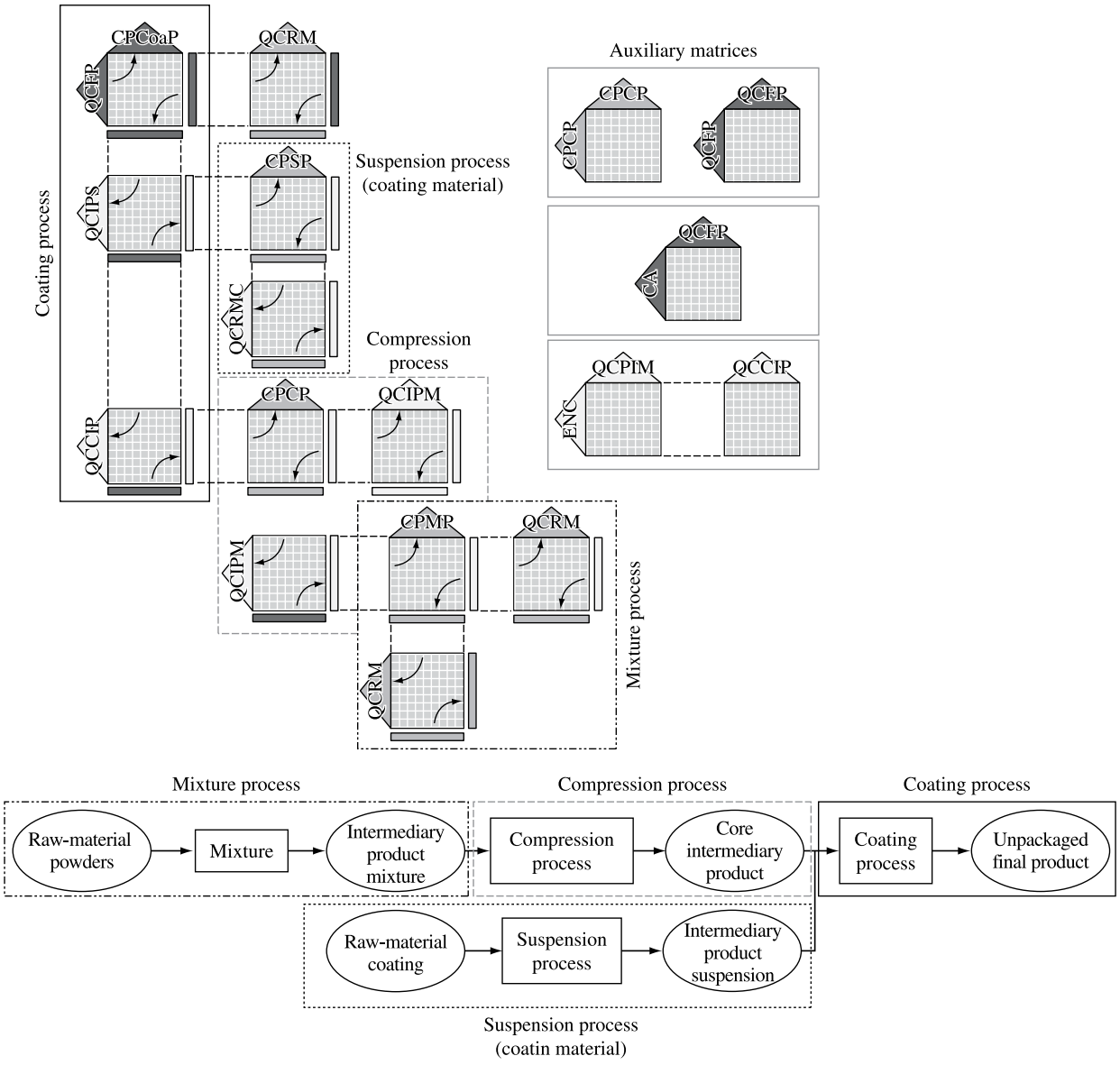


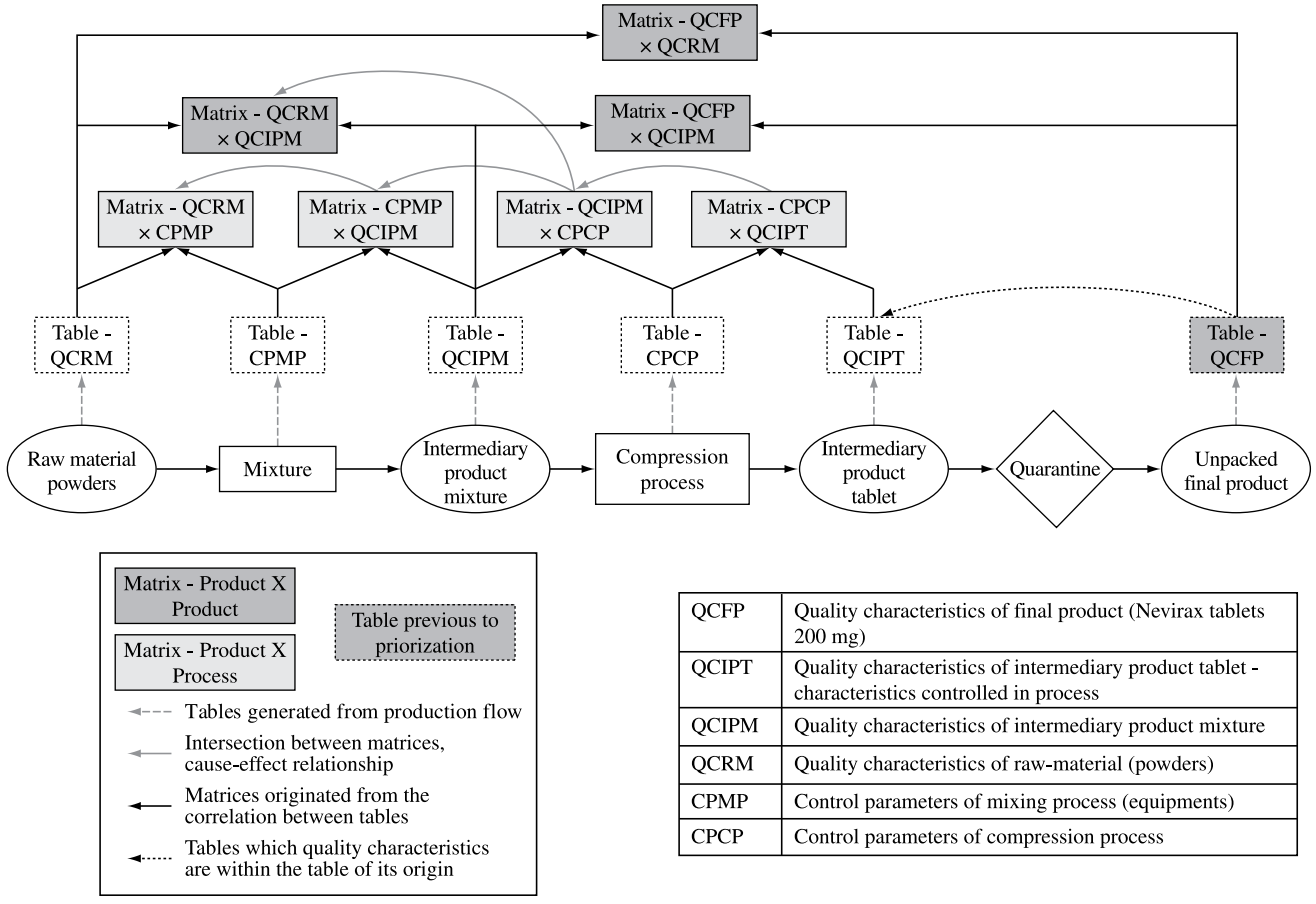
Figure 8. LZ conceptual model.

The parameters have to be established to modify the intermediary product mixture (DPCPxQCIPM).

- To meet the quality characteristics of the intermediary product mixture, there should be some control parameters for the mixing process, as well as certain quality characteristics for raw-materials (active substance and excipients) (QCIPMxMPCP and QCIPMxQCRM powders). The parameters have to be established so to modify the raw-materials (active substance and excipients) (MPCPxQCRM powders).
- There are also quality characteristics of the intermediary product mixture, quality characteristics of raw-materials that affect directly the quality characteristics of the final product (QCFPxQCIPM; QCFPxQCRM).
- Finally, Auxiliary Matrices are used whenever necessary for obtaining any important information for the project.

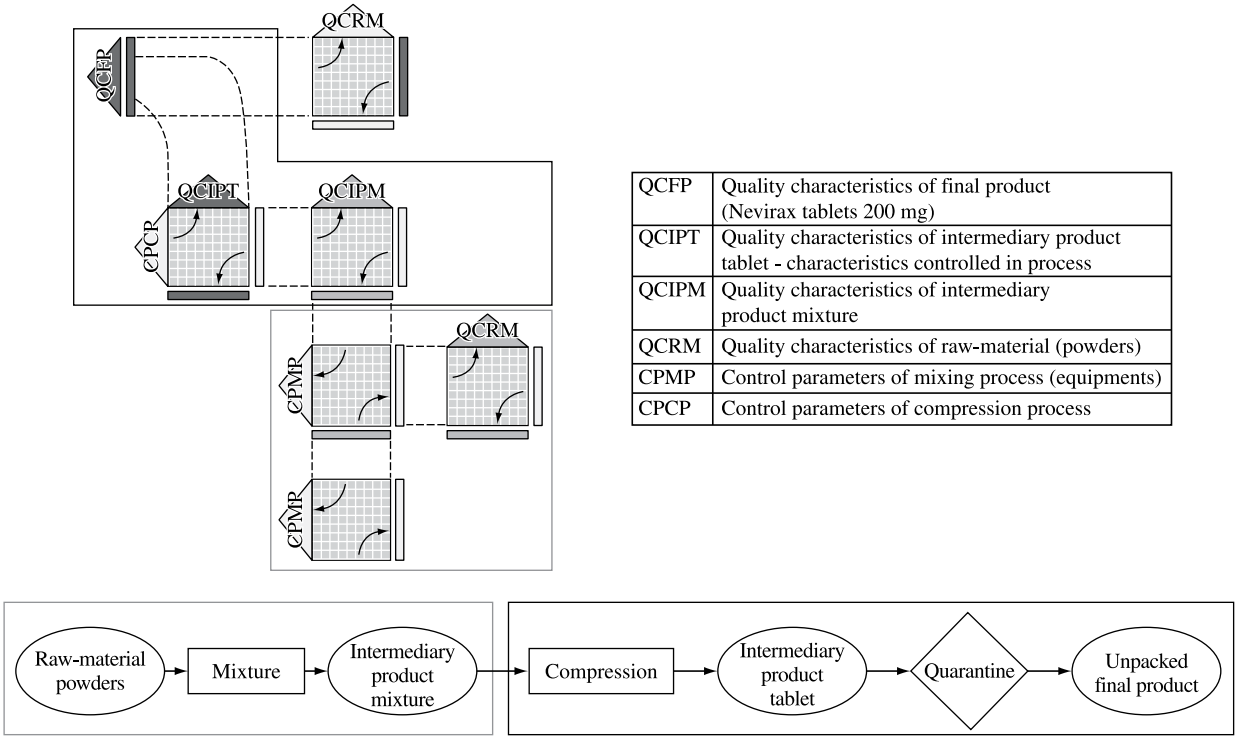
This model is flexible and adaptable to each individual case of application to generic drugs for oral use, especially during the preparation for production. Now, we will make a reversal reflection on how the three cases could have been generated from this platform conceptual model:

1 For the model of Amoxicillin, the adaptations would be: (a) inclusion of the matrix QCRM-capsule X CPPE in the discrete stage, because the raw-material capsule comes in the stage of encapsulation; and (b)



QCFP	Quality characteristics of final product (Nevirax tablets 200 mg)
QCIPT	Quality characteristics of intermediary product tablet - characteristics controlled in process
QCIPM	Quality characteristics of intermediary product mixture
QCRM	Quality characteristics of raw-material (powders)
CPMP	Control parameters of mixing process (equipments)
CPCP	Control parameters of compression process

Figure 9. Nevirapine conceptual model building logic.



QCFP	Quality characteristics of final product (Nevirax tablets 200 mg)
QCIPT	Quality characteristics of intermediary product tablet - characteristics controlled in process
QCIPM	Quality characteristics of intermediary product mixture
QCRM	Quality characteristics of raw-material (powders)
CPMP	Control parameters of mixing process (equipments)
CPCP	Control parameters of compression process

Figure 10. Nevirapine conceptual model.

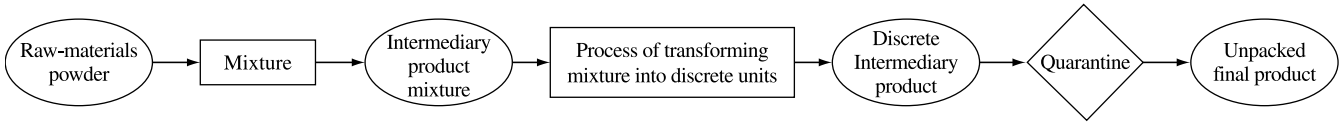


Figure 11. Flowchart of production process.

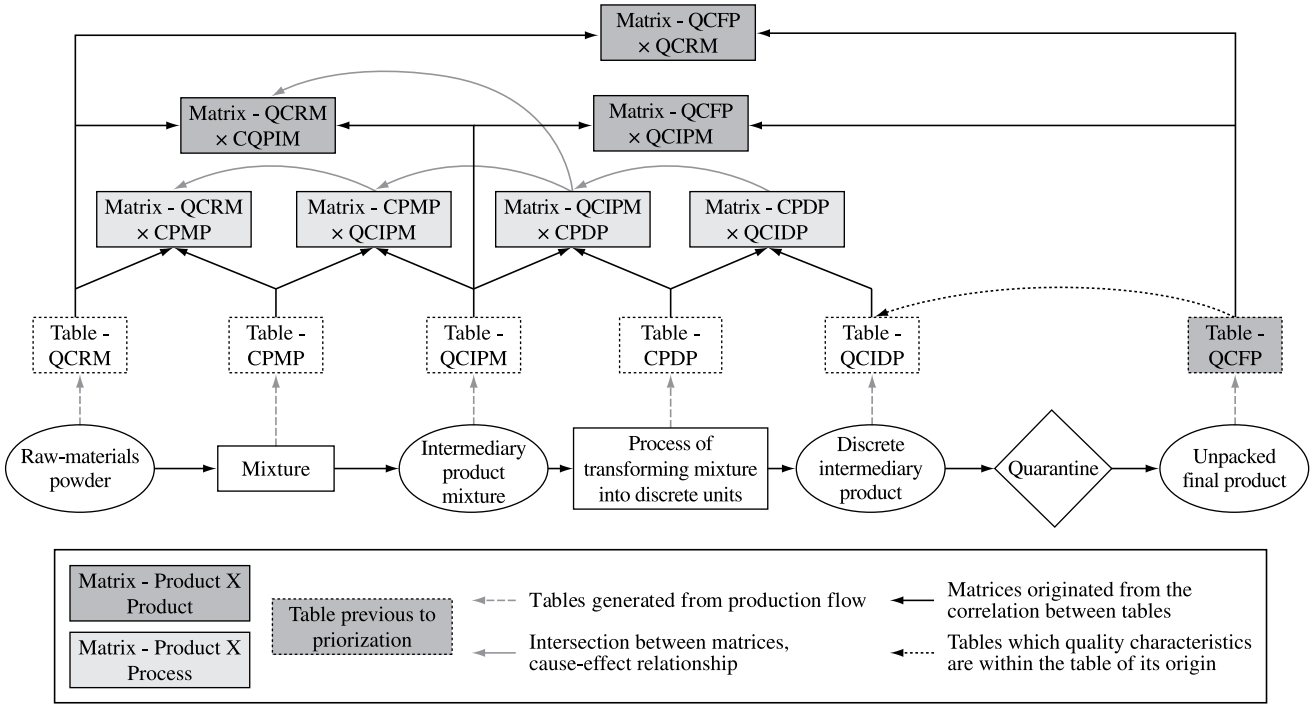
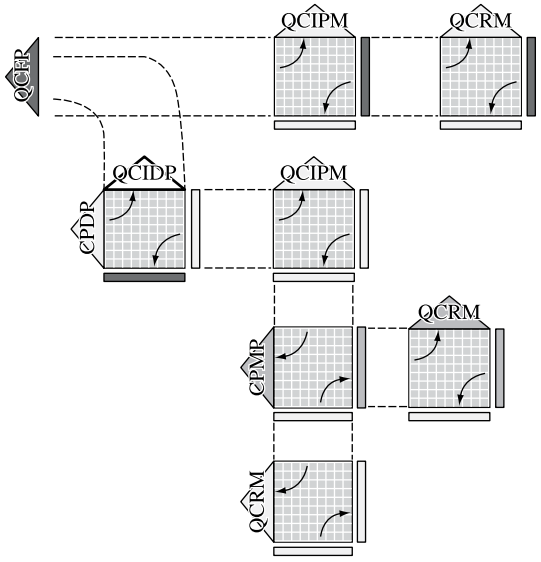


Figure 12. Building logic of the platform conceptual model.



QCFP	Quality characteristics of final product
QCIPM	Quality characteristics of intermediary product mixture
QCIDP	Quality characteristics of intermediary discrete product
QCRM	Quality characteristics of raw-material
CPMP	Control parameters of mixing process (equipments)
CPDP	Control parameters of discrete process

Figure 13. Platform conceptual model for solid generic drugs for oral use.

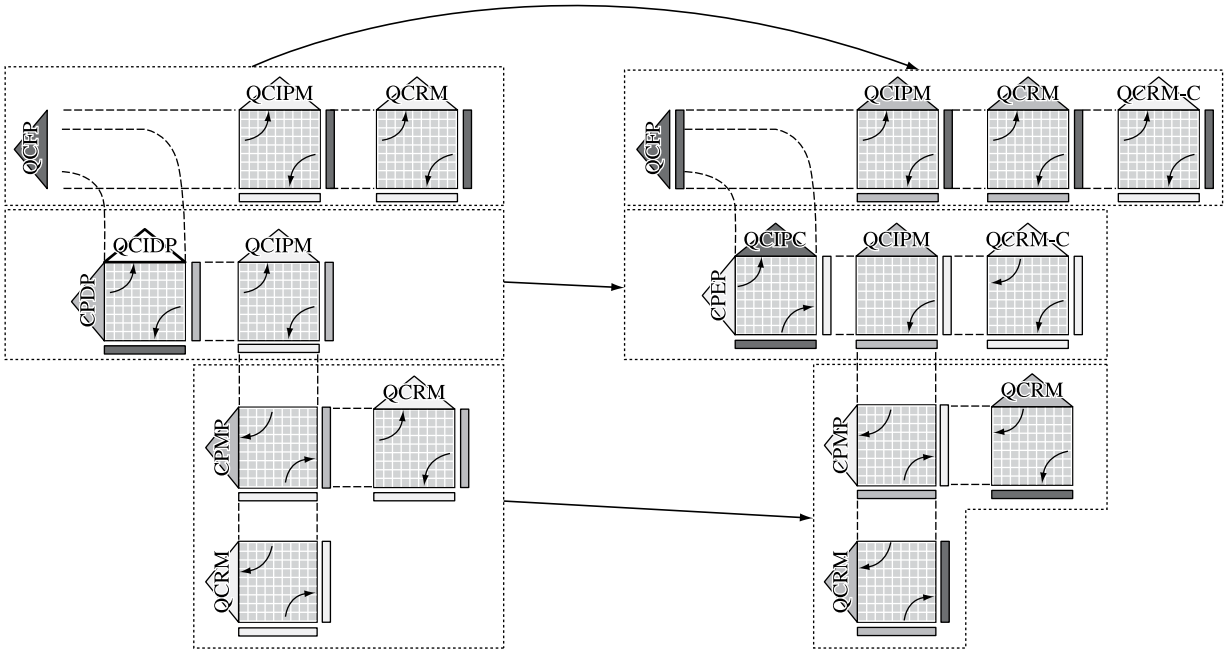


Figure 14. Comparing the platform conceptual model and the conceptual model for amoxicillin capsule.

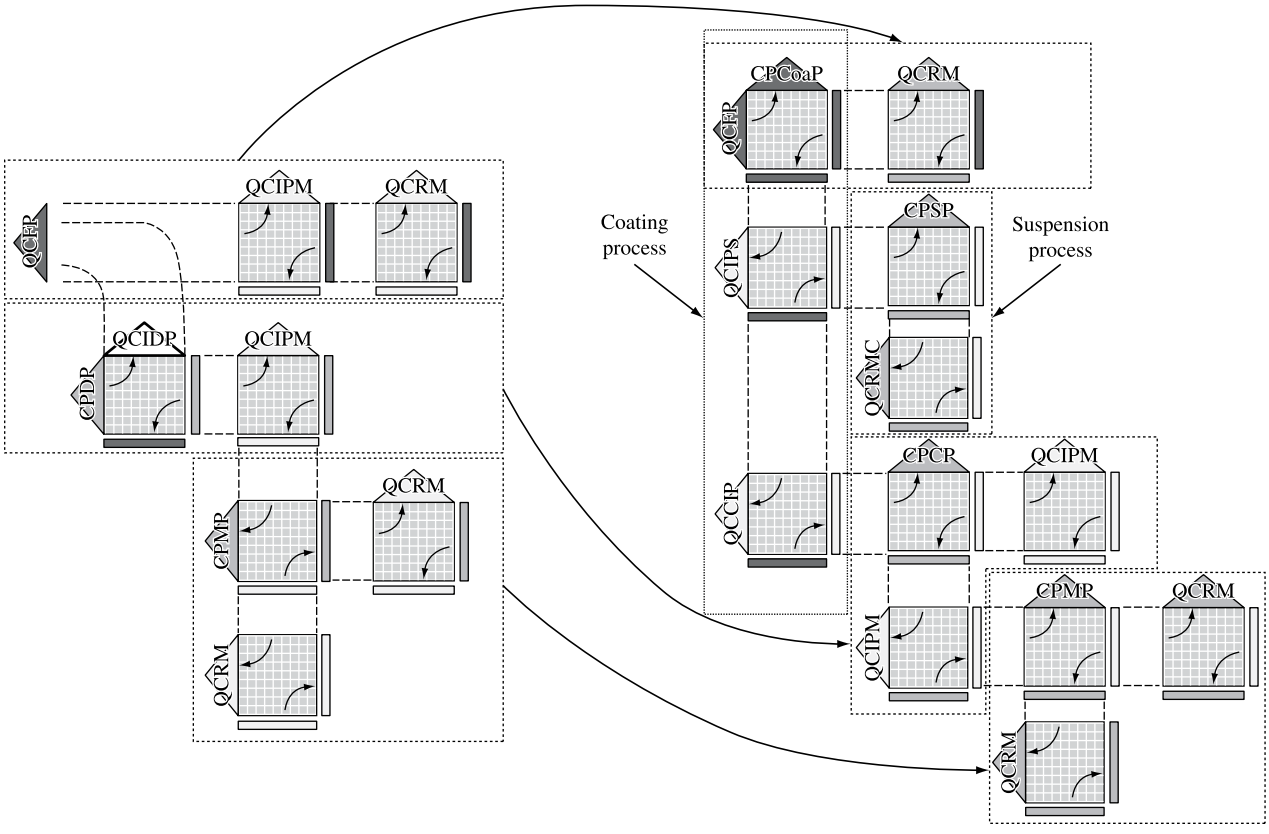


Figure 15. Comparing the platform conceptual model and the LZ conceptual model.

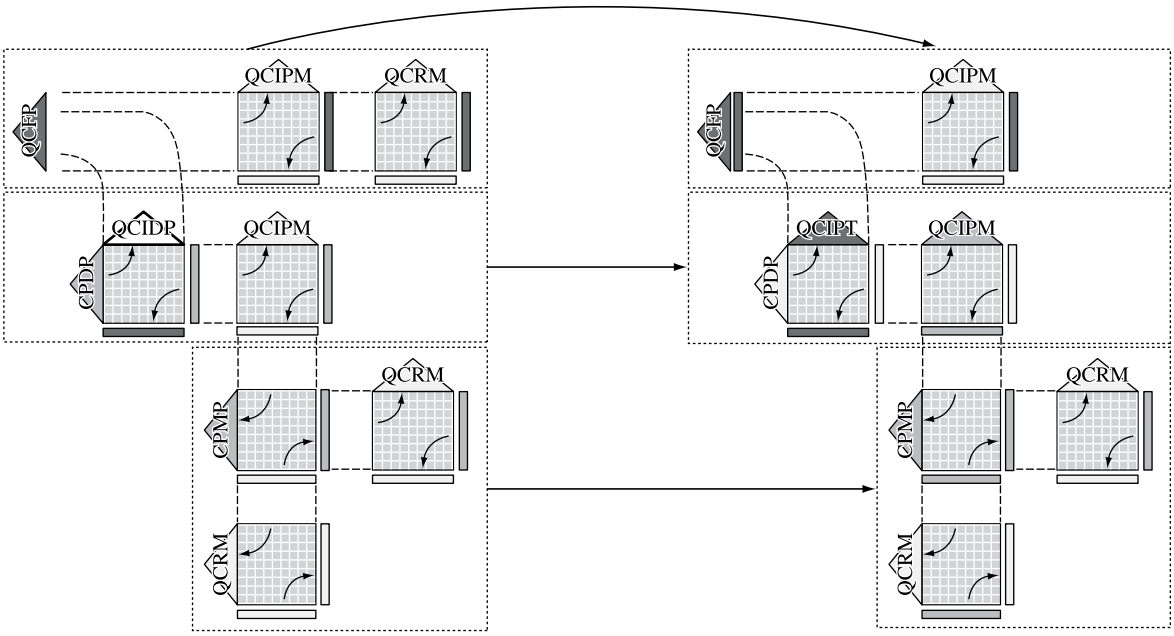


Figure 16. Comparing the platform conceptual model and the Nevirapina conceptual model.

QCFPxQCRM capsule, because the latter affects directly the final product. Figure 14 compares the two models.

2 For the model of LZ, the changes would be as follows: A- inclusion of a production process used for coating tablet called suspension; and B- inclusion of the coating process. The matrices CPCoaPxQCFP, QCIPSxCPCoaP, CPSPxQCIPS, QCRMCxCPSP and CPCoaPxQCCIP were part of theses processes. In addition, the matrix QCIPMxQCCIP was used for analyzing characteristics of the mixture which were not altered during the compression process but affect directly the uncoated tablet. Figure 15 compares the two models.

3 For the Nevirapine model the comparison is direct as presented in the Figure 16. The matrix QCIPMxQCFP was not included.

5. Conclusion

Our experience of implementing QFD in organizations through our Action Research Program has helped us to establish a seven steps procedure for building conceptual model in QFD. It is our belief that this procedure may help QFD beginners to go beyond the first matrix, quality table or house of quality, in their applications. The aim is to broaden and deepen the scope of QFD work through a flexible construction of Conceptual Model.

At the same time, we introduced in this paper the platform concept into QFD conceptual model building process, based on three applications in generic drug development in a government institution in Brazil. This was made possible because the conceptual models present common elements – in this case, manufacturing processes. It is envisaged that this platform conceptual model can be used in other similar applications, where the generic drug is of solid type for oral use. We see the concept of platform powerful in QFD as many models are platforms rather than for individual products. Thus, to develop product derivatives or to improve existing products from these models is simpler than expected, since the information accumulated in the lines, columns, tables and matrices can be easily retrieved, accessed, and managed. Viewing conceptual models as platform conceptual models makes it easier to input and update client voice and to generate product derivatives more rapidly, which shortens the development time to market. In addition, it enables the development team to evaluate permanently voice of customers, and helps to predict what comes next based on accumulated data.

Finally, many examples of QFD works in the development of consumer products of very competitive industries (car, electronic and food) are available in ISQFD proceedings and in reputed academic journals. However, very few QFD works are on pharmaceutical industry and, in particular, on pharmaceutical development of generic drug in developing countries. Development of allopathic drugs can be divided into four macro-phases: research and development of active

drug substance, production of pharma-chemicals, production of pharmaceutical specialties, and marketing and sales. Many developing countries, in general, are capable only to deal with last three, two, or even one stage. However, there is a huge impoverished population needing free ly distributed drugs. It is our hope that QFD works may bring more socially relevant contribution to those in real needs.

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