APPLICATION OF QUALITY FUNCTIONAL DEPLOYMENT TO THE ASSESSMENT OF AIRCRAFT MAINTENANCE EDUCATION

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Abstract - *To sufficiently and effectively handle the various demands in airl ine maintenance technician structures. The article proposes to apply "quality functional deployment" to cultivation of the aircraft maintenance technicians. The airline companies are treated as customers and our students as the formal products. We utilize the analysis method of quality functional deployment system as a tool to improve "curriculum design and teaching quality".*

Based on discussions, we conclude that what the airline industry wants the most is that novice aircraft maintenance technicians impr ove their reading capability of English technical orders and manuals; to posses relevant technical skill in aircraft repair and maintenance field; and to be able to work hard. All these demands can be fulfilled by school system through (1) universalizing E nglish education program (2) requiring and encouraging students to study manuals (3) enhancing the varieties of practical training classes and practicality (4) cultivating rigorous work attitude and concept.

In addition, by using practical training require ment and creating relevant classes in general knowledge education program, we can make our department students treasure the value of human life, team spirit, mutual respect, discipline and motivation, and spirit of service and devotions, life time learning , and keeping up with aircraft knowledge and technical skills. We hope that this will prepare our student well to meet the industry demands after they graduate. And they w ill become popular maintenance force in the airplane maintenance industry.

Index Ter ms — Quality Functional Deployment (QFD), Aircraft Maintenance Education, Assessment

I. Introduction

Due to government opening up airway, the passenger traffic and cargo traffic carried by domestic airlines increase at an enormous speed. Moreover, in order to expedite military reform and cooperate with Ministry of Economic Affairs in pushing the "GOCO" project, which aims to convert Taiwan's air force repair depots into government-owned company-operated facilities, Ministry of National Defense will open the military aircraft repair and maintenance market to civil defense contractors and unite domestic aviation and aerospace companies to make Taiwan become an Asia-Pacific regional maintenance and manufacture center. As the demand boosts and the technology greatly advances in aircraft maintenance, many domestic companies invest in expanding their production capacity. High-tech aircraft maintenance work need plenty of expert technicians. Nevertheless, our domestic maintenance education system could not provide enough well trained technical people for the market. This causes the speed of establishing maintenance power to lag the growth of aircraft repair and maintenance market. And it directly causes high turnover rate among maintenance workers, which negatively affects airline safety.

The major mission of the technology and vocational education of aeronautical department in Taiwan focuses on educating airline professionals with profound theoretical and practical knowledge in aviation technology and preparing them well for careers in aviation industry, especially in aircraft maintenance market. Though the goals of education and vocational training are not fully consistent, in addition to the professional skills for their future careers, school education should also help the students to develop appropriate flexibility and potentiality. Nevertheless, as job categorization becomes more specialized and diverse, school education have to comply with the social and economic trend to strengthen the inaction with the relevant industrial companies and provide the students with the practically effective skills and environment. The demands on the quality and the quantity of airlines maintenance worker structures vary as the current aviation industry changes rapidly. To sufficiently and effectively handle the various demands, the article proposes to apply current popular "quality functional deployment (QFD)" in "total quality management enhancement", which has successively applied in education and aircraft manufacture industries [1-10], to the cultivation of the aircraft repair and maintenance workers. We utilized the "QFD" method to analyze the requirements of airline companies, the possible employers of our students in the future, converted them into the quality characteristics of schools such as curricula,

faculty and facilities, systematically disclosed the complicated relationship between the requirements and the school characteristics, and promoted the evaluation efficiency. We compared relevant aviation departments in different schools, set up rational criteria for evaluation and provided our department a reference benchmark for future curriculum design and teaching guideline plan. We also hope to provide a foundation in planning Taiwan aircraft maintenance education strategy for the better cultivation of aircraft maintenance workers to meet the industry demands.

II. Quality Functional Deployment

II-1 Introduction to Quality Functional Deployment

As product structures become complicated and the demand in quality increases, quality conscious has turned into an indispensable professional quality to engineers. The QFD method is a linkage technique between customer demands and product development. It is used to translate the customer demands into the product characteristics through the various stages of design, product planning, engineering and manufacturing, and make the developing products satisfy customers demands. The merits of QFD are summarized as follows

(1) Reduce frequency of design alternation.
(2) Cut down research time.
(3) Lessen conflictions in manufacturing processes.
(4) Lower research expenditures.
(5) Promote consumers satisfaction.
(6) Transfer experiences effectively

II-2 Stages and Procedures of QFD

The following seven major procedures described in [11] are systematically used to establish the solid linkage between customer demands and product development in QFD

(1) WHAT?—Disclose the voice of customers

QFD begins with "WHAT"—i.e. the determination of customer demands. This is the most critical procedure in QFD. Only through the accurate determination of customer demands, can the product quality be guaranteed for customer satisfaction. The most often used method in the stage is questionnaire survey.

(2) HOW?—Measurement items for product specifications

Measurement items are determined based on customer demands. The measurement item must be measurable, controllable, predictable, and put no limit to product design.

(3) Relationship Matrix – The matrix between "WHAT" and "HOW"

Establish the relationship matrix of customer demands vs. measurement items, through which the relationship between demand and measurement can be fully exploited.

(4) How Much? –Determine product specifications

According to the measurement items, compare the company product with other competitive products. Determine the product specifications based on the consideration of regulations, company technology, financial status, and man power. .

(5) Correlation Matrix—The matrix between measurement items.

Analyze the relationship among the measurement items of product specifications. The goal is to examine any possible positive relationship and/or conflict relationship between the product specifications of developing products.

(6) Competitive Assessment—Assessment of competitive products

The procedure can be divided into two parts: (a) the customer's subjective assessment of the company's product and other competitive products based on customers' demands (b) the company's objective assessment of its product and other competitive products based on the measurement items. The purpose is to check the consistence between the customers' subjective assessment and the company's objective assessment; and provide a foundation to improve the product quality.

(7) House of Quality (HOQ) – Establishment of HOQ

Following the previous procedures, the complete results of QFD, which is called HOQ, can be established. According to the analyzed results in HOQ, both the product specifications and the measurement items may be determined and the next stage of deployment will begin.

III. Results and Discussions

QFD has been proven to be a very effective method to develop new products. The article utilized the method to analyze the link between domestic aviation industry and aircraft repair and maintenance education. We treated airline companies as customers and our formal products are our students. Also, we assume our main competitors are other aeronautic schools like ours. We applied the systematic method and principles of QFD to deploy the concrete subjective/objective assessment and connection between industry demands and school teaching resources. Through the analyses, we will find the directions in planning curriculum, faculty and facilities; and improve the aviation industry's satisfaction toward our students. We also compare our department with other aeronautic schools like ours to provide our department a reference benchmark for future curriculum design and teaching guideline plan. The results at every stage of QFD are given as follows:

Stage 1: Define the project and organize the team

The members of the core team were selected from faculty and students in our department. The experts from aviation industry are invited to be consultants to maximize the issues coverage and achieve the objective result.

Stage 2: Develop customer demands

(1) Disclose the customers:

We treat domestic airline companies and aircraft maintenance companies as customers. Though there are thirteen domestic airline companies including several helicopter companies and one aircraft maintenance company in Taiwan, we picked seven major companies as our research objects because of their scale, fleet, maintenance capacity, which include CAL, EGAT, FAT, TransAsia, UNI AIR, Mandarin airlines and ASIA.

(2) Develop customer demands:

Two ways are used to develop the customer demands：

(a) Inquiring the airline companies' requirements of recruiting aircraft maintenance technicians, including: education, experience, linguistic ability, gender, age, license and other objective requirements.

(b) Conducting a questionnaire survey regarding over the possible requirements of aircraft maintenance technicians. For the better and reliable results, the questionnaires are mailed to airline companies' personals, most in manger level.

Stage 3: Develop competitive products

We assume the students at other aeronautic schools like ours to be the competitive products of our department. We collected our competitors' information such as scale, facilities, curricula and faculty through Internet and international cooperation. Six schools in Taiwan and worldwide are selected as hypothetical competitors show in the following table. The results at the stage are used as reference in the objective/subjective assessment of competitive products.

School	Country
China Institute of Technology	Taiwan, R.O.C.
Yung-Ta Institute of Technology	Taiwan, R.O.C.
Pittsburgh Institute of Aeronautics	U.S.A.
Southern Alberta Institute of Technology	Canada
RMIT University	Australia
Kangan Batman TAFF	Australia
Perdue University (Aviation Technology)	U.S.A.

Stage 4: Organize consolidate and translate customer demands

According to the airline companies' requirements of aircraft maintenance technicians and the results of questionnaire survey, based on their importance, nineteen customer demand items are identified and divided into linguistic ability, computer ability, professional skills, curricula and facilities, faculty, academic-industry cooperation, working attitude as listed in the in the following table:

Demand category	Customer demands
Linguistic capability	Have good English listening skills
	Have god English reading skills
Computer capability	Possess basic operation capability
	Have aircraft CBT operation experience.
Professional Skills	Be able to read operation manuals and technical orders.
	Possess relevant technical skills in aircraft repair and maintenance field.
	Understand airplane system relevant theories.
	Be able to conduct basic trouble-shooting
	Be able to conduct aircraft inspection
Facilities and curricula	Pay attention to intern training.
	Provide real airplane body for student internship.
	Provide enough airplane engines for student internship.
	Provide airplane system trainer for student internship.
	Provide aircraft avionics system for student internship.
Faculty	Possess relevant aviation background.
	Possess the relevant airplane repair/maintenance experiences.
Academic-Industry Project	Possess relevant licenses.
	Have practical training experiences in airline companies.
Working attitude	Be able to work hard.

Stage 5: Customer importance rating

The information collected from the retrieved questionnaires was analyzed statistically. The 5-point scales, with 5

indicating the most important and 1 indicating least important, were used to rate each customer demand item based on the degree of its importance to the customers. According to the statistic results shown in the following table, the characteristics of aircraft maintenance technicians that airline companies appreciate most, with scale greater than 4, are listed in a descending order.

Item	Customer's Requirements	Scale
1	Be able to read operation manuals and technical orders.	5
2	Possess relevant technical skills in aircraft repair and maintenance field.	5
3	Be able to work hard.	5
4	Have good English reading skill	4
5	Understand airplane system relevant theories.	4
6	Have aircraft CBT operation experience.	4
7	Pay attention to intern training.	4
8	Provide real airplane body for student internship.	4
9	Provide enough airplane engines for student internship.	4
10	Provide airplane system trainer for student internship.	4
11	Teachers possess the relevant airplane repair and maintenance experiences.	4
12	Have practical training experiences in airline companies.	4

As the results show, the airline companies expect the raw aircraft maintenance recruits to improve their capability of reading English technical orders and manuals, acquire the relevant professional skills of aircraft maintenance, and work with diligent and endurable altitude. The possible explanations are

1. Capability of reading technical orders and manuals: the installation, repair, and maintenance of any parts of an aircraft have to follow exactly the appropriate manuals provided by the authorized aircraft manufacturing companies. Reading manuals and understanding the technical orders are indispensable skills for the qualified technicians.
2. Acquisition of the professional aircraft maintenance skills: Learning aviation technology is a time-consuming process. If the recruits can handle on-line jobs in a short time, it will benefit airline companies not only by reducing the training time for employees but also by saving the expenditure in man-hours.
3. Diligent and endurable altitude: Because aircrafts are expensive profit-making tools, which will produce revenue only in flight, to airline companies, the usage time of aircrafts is very precious and the maintenance schedules are very tight. Aircraft maintenance jobs are always under time pressure and require strict working rules to guarantee the aviation safety. Therefore, the endurable and diligent working characteristics are essential to aircraft maintenance technicians.

Stage 6: Establish company measure (HOWS); Organize and consolidate HOWS

The corresponding items of objective assessment are determined based on customer demands in group discussion. The items used for the companies' objective assessment are listed in the in the following table:

Item	Company measure
1	Semester number of English courses
2	Semester number of English professional aviation courses
3	Foreign faculty number
4	Number of English listening courses
5	Semester number of relevant computer courses
6	Aircraft CBT courses
7	Variety of aircraft CBT courses
8	Average number of computer users
9	Type of lessons requiring usage of manuals
10	Courses requiring usage of manuals
11	Variety of intern courses
12	Semester number of intern courses
13	Proportion of theorem in intern courses
14	Semester number of NDI
15	Semester number of aviation insurance courses
16	Quantity of aircraft system trainers
17	Variety of aircraft electronic system trainers
18	Variety of aircrafts
19	Quantity of aircrafts
20	Number of engines
21	Variety of engines
22	Quantity of student intern laboratories

23	Number of faculty owning aviation background
24	Number of faculty owning aircraft maintenance experiences
25	Number of faculty owning CAA licenses
26	Academic-industry relationship with airline companies

Stage 7: Complete the relationship matrix of customer demands vs. company measure

At this stage, we completed the relationship matrix of customer demands vs. companies' objective measure through group discussion. From the results revealed in the relationship matrix, the majority of the relationship between customer demands and companies' objective measure are one-on-one relationship. The results indicated that the customers demands items we chosen are over-delicate. The reasons may contribute to the close similarity in questionnaire design and correspondences.

Stage 8: Establish the preliminary targets for the company measure

We also compare our department with other imaginary competitors-other school like us. Nevertheless, because of the diversity in cultivation goals and school systems, the comparison is not fairly objective. The results are only for reference and not used to determine the specification.

Stage 9: Complete the correlation matrix

The relationship between companies' objective measure items, whether positive related such that they will effect each other in the same direction or in conflict with each other such that some compromises have to be made, were determined by assessing the correlation matrix. The results show that most of the companies' measures are positive related to each others and the major conflictions exist between the semester number of some courses and the department budget. For example, the increase of English courses will lead to the decrease of English Listening courses or the increase in the aircraft quantity will lead to the decrease in the engine quantity. It affects the budge allocation. Therefore, it has to be prudent in planning facilities and curricula based on their priority.

As far as the positive relationship concerns, the increase in one measure may lead to the increase in their corresponding measure. For example, the increase in the semester number of English professional courses will cause the increase in the number of courses requiring the usage of manuals. The hire of foreign experts may increase the number of faculty number owning license, faculty owning aviation background, faculty owning aircraft maintenance experiences and licenses. Student will be benefited more.

Stage 10: Develop the company measure importance

The importance and the percentage importance of each measure were determined from the relationship and the importance of customer demands. The results show that the important scales of each measure items are very close. Some of the most important measures are listed in the following table.

Measurement item	Total score	Percentage %
Variety of intern courses	80	7
Semester number of intern courses	66	6
Semester number of professional airline English classes	66	6
Variety of aircrafts	62	6
Quantity of aircrafts	62	6
Variety of engines	62	6
Quantity of engines	62	6
Variety of operational manuals	57	5
Semester number of English courses	50	5

VI. Conclusion and Recommendations

VI-1 Conclusion

We utilized the quality functional development method to study how to meet the requirements of the airline industry on airplane repair and maintenance technician cultivation. We treat airline companies as customers and our formal products are our students. Also, we assume our main competitors are other aeronautic schools like ours. We utilize the analysis method of quality functional deployment system as a tool to improve "curriculum design and teaching quality". We will also focus on curriculum, facilities and teaching areas to provide our department a reference benchmark for future curriculum design and teaching guideline plan. After the first phase of quality functional development of the whole process, the conclusion is as follows:

1. Based on the statistical results, the main requirements of airplane repair and maintenance workers of each individual airline company are shown in order below,

Item	Customer's Requirements
1	Be able to read operation manuals and technical orders.
2	Possess relevant technical skills in aircraft repair and maintenance field.

3	Be able to work hard.
4	Have Good English reading skill
5	Understand airplane system relevant theories.
6	Have airplane CBT operation experience.
7	Pay attention to intern training.
8	Provide real airplane body for student internship.
9	Provide enough airplane engines for student internship.
10	Provide airplane ordering system training for student internship.
11	Teachers possess the relevant airplane repair and maintenance experiences.
12	Have practical training experiences in airline companies.

From the results, we found that customers would like the novice workers to improve their reading capability of English technical orders and manuals; to posses relevant technical skills in aircraft repair and maintenance field; and to be able to work hard.

2. The measurements of the significance are correlated to the customer demands, which have certain degree of importance. Below is the list,

Item	Measurement item
1	Variety of intern courses
2	Semester number of intern courses
3	Semester number of professional airline English classes
4	Variety of aircrafts
5	Quantity of aircrafts
6	Variety of engines
7	Quantity of engines
8	Variety of operational manuals
9	Semester number of English courses

3. In the results of the measurement item correlation matrix, we found that the main conflicts are in the arrangement of curriculum semester number and the distribution of department budget. For example, if the semester number of English courses increases then the number English listening courses. University has certain standard in the class arrangement. If the number of airplanes increases, then the number of airplane engines decreases. This involves the budget allocation. It may cause the inconvenient of student study. Therefore, it is necessary to carefully plan the priorities of curriculum and facilities.

VI-2 Recommendations

1. On the enhancement of English capability side, even though increasing the semester number of aviation English relevant courses, it is not practical, due to the possible limitation of the university semester number standard. The English capability can be enhanced by increasing the number of classes taught in English such as hiring foreign professional technicians or having our department teachers try to teach classes in English. Because of our department's quality, we should have long-term plan for aviation professional English training and cultivation.
2. Regarding the variety of airplanes, our department has two types airplane. However, there might be a limitation of the airplane procurement budget and environment conditions. To expand students' maintenance experiences on current flyable airplanes, it can be archived by establishing the academic-industry cooperation to allow students to work for airline companies during summer for obtaining practical training experiences. In addition, our department can purchase airplane maintenance CBT software, so students can learn from computer based environment to access more current aircraft maintenance and technical skills.
3. On the improvement of student reading as well as the usage of operation manuals and technical orders side, in addition to teacher's additional requirement on practical training, the ordinary manual's orders arrangement and readings can be introduced in the Airline English classes. Also, other activity can be used to boost student's reading interests. For instance, organize a look-up on operation manual competition. Students can speed up the operation manual inquiries and feel proud of themselves.
4. Considering the variety of practical training and semester number, even though it might be limited by the facilities and the total number of student credits, it is suggested that teachers should actively participate in the advance study and training opportunities and augment the real usage of practical training.
5. By using practical training requirement and creating relevant courses in general knowledge education program, we can make our department students treasure the value of human life, team spirit, mutual respect, discipline and motivation, and spirit of service and devotions, life time learning, and keeping up with aircraft knowledge and technical skills. We hope that this will prepare our student well to meet the industry demands after they graduate. And they will become popular maintenance force in the airplane maintenance industry.

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