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Introduce to "Usability-quality Product Development Technology (UPDT) ": Taking the Design of Desk and Chair as an Example

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Abstract

This study refers to the "Usability-quality Product Development Technology (UPDT)", and explains the feasibility of UPDT by a case study of desk and chair design. The UPDT method is a new product development technology that combines "Focus Group" and "QFD (Quality Function Deployment)". Among them, the focus group method is mainly used to investigate and organize the consumer's product use requirements, while the QFD is used to convert the consumer's product use requirements into specific designs and ensure product quality. This study will use the desk and chair design as an example to illustrate the feasibility of the UPDT method. The research results show that the UPDT method can be used to develop products with usable quality. Based on this, this study suggests that the UPDT method can be used as one of the technologies for new product development.

Keywords:usability quality, product development, product design, QFD, Focus Group

1. INTRODUCTION

With the advancement of the times, people began to pay attention to the quality of life and humanized design, and the requirements for product safety, comfort, efficiency and effect are getting higher and higher[1][2].In order to survive, many companies have redesigned and improved existing products from the perspective of humanity, in an attempt to create successful products by identifying user needs. The most famous success stories are the iPad and iPhone of Apple Inc. of the United States and the Wii series of Nintendo of Japan. These products are aimed at investigating the human-induced operational problems found in existing products, proposing operational solutions that conform to user behavior patterns, and successful products developed with engineering technology. In the development of these successful products, the integration of human problems, the innovation of product use, and the integration of engineering technology are necessary.This means that if a product development engineering technology can be used to investigate the use of the problem and convert the use problem into a product function, this report believes that the technology will certainly help manufacturers or enterprises to create new business opportunities.The value of this technical report is to propose a set of product development technologies that can convert usage problems into product functions to assist manufacturers in developing successful products that meet user behavior patterns and meet user needs.The product development engineering technology used in this report and the product function transformation is called "Usability-quality Product Development Technology (UPDT)". UPDT combines methods such as "Focus Group" and "QFD (Quality Function Deployment)". Among UPDT, the focus group method is mainly used to investigate and organize the consumer's product use requirements, while the QFD is used to convert the consumer's product use requirements into specific designs and ensure product quality. This report will test the feasibility of the UPDT method with desk and chair design.

2. INTRODUCTIONOF UPDT

2.1. Theoretical Basis of UPDT

2.1.1.Product Developmentand QFD (Quality Function Deployment)

In fact, the development of new products cannot be completed in one step. It is a staged and process-oriented process.In other words, to propose a set of engineering innovation technology, the first condition of the engineering technology should be the concept of a phased process.Baxter [3] argues that an effective product development process can be divided into six phases : (1) Concept formation stage:The main work at this stage is to use the knowledge base of market marketing survey, customer demand, enterprise R&D and cumulative innovation concepts as the source of new

products, and to consider the manufacturing capabilities of the company itself and suppliers, and evaluate the feasibility of new products.(2)Embryonic design stage:The main tasks at this stage include defining the overall R&D schedule of the product, functional specifications, hardware structure design, and setting audits of the required raw materials to pursue the most suitable design of the product.(3)Product trial production stage:The main work at this stage is to perform a small amount of trial production of the first version of the product based on the results of the prototype design to verify the previous product design specifications and manufacturing procedures. (4)Planning for mass production:The main work at this stage is to plan the product mass production and sales by correcting the product specifications during the trial production phase, plus production resource constraints and sales forecasts. (5)Effective evaluation stage:The main work at this stage is to evaluate the overall process from the initial product design concept to the final actual production and sales.(6)Engineering change phase:The main work at this stage is to update the original product material standard table when the customer requests to change the product specifications, or when the raw materials required by the supplier to supply the product are changed. Chen, etc.[4]divides product development operations into five phases from the perspective of market demand: (1) concept generation and screening, (2) commercial analysis, (3) process design and mass production, (4) product sales measurement, (5) commercialization。In the book Design Principles, Roozenburg&Eekels[5] divides new product development into five stages from the perspective of industrial design units: (1) Research and analysis：The main purpose of the problem is to judge the problem. The work items include formulating work, collecting data, analyzing the actual situation, defining the target group and making briefings. (2) Conception: Mainly appealing to other solutions, work items include cancellation functions, finding fundamental alternative solutions, establishing alternative concepts, evaluating alternatives, and determining the underlying structure. (3) Drawing and proofing：The main appeal is to deal with problems. Work items include evaluating sketches, deciding sketches, developing CAD models, building actual models, and examining ergonomics. (4) Development and optimization: The main requirements are implementation, and the work items include processing details, improving overall design, coordinating purposes, checking costs, and implementing implementation. (5) Start mass production：Introduce the product into a stable and reliable mass production. According to the definition of product innovation and the concept of product development process proposed by different experts and scholars above, product innovation is actually a step-by-step process. The process should at least include three stages: product planning, product design and design concept evaluation.These three stages include at least consumer demand surveys, consumer demand definitions, consumer demand and product function conversion, product function positioning, product function and product component conversion, product component design, and design concept assessment. This means that a product innovation engineering technology proposed in this report should have at least the above-mentioned stage process steps in order to achieve the efficacy and goals of innovative products. In order to ensure effective understanding of product quality, many scholars have proposed various product quality control methods.Among the various product quality control methods, the most widely known product quality control method whose purpose is consistent with the product quality definition of this report is the "Quality Function Deployment (Quality Function) proposed by Japanese scholar Akao[6]. Function Deployment, referred to as QFD).Quality Function Deployment (QFD) is a systematic structured product development planning tool. QFD originated in Japan in the latter half of the 1960s.The earliest document on the concept of QFD is the article "New Product Development and Quality Assurance - Quality Development System" in the 1972 "Standardization and Quality Management" monthly magazine.After that, QFD was introduced to the United States in the early 1980s and quickly spread to countries around the world.QFD uses the concept of binary matrix transformation (Figure 1) to expand the design, parts, process and cost of the product one by one.Its purpose is to enable a series of activities such as product development and production, and to design and design products based on the needs of customers. This is in line with the engineering purpose of this report.Therefore, this research report regards QFD as one of the core technologies of UPDT(Figure 2).

2.1.2.Focus Group

Nielsen [7] divided the evaluation methods of usability into three categories: Testing, Inspection, and Inquiry. (1)Usability testing:Usability testing is done by a representative user operating system or system prototype (Prototype) to understand the extent to which the interface assists the user. The system prototype is the basic model of the product and can be tested in place of the final product.Early system prototypes included paper prototypes or a rougher simple system model, albeit briefly but could have a significant impact on subsequent development processes. Rubin (1994) pointed out that early exploratory testing is very important, and the process is usually filled with experimenters and subjects to interact and cooperate. Mister [8] pointed out that in order to effectively understand the usability problem, the data collection and analysis of the experiment is very important. The quantitative data in the usability test should

include three indicators: Effectiveness, Efficiency, and Satisfaction.(2)Usability inspection:Nielsen [7] defines a usability review as "a set of methods used by an evaluator to examine or examine the aspects of the interface related to usability." The evaluator can be an expert in usability, a software development consultant, an end user with relevant knowledge background (End users) or other experts.Common usability methods include Heuristic evaluation, Focus Group, Cognitive walkthrough, Feature inspection, Pluralistic walkthrough, Perspective-based inspection, Standard review/Guidelines List (Standards inspection/Guideline checklists), etc.Among them, Focus Group is the most

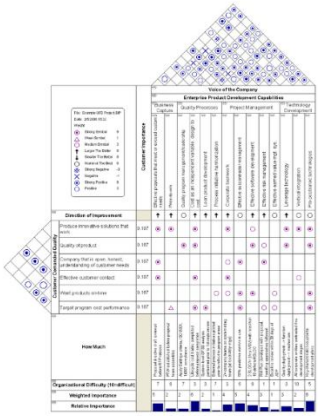


Figure 1 concepts of QFD

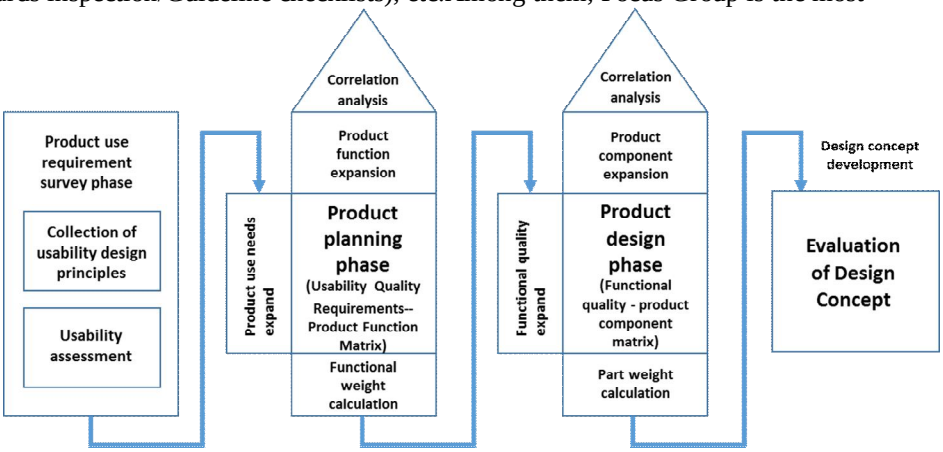


Figure 2UPDT

commonly used test method to explore various usability problems.The Focus Group is proposed by Nielsen [7] and is usually reviewed and evaluated by a small group of evaluators based on specific usability principles or rules of thumb (Heurstics). The purpose of Focus Group is to use the product in the product. In general, the focus of the Focus Group operation is about one to two hours. If you evaluate a more complex system, you can divide the process into several stages. During the evaluation process, the evaluator browses the product at least twice, for the first time to feel the continuity of the entire interaction process and to have a general understanding of the product's theme (function). The second tour is primarily to allow evaluators to focus on specific projects in the product and assess whether they are compatible with the overall environment. The Focus Group examines the various items in the dialog based on a set of Usability principles. These principles are general principles for describing usability characteristics, and evaluators can also increase assessments as appropriate [7].Nielsen [7] pointed out that an assessor can usually find 35% of the usability problems, and the number of people can find more problems. Usability surveys are conducted by verbal inquiry, questionnaires, interviews, or observations of the use of the system by the usability assessor in actual work situations, and collecting their opinions to understand the user's preferences, needs, and understanding of the system.According to the above-mentioned literature of the Focus Group, the Focus Group is an engineering technology that is commonly used to investigate product usability problems.According to the above-mentioned requirements for the use of the QFD-incorporated usability survey technology, the current usability assessment technology-focus group method meets the requirements of this technical report. Therefore, this technical report is intended to be combined with the focus group method. QFD technology as a tool for “Usability-quality Product Development Technology”(abbreviationUPDT).The focus group was involved in the product use requirement survey phase of UPDT to collect customer product usability requirements information.

2.2. Concept of UPDT

The purpose of UPDT (Figure 2) technology is to provide designers with a step-by-step product development process which is to make the design concept quality and innovationintegrate the consumer's product use requirements, set product functions, concept design and other three stages.UPDT, with the first letter of each word as an abbreviation or naming, is mainly to integrate "Focus Groups" and "Quality Function Deployment (QFD)". The main architecture of the UPDT (shown in Figure 2) is also based on the design process model that meets most of the product development programs composed of four stages:“ demandsurvey→ productplanning→ productdesign→ concept evaluation” .The various stages of the UPDT are product use requirement survey phase, product planning, product design and evaluation of design concept. Among them, the product use requirement survey is conducted by the focus group method, while the product planning and product design are integrated by QFD technology.The purpose of UPDT's product use requirement survey is to obtain the requirement of the user's product. The product plan is to find out the main functions corresponding to the consumer's product use requirements. The purpose of the product design is to ensure that the design of the product components can be confirmed. Finally, the purpose of the design concept assessment is to

determine the consistency of the design concept and requirements of the output to ensure that the design meets the user's needs.

3. TAKING THE DESIGN OF DESK AND CHAIR AS AN EXAMPLE

3.1. Phase 1 :Product Use RequirementSurvey Phase

3.1.1. Collection of usability design principles

First, explain the steps taken by UPDT to collect the usability design principles of design objects：

- Looking for design research literature：

  In the design case of the school desk and chair, UPDT first used the National Digital Library of Theses and Dissertations in Taiwan to search for two research papers on the design of school desks and chairs: “A study of desk and chair design for elementary school children”[9]and “A Study on the Angle and Height of a Table and Chair for Senior High School Students”[10].

- Organize the usability principles：

  After studying the papers on the design of two school desks and chairs, the designers involved in the case immediately extracted the usability design principles of the school desks and chairs with their experience. These usability principles have a total of four: A.There should be enough School bag placement space, B.There should be enough thigh space under the table, C.The table should have an appropriate height, D.The desktop should have an appropriate line of sight.

- Fill in the product use requirements questionnaire with usability principles：

  After obtaining the four usabilityprinciples of the school desks and chairs, the designers of the case immediately filled in the usability requirements questionnaire with the fourusability principles of the school desks and chairs (Figure 3).

Subject information			
Age：20	Gender：M	Career：student	Education background：University
Discussion meeting host：DesignerChen Mingzuo			
Task description			
Test sample：Student chair   			
Product usability assessment			
Usability principle		Usability problem	
A.There should be enough School bag placement space		a.Table cannot accommodate personal belongings	
		b.Table cannot be classified as personal items	
		c.Can't hang or store clothes	
		d.Unable to hang a schoolbag, the bag must be placed in the aisle	
		e.Unable to store personal trash	
B.There should be enough thigh space under the table		f.Inconvenient to turn around when discussing group discussions	
		g.Inconvenient to discuss interaction with others	
C.The table should have an appropriate height		h.Tables and chairs are too small, some people are not convenient to sit	
		i.Inconvenient to move when the classroom is cleaned	
D.The desktop should have an appropriate line of sight		j.When the teacher is working on the demonstration, he needs to go to the front	
		k.It is necessary to go to the podium or specify a computer to report easily	

Figure 3product use requirements questionnaire

3.1.2. Usability assessment

After obtaining the usability principles, the UPDT then performs a usability assessment of the design object in a focus group. The focus group collects the usability problem mainly by the human factors expert that guides the user to describe the usability problem. In the school desk and chair design case,the implementation steps of the usability assessment are as follows, and the describedusability problemsare showed in Figure 3:

(1). Select discussion meeting host:

The discussion meeting host in this design case is a senior design specialist of HarvestLink International Co., Ltd. who has more than 14 years of school desk design experience.Thename of discussion meeting host is filled in the product use requirement questionnaire (Figure 3).Thediscussion meeting host is the moderator of the focus group of the case.

(2). Organization of focus groupmember (subjects):

The focus group of this design project is composed of 20 students from the University of Ling-Dong University of Science and Technology.The 20 students were selected from the various departments of Design College and Information College in Ling-Dong University of Science and Technology.

(3). Selecttest sample:

The test sample of the case is a student chair collectedform Ling-Dong University of Science and Technology. The picture of the student chair is filled in the product use requirement questionnaire (Figure 3).

(4). Select experimental location:

The experimental locationof the case is the Human Factors Engineering Design Laboratory (SY820) at Ling-Dong University of Science and Technology. The experimental environment has a room temperature of 27 degrees.

(5). Usability problem assessment process:

First, the discussion meeting host asks the subject to fill out the basic information of the subject of the product use requirement questionnaire (Figure 3).The discussion meeting hostthen informs the focus groupmembers, the usability design principles, the operational tasks, and the mission objectives, and then begins the usability assessment.During the implementation of the assessment process, the discussion meeting host guided the focus group team members to explain the usability problem ofindividual use criteria that do not meet the usability principles in Figure 3.The entire conference discussion process will be recorded.When all the subjects have written down theusability problem oftest samplethey found, the moderator will then guide the focus groupmember to summarize the final usability problem.In this design case, a total of 11 usability problems are collected as follows: a).Table cannot accommodate personal belongings, b).Table cannot be classified as personal items, c).Can't hang or store clothes, d).Unable to hang a schoolbag, the bag must be placed in the aislee, e).Unable to store personal trash, f).Inconvenient to turn around when discussing group discussions, g).Inconvenient to discuss interaction with others, h).Tables and chairs are too small, some people are not convenient to sit, i).Inconvenient to move when the classroom is cleaned, j).When the teacher is working on the demonstration, he needs to go to the front,k).It is necessary to go to the podium or specify a computer to report easily.

3.2. Phase 2 :Product Planning Phase

3.2.1.Product use needs expand

A. Usability problems and usability quality requirements conversion

After getting the initial usability problem, the next step in the UPDT is to convert the collected usability problems into usability quality requirements. This case converts 11 usability problem in Figure 3 into 11 usability quality requirements: a). It is convenient to interact with others, b). Can interact with multiple people at the same time, c). Can store personal items, d). Can sort personal items, e). Can hang clothes, f). Can hang school bags, g). Chairs are convenient for users Move and turn, h). Report without the front platform, i). Can store garbage, j). In the in-situ, you can see the teacher demonstration without going to the front, k). The seat can be adjusted according to the user's body, l). Classroom neatness Or convenient to store when not in use. The conversion results are shown in Table 1.

Table 1School desk and chair usability problemsand usability quality requirementsconversiontable

Usability problem	Usability quality requirements
Table cannot accommodate personal belongings	It is convenient to interact with others
	Can interact with multiple people at the same time
Table cannot hang or store clothes	Can sort personal items
Table cannot hang or store clothes	Can hang clothes
Unable to hang a schoolbag, the bag must be placed in the aisle	Can hang school bags
Inconvenient to turn around when discussing group discussions	Chairs are convenient for users Move and turn
When the teacher is working on the demonstration, he needs to go to the front	Report without the front platform

Unable to store personal trash	Can store garbage
It is necessary to go to the podium or specify a computer to report easily	In the in-situ, you can see the teacher demonstration without going to the front
Tables and chairs are too small, some people are not convenient to sit	The seat can be adjusted according to the user's body
Inconvenient to move when the classroom is cleaned	Classroom neatness Or convenient to store when not in use

B. Create the product use needs expand table

After conversionofusability problemsand usability quality requirements, the next step is to makeproduct use needs expand table. Firs, usability quality requirements is to draw into labels, the purpose of which is to facilitate the grouping of the requirements using the project.In this application example, UPDT uses the KJ method to organize the grouping skills into three major factor groups: convenient use, convenient interaction, sit comfortably, etc. After the usage requirements are grouped, you can create a product use needs expand table.The product use needs expand table completed according to the above method is shown in Table 2.

Table 2school desk and chair product use needs expand table

			Evaluation					Importance calculation	
First level	Second level	Third level	5	4	3	2	1	Total score	Importance
Easy to use	Convenient storage	Can sort personal items	50	16	3	0	0	69	4.60
		Can hang school bags	50	12	3	2	0	67	4.47
		Can hang clothes	15	32	9	2	0	58	3.87
		Can store garbage	5	12	15	8	2	42	2.80
	Convenient interaction	It is convenient to interact with others	50	16	3	0	0	69	4.60
		Can interact with multiple people at the same time	30	32	3	0	0	65	4.33
		Chairs are convenient for users move and turn	35	28	3	0	0	66	4.40
		Report without the front platform	55	12	3	0	0	70	4.67
		In the in-situ, you can see the teacher demonstration without going to the front	40	16	6	2	0	64	4.27
	Sit comfortably	The seat can be adjusted according to the user's body	5	8	30	2	1	46	3.07
		Classroom neatness or convenient to store when not in use	0	8	3	20	2	33	2.20

C. Use demand importance calculation

After completing the usage requirements expansion table, UPDT can perform the importance calculation on the usage requirement items in the use requirements expansion table.In the application example, UPDT first uses five pointsevaluation (values ranging from 1 to 5) to distinguish the importance of each usability quality requirements. The larger the value, the greater the importance. The right side of Table 2 is the importance of each usability quality requirements for the desk and chair design.The results in Table 2 show that students are most looking forward to the improved use of desks and chairs, including:Can sort personal items (importance of 4.6 points), Can hang school bags (4.47 points of importance), It is convenient to interact with others (importantof 4.6 points),Can interact with multiple people at the same time (with 4.40 points of importance),Chairs are convenient for users move and turn (importantof 4.6 points),Report without the front platform(with 4.67 points of importance), andIn the in-situ, you can see the teacher demonstration without going to the front(with 4.27 points of importance).Therefore, in the design thinking, these important usage requirements items with greater importance scores become the focus of design thinking.

3.2.2. Product function expansion

After obtaining the importance of the demand for use, UPDT then produced the product function expansion table of the desk and chair.Before making the product function expansion table, UPDT first uses the demand item to find out the

corresponding product features, and then makes these product functions into product function labels.After completing the product function labels, UPDT uses the KJ method to sort the product function labels.Product functions are defined at a fixed time, with simple and clear functional characteristics, so as to distinguish one from the use requirements.The product functions of the desk and chair divides the functional items into three major groups, namely, storage, interaction, comfort, etc.The product function expansion table is shown in Table 3.

3.2.3.Usability quality requirements--product function matrix production

When the product use requirement expansion table and the product function expansion table are completed, the usability quality requirements-product function matrix can be performed.The main steps of usability quality requirements-product function matrix are as follows, first establish usability quality requirements-product function matrix diagram.Usability quality requirements-product function matrix diagram is created by product use needs expand table and the product function expansion table which are put into the left column and the uppercolumn of the matrix diagram, respectively, so that it becomes a form of orthogonal arrangement.Then, the designer examines the relevance of each product use requirement item and each product function item one by one. If there is arelationship, fill in the correlation Symbols, like◎(Strong correlation)、○ (Related)、△(Weak correlation). If there is no relationship between them, the field will be empty and will not be marked. Each use requirement item must correspond to at least one product

Table 3 school desk and chair product function expansion table

First level	Second level	Third level
Easy to use	Convenient storage	Storage item function
		Classified item function
		Hanging clothes function
		Hanging bag function
	Convenient interaction	Garbage collection function
		Can be combined with other seats at will
		The chair can move and rotate
		Table has a reporting function
		Table viewing demonstration function
	Sit comfortably	Seat has resizing function
		Folding storage function

function item correlation mark. If there is no corresponding product function item relevance mark, it means that the product use requirement item is not associated with any one of the product function items, then it must be remove the product using the demand item.Figure 4 shows the usability quality requirements-product function matrixof school desk and chair.

◎ Strong correlation：5point、○ Related：3point、△ Weak correlation：1point

			first level	easy to use											
			second	convenient storage					convenient interaction				sit com fortably		
			third level	Storage item	Classified item	Hanging clothes	Hanging bag	Garbage collection	Can be combined	The chair can move	Table has a reporting	Table viewing demonstration	Seat has resizing	Folding storage	Im portanc
first level	second level	third level		1	2	3	4	5	6	7	8	9	10	11	
Easy to use	Convenient storage	Can sort personal items	1	◎	◎	○								○	13
		Can sort personal items	2	◎	◎	△									11
		Can hang school bags	3	○	△	◎	◎			△			◎		20
		Can hang clothes	4	△	△	◎	◎		△	△			◎		19
		Can store garbage	5	△	◎			◎						○	14
	Convenient interaction	It is convenient to interact with others	6						◎	△	◎	◎	△		17
		can interact with multiple people at the same time	7						◎	○	○	◎	△		17
		Chairs are convenient for users Move and turn	8						△	◎		○	△		10
		Report without the front platform	9						△	△	◎	◎			12
		In the in-situ, you can see the teacher demonstration without going to the front	10							△	◎	◎			11
	Sit com fortably	The seat can be adjusted according to the user's body	11										◎		5
		Classroom neatness or convenient to store when not in use	12											◎	5
	Im portanc	Absolute weight		15	17	14	10	5	13	13	18	23	18	7	
		Percentage weight		10%	11%	9%	7%	3%	8%	8%	12%	15%	12%	5%	

Figure 4 usability quality requirements-product function matrix of school desk and chair

3.2.4. Function weight calculation

The final step in the product planning phase is to calculate the function weights of product function. In this desk and chair design case, UPDTuses absolute weightand percentage weight for function weight calculation. Complete the function weight calculation,and calculation results are filledin the usability quality requirements-product function matrix. At this time, the few product functions with higher function weight become particularly important product functions. These product functionsare the items that are particularly important for future product development.The function weights of school desk and chair are shown at the bottom of Figure 4.The function weights in Figure 4 show that the students most expect the desk and chair functions include storage item function (percentage weight10%), classified item function (percentage weight11%), table has a reporting function (percentage weight12%), Table viewing demonstration function (percentage weight15%), Seat has resizing function (percentage weight12%). Based on these product functions, it becomes easier for designers to develop which desk and chair functions to meet the needs of students.

3.3. Phase 3 : Product design phase

3.3.1.Functional quality expand

In order to sort out the components that meet the needs of the use, UPDT's product design phase continues to screen out the product function items and expand them in the functional quality expand step of the product planning stage.The method of functional quality expanding is the same as the step of product use needs expand stage, mainly to reclassify product functional items and define their group relationships (Table4). The functional quality items of this school desk and chair are mainly divided into three categories(Table4), which are storage function, interactive function and comfort function.The storage function mainly considers the items storage when the students use the desks and chairs.The interactive function is mainly to consider the interaction of students when using desks and chairs.The comfort is mainly based on the comfort of the students when using the desks and chairs.The functional quality importance calculation is also performed by using the demand importance calculation method. In the Table 4, the right side are the importance calculationresults of each function quality item of this school desk and chair development case.As can be seen from the results of Table 4, students most expect the storage item function (importance of 4.53 points), classified item function(importance of 4.80 points), table has a reporting function (important of 4.40 points) and table viewing demonstration function (importance of 4.53 points). These functional quality items with large importance scores are the focus of design thinking step.

Table 4school desk and chair function quality expansion table

			Evaluation					Importance calculation	
First level	Second level	Third level	5	4	3	2	1	Importance calculation	Importance
Easy to use	Storage function	Storage item function	50	12	6	0	0	68	4.53
		Classified item function	55	12	3	2	0	72	4.80
	Interactive function	Table has a reporting function	45	12	9	0	0	66	4.40
		Table viewing demonstration function	50	12	6	0	0	68	4.53
	Comfort function	Seat has resizing function	10	36	9	1	2	58	3.87

3.3.2. Product component expansion

This step is to make the product component expansion table mainly for the important components related to the design object.The establish method of product component expansion table is the same as the step of producing the product function expansion in the product planning stage. The main step is to find out the important components related to the functional quality items, and then to make these parts classified by KJ method. The components of this desk and chair design case are divided into several large groups: the table and the chair body (Table 5)

Table 5 school desk and chairproduct component expansion table

First level	Second level	Third level
Easy to use	The table	Table
		Table legs
		Pipe plugs
		Semi-circular head Phillips screws

	Chair body	Chair seat panels
		Chair legs
		Grids
		Foot plugs
		Shared screws

3.3.3. Functional quality - product component matrix production

UPDT's functional quality - product component matri**x** is produced in the same wayas the production of usability quality requirements-product function matrix.The functional quality - product component matri**x** is mainly filledwith the function quality expansion table and product component expansion tablein the left column and the upper column of the matrix diagram respectively, and then the designer examines the relevance of each functional quality item and each product part item one by one. The functional quality - product component matri**x**of student desk and chair is shown in Figure 5.

◎ Strong correlation：5point、○ Related：3point、△ Weak correlation：1point			first level	desk and chair										Importance
			second level	desk				chair						
			third level	table	table legs	pipe plugs	semi-circular head Phillips screws	chair seat panels	chair seat panels	chair legs	grids	foot plugs	shared screws	
first level	second level	third level		1	2	3	4	5	6	7	8	9	10	
easy to use	storage function	Storage item function	1	△	○						◎			9
		Classified item function	2								△			1
	interactive function	Table has a reporting function	3	◎	○	○								11
		Table viewing demonstration function	4	◎		△								6
	comfort function	Seat has resizing function	5		○		△	◎	△	△			△	12
	Importanc	Absolute weight		11	9	4	1	5	1	1	6	0	1	
		Percentage weight		28%	23%	10%	3%	13%	3%	3%	15%	0%	3%	

Figure 5 functional quality - product component matrix of school desk and chair

3.3.4.Component weight calculation

Component weights are also calculated using the independent point method. The weight calculation results of the components of the desk and chair design are shown in Figure 5.In Figure 5, the items with higher component weight scores are particularly important component items.These components will be selected as the key factor of design development to design a school new desk and chair. According to the components weights of Figure 5, the most important components for the design of a schooldesk and chair includes table (percentage weight28%), table legs (percentage weight23%), chair seat panels (percentage weight 13%) and grids(percentage weight15%).These product components require designers to better focusto design in order to better meet the needs of the product.

3.3.5.Design ideas development

After completing the component weights calculation step, you can proceed to the final step of the UPDT's product design phase - design ideas development. The design ideasdevelopmentis to develop a new product ideain according tothe product componentswith higher percentage weightscores in the functional quality - product component matri**x** diagram.The new design ideas is first expressed in a hand-drawn form. After the case is finalized, the final result of the ideas is presented in a 3D drawing.The new designideas of the school desk and chair design case of this report is shown in Figure 6(IdeaA, IdeaB, IdeaC).The design strategies of these ideas focus on the solution of the components selected in the Component weight calculation step towards the associated quality requirements.For example, the back of the chair can be designed to be able to hang a school bag, hang clothes, easily interact with others, and can be easily turned by the user. With the multi-person interaction function of the table, the personal things can be stored and classified,in addition, the report can be executed without going to the front platform, and the teacher can be seen in the in-situ without waiting for the front view. The seat also can be adjustedin according to the user' body size; the storage grid is

oriented to accommodate personal items, can sort personal items, can hang school bags, can hang clothes, can store garbage, etc.

IdeaAIdeaB

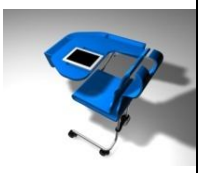
Ideac

Figure 6desk and chair design concept

3.4. Evaluation of Design Concept

The UPDT suggests that the design ideas resulting from the development steps need to be evaluated through an appropriate usability checklist. The UPDT recommends that the design concept evaluation steps include the development of a usage checklist and the evaluation of the assignment.The design concept evaluation process of this desk and chair design case is as follows: First develop a usage checklist. The source of this checklist is theusability design principlesinFigure 3. There are 12 design principles in this desk design case. Secondly, the assessment work is carried out: the design principles are used as an evaluation tool to evaluate the consistency between the design ideas and the userequirements. In the evaluation process, the symbols "○" and "●" are used as the basis for judgment ("○" means that the design concept does not satisfy the quality requirement of the use, "●" represents that the design concept satisfies the quality requirement of the use). The greater thenumber of "●"symbols, the more the design ideas fits the user's needs.In other words, the design ideas is more usable in the consideration of user behavior operation design.Conversely, ifthe product development team believes that the proposal design ideas is not most fitted the user's requirements, the entire or partial process of UPDTprocessmust be re-executed.Table 6showed the evaluation results of school desk and chair design ideas.

Table 6The evaluationof school desk and chair design idea

Use checklist	Assess target		
	IdeaA	IdeaB	IdeaC
Inspection project （According to the quality requirements）			
1. Easy to interact with others	●	●	○
2. Can interact with multiple people at the same time	○	○	●
3. Can store personal belongings	●	●	●
4. Ability to classify personal items	●	●	●
5. Can hang clothes	●	●	●
6. Can hang a schoolbag	●	●	●
7. The chair is convenient for the user to move and turn aroun	●	●	●
8. Report without going to the front desk	●	●	○
9. Can store garbage	○	○	○
10. In the in-situ, you don’t need to go to the front to see the teacher demonstration.	●	○	●
11. The seat can be resized according to the user's body	●	●	●
12. Convenient storage when the classroom is clean or not in use	○	○	●

4. CONCLUSION

This study refers to the "Usability-quality Product Development Technology (UPDT)", and explains the feasibility of UPDT by a case study of school desk and chair design. The UPDT method is a new product development technology that combines "Focus Group" and "QFD (Quality Function Deployment)". The case study of desk and chair design shows that the UPDT method can be used to carried out a new product idea. Based on this, this study suggests that the UPDT method can be used as one of the technologies for new product development.

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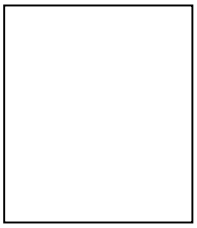

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