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DEVELOPMENT OF ONLINE AVIATION COURSE BASED ON 3D  
VISUALIZATION MODEL

THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES  
OF  
ATILIM UNIVERSITY



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VISUALIZATION MODEL

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FOR  
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Approval of the Graduate School of Natural and Applied Sciences, Atilim University.

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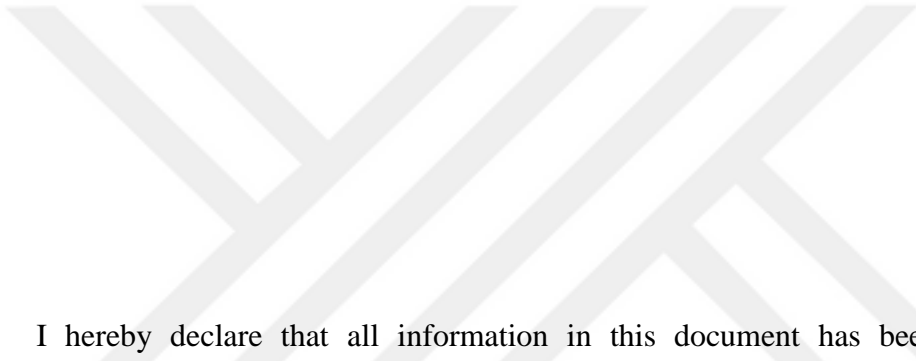
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## **ABSTRACT**

### **DEVELOPMENT OF ONLINE AVIATION COURSE BASED ON 3D VISUALIZATION MODEL**

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The development of smart courses and training known as web-based interactive 3D visual educational environments enable students to increase their competencies and abstract problem-solving capacities and to decrease the memory loads. At the same time, the fact that the environments provide instant feedback, facilitate the successive approach that requires experience, accelerates the training process and provides the best understanding of the subject has led to the preference of them. In this study, a training environment that provides information about the weight and balance of the aircraft was designed by using smart training tools, simulations and technologies accepted as a basic technology for employees who will be aircraft load-master in Iraqi Airways. 3D visualization and E-Learning technologies have been used in the developed educational environment. The averages of the exam results of the training group using 3D visualization and the traditional training group were compared using a t-test to evaluate the effectiveness of the visual application. Three methods were used to measure the satisfaction of the 3D group regarding the visual education method. According to the findings, the visual learning environment designed is much more effective and successful than the traditional education environment. According to the t-test, which shows that the result is statistically significant, the effect size is 8.67%. It is recommended that the Iraqi Airways company be encouraged to adopt and support the visualization of education within their future plans. The study has been beneficial in terms of facilitating education and educator, reinforcing theoretical

knowledge, and providing education in a realistic environment with visuals. It is also important because it reduces the possibility of an operational error.

Keywords: 3D visualization, Aviation, E-Learning, Training, Simulation.



## ÖZET

### 3D GÖRSELLEŐTİRME MODELİ TABANLI ÇEVİRİMİÇİ HAVACILIK DERSİ GELİŐTİRİLMESİ

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Web tabanlı etkileşimli 3 boyutlu görsel ortam olarak bilinen akıllı özel ders ve eğitimlerin geliştirilmesi, öğrencilerin yeterliliklerini ve soyut problem çözebilme kapasitelerini artırırken bellek yüklerini azaltmalarını sağlamaktadır. Aynı zamanda ortamların anında geri bildirim sağlaması, deneyim gerektiren ardıl yaklaşma işlemini kolaylaştırması, eğitim sürecini hızlandırması ve konunun en iyi şekilde anlaşılmasını sağlaması, bu ortamların tercih edilmesine sebep olmaktadır. Bu çalışmada Irak havayollarında kargo kabin görevlisi olacak çalışanlara yönelik akıllı eğitim araçları, simülasyonlar ve temel teknoloji olarak kabul edilen teknolojiler kullanılarak, hava taşıtının ağırlığı ve dengesi hakkında bilgi veren bir eğitim ortamı tasarlanmıştır. Geliştirilen eğitim ortamında 3D görselleştirme ve e-Öğrenme teknolojileri kullanılmıştır. Görsel uygulamanın etkinliğini değerlendirmek için t-testleri kullanılarak 3D görselleştirme kullanılan eğitim grubu ile geleneksel eğitim grubunun sınav sonuçlarının ortalamaları karşılaştırılmıştır. 3D grubunun görsel eğitim yöntemiyle ilgili memnuniyetlerini ölçmek için üç yöntem kullanılmıştır. Elde edilen bulgulara göre, tasarlanan görsel öğrenme ortamı geleneksel eğitim ortamından çok daha etkin ve başarılıdır. Sonucun istatistiksel olarak anlamlı olduğunu gösteren t-testine göre etki büyüklüğü %8,67 dir. Bu çalışma ile Irak havayolları şirketinin gelecek planları içinde eğitimde görselleştirme uygulamasını

benimsemesi ve desteklenmesi için teşvik edilmesi tavsiye edilmektedir. Çalışma eğitime ve eğitimciye kolaylık sağlaması, teorik bilgilerin pekiştirilmesi, görseller ile gerçeğe yakın bir ortamda eğitim yapılmasını sağlaması açısından faydalı olmuştur. Aynı zamanda operasyon hatası olasılığını düşürdüğü için de önemlidir.

Anahtar kelimeler: 3D görselleştirme, Havacılık, E-Öğrenme, Eğitim, Simülasyon.





*To my family, friends and loved ones...*

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## CHAPTER 1

### THE INTRODUCTION

#### 1.1 Introduction

In the era of modern computerized systems, many technologies were used like 3D visualization and E-learning to keep pace with the era of speed through using these technologies to raise the speed and performance of all systems in most areas of life. Any complex system can be simplified using an advanced modern technology, which can provide clear and effective form to clarify the most difficult ideas as well as simplifying complex techniques. These technologies are developed using computer programs and applications, creating a virtual environment that matches reality.

Computerization is an aspect of artificial intelligence, which is about equipping something with or the utilize of and associated automation through computers and software. It's a business process reengineering which converts a manual process into one that is done by a computer. This is achieved by equipping with a comprehensive purpose computer, computer system or embedded computer.

The computerized system has important advantages, one of those is to save time for businesses, and it is highly secure, they have scalable and reliable and done with high speed. Computerized systems include making utilize of computer programs and software to record, store and analyze data [1].

In this documented study, the author directs the research towards developing an advanced mechanism, which can employ modern technologies using a computer and its applications, to develop explanation method for Aircraft Weight and Balance course, to gain an effective training tool and provide a clear overview about actual action and the required reaction.

Intelligent tutoring systems (ITS) described as computerized teaching environments that associate computational models in educational sciences cognitive sciences,

artificial intelligence computational linguistics, mathematics, and other fields. There is a strong relationship between those three close areas, cognitive learning theories, design and training smart. ITS evolution is the marked development of the relationship between research in educational technologies and educational research. ITS research contains seven fields of investigation: aspects of learning, an aspect of teaching cognitive science, assessment, structuring knowledge, intelligent interfaces and intelligent instruments.

Development and Design of an intelligent tutoring system could be abbreviated in four iterative phases: 1- needs assessment, 2 - Cognitive task analysis, 3 - implementing the initial instructional stage, 4 - and evaluation [2].

The rules of design and improvement of an intelligent tutoring system are target structure, training, student competence, promoting the best understanding of abstract understanding of problem-solving, reducing working memory load, giving immediate feedback mistakes, facilitating successive approximation required experience, limiting the size of the training packages, ITS provided students with more individualized approaches like learning, flexibility in time and space and real-time feedback [3].

The Internet has become the most animated way to gained available resources for learning, research, and training for both teachers and students to fully share and acquire information. Technology-based E-learning involves the use of the internet and other significant technologies to produce practical techniques and materials for learning, teaching learners, training and also to regulate courses in an organization. E-learning as a concept contained a domain of applications, processes and learning methods.

This study suggested a new training method in the aircraft sector, by employing E-learning technology, E-learning recently being accessible utilizing technological instruments which are web-distributed, web-based or web-capable. E-learning not just includes content and instructional methods to relocate through CD-ROM, the Internet or an Intranet, but it also includes audio- and videotape, interactive TV satellite broadcast [4].

The core of this study is about Aircraft Weight and Balance, the center of gravity (CG), which means the point about which an aircraft could balance if it were possible to suspend it at that specific point. It is the mass core of the aircraft, or it could be considered the theoretical point where the entire weight of the aircraft is supposed to be concentrated. The Balance point (CG) is so important throughout the flight, because of its impact on the stability and performance of the aircraft and the structural strength of the aircraft too; determine the maximum weight the aircraft could safely carry.

The major target of Aircraft Weight and Balance control is safety. Another purpose is to attain the utmost efficiency through the flight. Improper loading decreases the efficiency of an aircraft from the standpoint of the ceiling, rate of climb, speed, maneuverability and also fuel consumption [5].

Aircraft weight and balance estimates are utilized to avoid overloading an airplane and averting weight variation for safety considerations. The existing Federal Aviation Administration (FAA) advisory, which is utilized by most airlines, demands the airlines to utilize estimated passenger baggage weights. The average passenger and passenger baggage weights are estimated such as the average passenger weight including carry-on luggage is about 190 lbs. On the other hand, Check-in bags are presumed to weigh 30 lbs. These estimations have to be utilized by the pilot manually to specify the weight and balance of the airplane are within safety margins.

The traditional training of the "Aircraft Weight and Balance" course which given in the Iraqi Airways Training Center is using a traditional way of training, where the instructor uses a plastic airplane (0.5-meter height) and explains the course topics and method on that model. Figure 1.1 shows a near example of a plastic airplane.



Figure 1.1 A plastic airplane model.

This old-style method of explanation will not support student's understanding, and probably they will not remember and recognize what they saw on that model, even if they will see a few simple photos that explain the main important topics and methodology on the airplane body. Many significant aspects of load and balance course will be absent, Despite the utmost importance and accuracy for the required explanation.

The trainee who was trained by an instructor depending on the plastic airplane model, when they go to the practical work on load and balance they won't have enough knowledge of the aircraft body and remembering what was explained using the plastics aircraft model, so they will take a longer time and using more information from the supervisor till they can handle doing the flight load sheet.

This gap in the old way needs to adopt modern technology, that utilizes computerized application and adopted 3D visualization to perform some kind of E-learning training, which overcomes the defects in the old traditional way. The newly adopted method used to practicality explains the calculation of weight and balance in a precise way to ensure safety during the take-off. With the implementation of a technical explanation method, which is characterized by speed and accuracy, and develops the understanding for the trainee who was trained with the high-quality application. It goes with all interest to discuss all the important details. The present training method in this research relates to the domain of understanding the aircraft body which helps in computing an aircraft's weight and balance, and more especially to determining an evaluation of the weight and balance of an aircraft automatically in advance and up to the point of take-off. Given the significant importance of the theory of weight and balance, this will make the process of decision-making easier, faster and more accurate.

The expression 3D visualization is utilized synonymously with, 3D rendering, 3D graphics, computer-generated imagery (CGI), and also with other expressions. All of them essentially refer to the procedure by which graphical content is generated utilizing 3D software. It's a technology that has become the mainstream through the last few decades and has improved into one of the most applicable options for creating high-quality digital content.

So 3D visualization defined as the process by which graphical content is generated, which means that the result is visual content like images and animations. It's referring to the production of content, like computer-aided design (CAD) files, that are produced by engineers or industrial designers and planned for manufacturing purposes. It could be described the dynamic graphics that blend both technical skill and artistry.

3D visualization has been one of the prime issues in different areas, like surgery training, in architecture, in landscape and environmental planning, and also has brought in refinements to various aspects of the quality of work execution. So why not use it then in Aircraft Weight and Balance Load Control? From this point of view, our designed method comes from the utilization of 3D visualization

technologies in Weight and Balance, which may be one of the significant features of the future Load Control.

Five main advantages that load controllers could attain from the utilization of 3D visualization technologies: mistakes minimization based on effective load plan designs, the backing of operational stability, refinement of load controller performance, simplifying of training and learning, and refining communication between Ramp Agent and Load Controller [6].

This study explores educational uses of 3D visualization technology especially for application workflows in training aviation courses. It describes the status of an ongoing application which is going to be implemented, highlighting the initial related studies and the suggested outline of the application to be developed.

## **1.2 Problem statement**

The traditional training of (load and balance course) which given in the Iraqi Airways training center is using a traditional learning way, where the instructor uses a plastic airplane (0.5-meter height) and explains the course topics and methods on that model.

The trainees who were trained by instructor depends on the plastic airplane model when they go to the practical work on load and balance they don't have enough approach to the aircraft body and retain what was explained depending on a plastic aircraft model, so they take longer time and effort from the supervisor till they can handle doing the flight load sheet.

Determining weight and balance is considered as a major issue in aircraft safety. Because mistakes related to weight and balance errors can lead to major problems and even accidents.

Some of the critical errors for misunderstanding of the Aircraft weight and balance process, is using improper weight and balance information, math errors, only knowing one method to determine weight and balance, overloading the aircraft, rounding weights, forgetting to convert and more [7].

These are critical errors faced by the pilot during the flight where the actual application is necessary, the poor implementation, will be caused by inaccurate

learning and ineffective training, which depends on traditional methods lacks many aspects of illustration as well as understanding.

This gap in the old way needs to adopt modern technology, that utilizes the computerized application, which overcomes defaults and defects in the old way.

### **1.3 Research Objectives**

This study will provide a developed technical solution for the course training (Aircraft Weight and Balance), The created computerized training methodology comprises a system, method, and computer program product, as well as providing 3D visualization models which will be explained as a part of E-learning training. To provide a modern learning environment with several tools to facilitate teaching, training method and to improve the level of the training, where the researcher will develop an online application, that the students could yet access it with an instructor from anywhere worldwide. The instructor will explain the course by using a 3D aircraft virtual model, that will provide him with a complete ability to explain all load and balance visual topics by using that 3D model with designed drawings, photos, text, and videos on that computerized model.

In this study, the following research question will be explored "is the newly developed simulated training environment based on 3D visualization for Aircraft Weight and Balance course more effective than the traditional training approach?".

### **1.4 Methodology requirements**

The initial requirement for the development of new learning technology is an online website. It will contain the content of the Aircraft Weight and Balance course virtualized, using 3d aircrafts objects, 360-degree rotation aircraft, simulator for the loading sheet, simulator for important communications, and some simple interfaces to learn important topics in the course, as figure 1.2 shows the initial application.

The (experimental group) will be 43 trainees/students who took the Aircraft weight and balance course in the new virtual method, the (comparison group) will be 43 previous trainees/students who took the Aircraft weight and balance course in the old

traditional method. The average of exam results of experimental group will be compared with the average of exam results of comparison group.

Both groups came from the same scientific background. Both groups took the same course content but in two different methods (virtual vs. traditional) and by the same trainer in the same year. A fast satisfaction questionnaire was filled by the experimental group and the trainer was interviewed to get feedback about the significance of the virtual course.

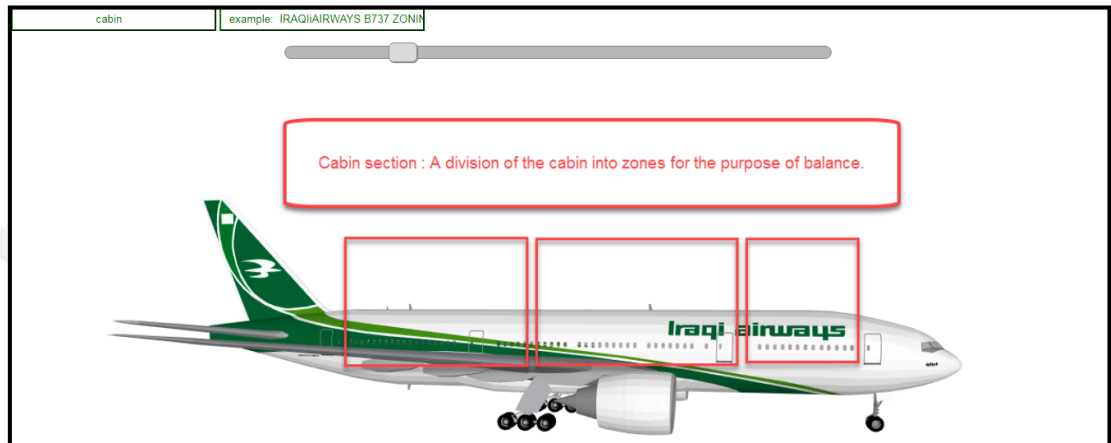


Figure 1.2 The initial application.

## 1.5 Overview of the study

This study consists of five chapters as follow:

Chapter one: it will contain briefly introduction about this study, clear view of the research problem, the study main objective, and overview.

Chapter two: it will contain a literature review about computerization, 3D visualization, weight, and balance, previous studies in the role of 3D visualization in supporting different science.

Chapter three: it will include the complete methodology implementation and the main study approach.

Chapter four: it will include the results of the research, comparison through both traditional and recent training methods and presentation of the final finding of the study.

Chapter five: it will include the main discussion, conclusion, and recommendation for the future scope, according to references and appendices at the end of all chapters.

## **CHAPTER 2**

### **REVIEW OF RELATED LITERATURE**

#### **2.1 Theoretical background**

Technology keeps on to make our lives more effective, make training professionals easier and more challenging, while many others still spending a lot of time through the years learning how to best utilize software like Flash and Captivate to simulate software applications for different training purposes. The truth was that even the better "simulations" are just that. Given the lack of assist for depth in current quick simulation authoring software, anything researchers could do to support realism while not increasing design and development time was a step forward. Leverage of virtualization to support the quality of the training offerings, in both the traditional classroom domain and as part of synchronous and asynchronous E-learning is considered very important [3].

##### **2.1.1 E-learning**

E-learning indicates the utilization of information and communication technologies to qualify access to online learning, teaching, and training resources [8].

E-learning technology has converted from a fully-online course to utilizing technology to convey part or all of a course independent of constant time and place. E-learning is described as the utilize of advanced multimedia technologies with the Internet to increase learning and training quality by easing entrance to facilities and different services as well as collaboration and distant exchanges.

E-learning reflected a new environment for learning which is centered on electronic networks has permitted learners in universities and different academics to acquire individualized support and also to gain learning schedules which is more appropriate to them as well as separate from other learners. This simplifies a high interaction and cooperation level between teachers or instructors and peers than the traditional

environment for learning. E-learning characterized by the utilizing of multimedia constructs made the method of learning more effective, interesting and also enjoyable [9].

### **2.1.2 E-learning types**

There are multiple ways of classifying the kinds of E-learning; there have been classifications depending on the range of their engagement in education, while other classifications depend on the timing of interaction. E-learning divided into two main types, containing computer-based and internet-based E-learning. The computer-based learning includes the utilization of a full range of hardware and software mostly that are available to utilize of information and communication technology and also every component could be used in either of two ways: the first one is computer-managed instruction and the second way is computer-assisted-learning. In computer-assisted-learning [10].

Computers are utilized instead of the traditional technique and procedures by providing effective software as a support instrument within the class or like a tool for self-learning outside the brand. While in the computer-managed-instruction, the computers are utilized for the goal of storing and retrieving information to support in the education management. The internet-based learning is moreover the development of computer-based learning; it activates the content to be available on the internet, with the willing of links to related recognition sources[4].

### **2.1.3 E-learning utilization in education and its advantages**

The significance of E-learning is presently a given fact. It could offer an alternative that is much cheaper, faster and potentially better. Due to the development of information technologies and multimedia, the use of the internet as a new method of teaching has made revolutionary changes in the traditional procedures of teaching. Developments in the information technology domain has produced more choices for recent education. The organizer of schools, universities and educational institutions has known E-learning as having the probability to transform people skills, knowledge and performance. Also, different colleges, universities, and also other institutions of higher learning race to improvement online course capacity in a

speedily expanding cyber education market. E-learning has come to take a more important role in institutions of higher education and initiating various changes in higher education institutions, specifically in the educational delivery and in the support processes.

E-learning supports the efficacy of knowledge and qualifications through the ease of access to a massive amount of information. E-learning helps exclude barriers which have the possibility of hindering participation involved the fear of talking to other learners, also it motivates students to make contact with others, as an exchange and respect different points of view. It allows communication and helps to develop the relationships which sustain learning. The main important advantages of E-learning for recent students to keep the learner's desire relevant, mobile, self-paced, and individualized content. Fulfilling this need achieves with the online method of learning, this style of teaching let the students learn according to their requirements and comforts. and give them an analytical look at the benefits of online learning [11]. Online Learning accommodates all student's needs, the online technology of learning is better suited for every student, this digital revolution has driven to satisfying changes in how the content is entered, used, discussed, and shared, online educational courses can be taken up via office workers in addition to housewives, and at the time that is suitable for them depending on their comfort and availability.

More advantages to learners, is access to updated content, scalability, consistency, with reduced costs, and quick convenience of lessons. The lessons start readily and also enveloped up in a single learning session, this allows training programs to simply roll out within some weeks or may even days.

Learners can identify their speed of learning rather than following the speed of all trainees. It saves time because the student does not need to attend to a specific training place. Students can choose to study relevant and specific areas of the learning items without concentrating on every area. E-learning Effectiveness, E-learning provided a positive effect on an organization's profitability. It results in developed scores contests, certifications, or any types of evaluation, its also enhances student's ability to learn and perform the new operations or knowledge at the workplace, and support retaining information for a longer time [10].

#### **2.1.4 E-learning in aviation**

As traditional classroom instruction needs pilots to be drag 'offs the line', training ease to be maintained and instructors to be a reward, E-learning is highly cost-effective and thus a better alternative. However, E-learning just saves money if the training was efficient. to gain financial benefits, the E-learning seminar has a history of modifying dramatically in quality. The weak and imperfect courses are those which directly switch classroom-based presentations to another online style, not perceiving that computer-based instruction is a completely different domain. Handle this issue immediately, E-learning in Aviation inspects the features of computer-based course multimedia and design which are connected with developed learning. then it guides how to utilize research-based instructional design rules to plan, develop, design, and perform an E-learning course within an aviation institution and continually estimate whether or not the course was accomplishing educational goals.

A mixed learning strategy, that incorporates both computer-based instruction and face-to-face, was supposed as the most suitable choice for the plurality of aviation companies. The target of this approach is to employ E-learning as a tool to decrease time at the training medium and thereby excess pilot productivity and potentially develop the type of training [12].

#### **2.1.5 Virtualization**

Virtualization defined as the generation of a virtual rather than a genuine version of something, like a server, an operating system, a storage device, and network resources.

Virtualization characterizes a technology in which an application, data storage, and guest operating system are distracted away from the real underlying hardware or software, a prime utilization of virtualization technology is server virtualization, which employs a software layer named a hypervisor to simulate the underlying hardware. This usually contains the CPU's memory, Input/output, and network traffic. The guest operating system, generally interacting with real hardware, was doing the same with a software emulation of that hardware, and general, the guest operating system doesn't have an idea that it's on virtualized hardware. where's the

performance of that virtual system is not the same to the performance of the operating system that operating on real hardware, the notation of virtualization work because all guest operating systems and their applications don't require the complete use of the underlying hardware. This permits for better flexibility, dominance, and isolation by eliminating the dependency on a presented hardware platform. Whilst initially intended for server virtualization, the idea of virtualization has distributed to applications, data, networks, and desktops [13].

A technique of virtualizing an application to perform on a multitude of operating systems without installation. The technique contained creating an input configuration file for every operating system. The templates each involved a collection of configurations that were made by the application through installation on a computing device performing the operating system. The templates are joined into only one application, the template having a layer containing the collection of configurations for every operating system. The collection of configurations contained files and registry login. The collections also recognize and configure environmental systems, variables, and the like. Files in the collection of configurations and the references to these files might be replaced with references to other files stored on installation media. The application template was utilized to construct an executable of the virtualized application. The application template might be combined into a clear listing of other application templates and do them obtainable to users from a website [14].

### **2.1.6 3D Visualization**

Data visualization is the domain of computer science which is concentrated on displaying information. In specific, it presents information in a method that is simple to understand and consume. It might not realize it, but it encounters instances about it almost daily, like graphs, charts, digital images, and movies. Visualization can carry more details about a topic than the original data could on its own.

3D Visualization software is utilized to show and interrogate 3D models and other deliverables formed with Mechanical Computer-Aided Design software, 3D visualization was becoming widely popular for distinct event simulation, the 3D

visualization considers as the most quickly developing technology that utilizes computer graphics, audio, video, and different multimedia applications.

3D data visualization considers as a subset of data visualization. In multiple respects, they are the same. There are a couple of objects should be noted which create 3D Data Visualization apart:

**Visual Style:** 3D utilizes an extra dimension, execution resort to have a feeling of depth, although when it is performed on a two-dimensional page.

**Number of Dimensions:** This is the clearest one, regular data visualization could utilize any number of dimensions, even though it is often some variation of two - length and width. 3D visualization generally utilizes three -width, length, and depth.

**The volume of Information:** 3D visualization tends to have more data connected with it than regular data visualization.

Data representations through utilizing 3D visualization reducing data complexity which tackled in CG by following data reduction and multi-resolution representation mechanisms, this could also be achieved based on the use of filters that implement ad hoc visual interpretations of the data.

Visualization support in boosting human's cognitive procedures, it has been confirmed to provide a range of benefits to the process in which people obtained knowledge, that includes (1) perception of big data, (2) unexpectedly pleasant ways of understanding information, (3) fast recognition of mistakes and outliers in data set, (4) recognition of patterns in data, and (5) facility at hypotheses formation out of the information [15].

### **2.1.7 Weight and balance**

The aircraft's weight and balance data is significant information for a pilot that should be repeatedly reevaluated. Although the aircraft was weighed through the certification procedure, that information is not correct indefinitely. Instruments and devices changes or alterations affect the weight and balance data. Too often pilots decrease the Aircraft Weight and Balance into a general rule.

The most significant part of preflight planning is deciding how the aircraft is loaded, thus, its weight, and CG location are within the permitted limits. The significance of

the CG was emphasized in the investigation of stability, performance, and controllability. Unequal load allocation raises accidents. An expert pilot understands and respects the impact of CG on an aircraft [16].

The methods for implementing this are the traditional manual computational method utilizing weights, arms, and the moments, the chart method which utilizing weight and moment indexes. As shown in Figure 2.1, also using the loading graph method, which excludes the need for different mathematical calculations.

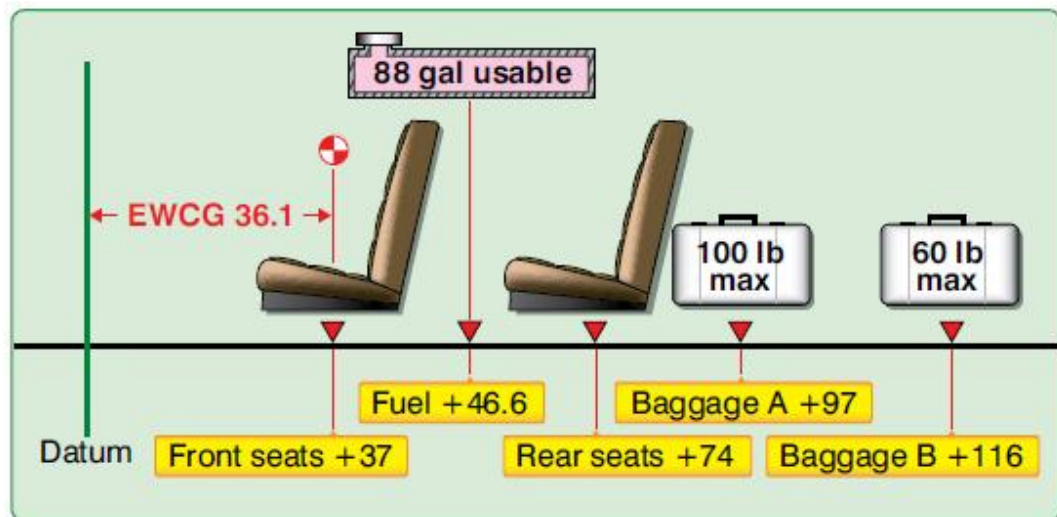


Figure 2.1 Airplane loading diagram

Weight and balance are important components in the employment of an aircraft to its fullest possibility. The pilot should know how much fuel could be loaded onto the aircraft without exceeding CG limits, as well as weight limits to conduct short or long flights with or without a whole complement of permissible passengers.

More weight to the load of the aircraft might or might not place the CG outside of the CG warped, but the highest total weight could be exceeded. The surplus weight could overstress the aircraft and decline the performance [17].

Aircraft for weight and balance are certificated on two main reasons:

The impact of the weight on the aircraft's fundamental structure and its performance attributes. The impact of the location of this weight on flight properties specially set up and spins retrieval and constancy.

### **2.1.8 Impact of Weight on Flight Performance**

The takeoff and landing implementation of an aircraft is specified based on its maximum permitted takeoff and landing weights. A massive gross weight causes a longer takeoff run and results in a shallower climb, and causes a quicker touchdown speed and also a lengthy landing roll. Even a slight overload could make it unattainable for the aircraft to overcome an obstacle which normally would not be a problem via takeoff under more suitable conditions.

The destructive effects of overloading on implementation are not restricted to the immediate hazards associated with takeoffs and landings. Overloading has an opposite impact on the whole climb and turn performance, which results in overheating through climbs, raises wear on engine portions, incrementing fuel consumption, slower cruising speeds, and decreased range [17].

### **2.1.9 Impact of weight on aircraft structure**

The impact of additional weight on the wing structure of an aircraft is not easily apparent. Airworthiness requirements determine that the structure of an aircraft certificated in the usual denomination should be strong and adequate to resist a load factor of 3.8Gs to take care of dynamic loads resulting from gusts and maneuvering, which means that the base structure of the aircraft could withstand a load of 3.8 times the suitable gross weight of the aircraft without structural defeat happening. If this is admitted as indicative of the load features which might be imposed through operations for which the aircraft is designed.

Structural failures caused by overloading might be dramatic and catastrophic, but moreover, they influence structural components progressively in a case that is hard to detect and expensive to mend. Frequent overloading tends to reasonably add cumulative stress and deterioration that might not be detected via preflight inspections and caused a structural failure even after completely normal procedures. The additional stress set on structural portions by overloading is supposed to accelerate the appearance of metallic fatigue failures [16].

### 2.1.10 Most common weight and balance mistakes

Weight and balance mistakes and misunderstanding that could result from the unclear explanation, ineffective training and the use of traditional means of clarification don't correspond to the importance and gravity of the aircraft weight equation which determines at the moment of takeoff and landing could lead to major problems and even accidents.

Employ improper weight and balance information: When specifying the weight and balance for the aircraft, it must use the weight and balance for that specific aircraft. Weights that between a generic POH and the specific aircraft POH might be considerably different.

Knowing just one method to decide weight and balance: various aircraft manufacturers provide different methods to compute weight and balance, those contained tables, graphs, and common computational techniques when it is necessary to calculate weight and balance for an aircraft the pilot is not familiar with, he might be using a different method which he could familiar with.

Math mistakes: Using a computational method to specify weight and balance, it's important for the pilot to double-check his calculations because a simple miscalculation might put pilot out of weight and balance limits. Overloading the aircraft: Not taking extreme gross weight critically could hurt flight features, so pilots should remember, that max gross weight isn't a performance restriction, but it's a structural limitation. Rounding weights: The pilot should try to as accurate as possible by determining the weights of different items that might be on board. Doing that could prevent accidentally flying an overweight aircraft, which pilot may thoughts that it was within weight and balance. Forgetting to convert: When the pilot calculates weight and balance, he should remember that fuel will be given in gallons, and it's his responsibility to convert gallons to pounds. Because forgetting to do so might put the weight and the balance computations off by more hundreds of pounds [18].

In the specific context of an aviation application domain, it is important to note that not just pilots but aviation maintenance personnel too are a highly mobile

international end-user group. When implementing operational and maintenance operations on the flight line or at various maintenance facilities, directly on the airplane or in the workshop, those persons require the possibility to work independent of their positions, while still following the strict commands for continuing airworthiness.

This study explores educational uses of 3D visualization technology especially for application workflows in training aviation courses. It describes the status of an ongoing application which is going to be implemented, highlighting the initial related studies and the suggested outline of the application to be developed.

In this study, the idea is to computerizing 3D visualization through E-learning technology to provide an effective training and educating method for Aircraft Weight and Balance course by using 3D object, which considered as virtual reality, virtualizing and visualization, as the combination of 3D visualization technique that could be used for effective and to maximize the training and learning resource and services.

## **2.2 Related previous study**

Academic research on E-learning through utilizing different technology like 3D visualization has increased widely over the past few years. Although different multi-criteria for utilizing E-learning methods have been developed to evaluate and examine the effectiveness of E-learning, on the other side there is still a lack of study concerning systematic literature study and classification of research in this domain.

In this study, the author improved new methodology which depends on employed E-learning mechanisms to provide an advanced learning method in computerizing Aircraft Weight and Balance course, using 3D objects upon that which has investigated and evaluated different related studies within this area.

### **E-learning**

[19]. Displayed in their paper The importance of utilizing technologies like E-learning in various disciplines. They have measured the effectiveness of E-learning in several domains, the advantages of those learning techniques and the positive university atmosphere concerning the use of online learning. Therefore, their study

aims to compare the effects of both methods of teaching (virtual versus traditional) on student learning. This post-test just design study approached 40, From this group, 35 students accepted to participate. Those students were randomly divided into two groups, experimental (virtual learning) and comparison (traditional learning). To guarantee similarity among groups, they compared GPAs of whole participants by the Mann–Whitney U test ( $P > 0.05$ ). The experimental group acquires a virtual learning environment courseware package particularly designed for that study, whereas the other control group takes the same module structured in a traditional lecture style. The virtual learning environment includes offline and online materials. Post-tests which consisted of 40 multiple choice questions, and another 4 essay questions were managed immediately (15 min). Data were analyzed using SPSS version 20. Results: A comparison showed that virtual learning was more efficient than traditional learning (effect size = 0.69. [19].

[20]. Explained in their study that 3D design and 3D tools were becoming ever so widely used in today's technology. towards the 3D content platform all the world is influential, 3D TV sets, 3D mobiles, 3D medical applications, and other more. based on the technologies nature, they usually demand on-site aggravating training, which is time-consuming and so expensive. There is an actual necessity for a responsive virtual training environment that the users could be trained at any time and from anywhere, as they want. Their study explained the improvement of a web-based interactive 3D virtual environment for a two skin measurement tool to work for this purpose. The virtualized application contained a detailed virtual user booklet having a step by step instructions which will direct the users on how to utilize two skin measurement instruments. The virtual environment benefits users by giving users a very realistic feel about how instruments work. The study result shows that Virtual Reality is an essential technology that delivered experience and knowledge to users [20].

[21]. Explained that several studies explored the process of learning and its impact on education and training. utilizing a Collaborative virtual environment for studying and described aircraft evacuations in a virtual reality environment consider as a powerful education and training tool. They believed that people learn best via actual life experiences and that emotion of presence was developed in a virtual environment which could provide real-world experience and knowledge, their suggested multiuser

environment contained aircraft, runways, an airport, and a control tower, virtual reality experience with virtual discharged drills was needed to examine human behavior under terror or stressful cases which cannot be investigated in the real world. The utilize of collaborative virtual environments to work virtual evacuation drills for a contingency evacuation end risk of hurt to contributor and permits for the testing of scenarios which could not be examined in real life due to legal affairs and potential health risks to participants, their contribution based in their approach to merge computer-simulated operator and user-controlled independent agents in a collaborative virtual environment to implement virtual evacuation drills. The outcome of this study could be utilized to measure the protocols, the effectiveness of the present process, and also the effectiveness of training for airline and other security risks [21].

[22]. Demonstrated that 3D virtualization technology whose application could acquire an inclusive sensory stimulation to simulate a pragmatic environment has penetrated different industry domains, and with application development of multiple areas, using 3D visual virtual reality to receive the training environment could develop the technical level and operational specifications. due to the three-dimensional visual virtual reality technology adopted in the evaluation and the maintenance environment, which improved the training accuracy and reduced the probability of operational errors [22].

[8]. Show in their study that at institutions of higher learning, there was an increased need and request for online courses. While the number of faculty improving and teaching those courses does not meet the development in online education. The main aim of this study was to specify perceived obstacles for online teaching experienced by multiple faculty groups at a generic institution placed in the southeastern United States utilizing new survey tools, which was improved from recent research results. This study looks to detect the most common barriers to online instruction for the faculty group examined. Also, those findings might detect prevalent barriers for faculty groups to notify managerial decisions concerning training, policy, and restitution as well as to facilitate participation for specific kinds of online instruction for faculty improvement. A set of novel and significant differences were found in the perceived barriers which occur between faculty groups on four constructs defined through exploratory factor analysis. Those factors were as follow: (1) interpersonal

barriers (2) training and technology barriers (3) cost and benefit analysis barriers. (4) institutional barriers. The findings of this study might be of utilizing to other institutions as they improved online instruction training courses [8].

[23]. Shows that there is evidence that latest developments in Augmented Reality (AR) and Virtual Reality (VR) technology can be implemented as pervasive media on many devices in different methods and contexts, mostly with low-cost devices involving (MAR) Mobile Augmented Reality applications on smartphones or different Pocket-PCs. In this study, they present a framework to join the pervasive e-education notations with augmented reality components for E-training. They analyze recent research, discuss some cases from ultra-light / light-sport aircraft maintenance and display how to perform this framework generically. They present a learning engine to carry this special kind of content and extend a further outlook of future studies. A user-centered approach should ensure that the developments could stimulate motivation and support the performance of the end-users in various training sessions. The main advantages are, that the end-users are qualified to better perceive sophisticated, technical facts, systems and their components [23].

### **Data visualization**

[15]. Showed in their study that Information visualization support users vastly identify interesting and important events and patterns from data that are otherwise too detailed or sophisticated to grasp and understand. As an example, rich content and suitability provided through social networks permit students to exchange ideas and sharing collaborate. In this context, students were interested in investigating the learning tasks of another student without having to read via many of textual contents. Students have the interest of discovery information about their majors, contents of the topics and their co-learners. So, with a large amount of information obtainable, it is hard to detect relevant information for the users. In this study, they highlight obstacles and opportunities in the visualization of big data and training activities on social networks and present new techniques of visualizing the learning activities of students on multimedia and social networks. The technology permits students to see trends in content and actions near them and around the world. A new application was

developed depending on the method and is evaluated. Study results showed that students found it fun and simple to explore the learning activities of their peers [15].

### **3D visualization in medicine**

The integration of computerized imaging and medicine has constructed the utilization of the method of Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET) and Ultrasonography, all of which result in volume imaging data. Those data might be present as acquired, mostly as a series of slices oriented in the gaining plane. This kind of 3D visualization display has confirmed to be quite useful for diagnostic, it is simple and needs unsophisticated computer resources [24].

[25]. This study compared the effect of two-dimensional versus three-dimensional visualization on both subjective and objective measures of laparoscopic implementation utilizing the validated Fundamentals of Laparoscopic Surgery (FLS) proficiency group.

**Study Subjects and Methods:** Thirty-three individuals with different laparoscopic experience completed three major drills from the FLS proficiency group (pattern cutting, peg transfer, suturing and knot tying) by both 3D and 2D, participants were randomized to start all tasks in either 2D or 3D. Time to fulfillment and the number of experiments required to attain proficiency were measured for every task. There were Errors noted. Participants finished questionnaires and then evaluating their experiences by both visual modalities.

**Results of the study showed that:** through all tasks, super speed was accomplished in 3D versus 2D: peg transfer, 183.4 versus 245.6 seconds ( $P < .0001$ ); suturing/knot tying, 255.2 versus 329.5Seconds ( $P = .031$ ) and pattern cutting, 167.7 versus 209.3 seconds ( $P = .004$ ). Slight errors were committed in the peg transfer function in 3D versus 2D ( $P = .008$ ). Fourteen participants need various attempts to obtained proficiency in one or more functions in 2D, compared with 7 in 3D.individuals measures of efficiency and precision preferred 3D visualization.

The priority of 3D vision preserver independent of participants' level for technical expertise, novice, intermediate or expert. No differences were reported to any side

effects between the two types of visual modalities. About 87.9% of participants extremely preferred 3D visualization.

**Study Conclusions:** 3D visualization appears to strongly support laparoscopic proficiency depends on objective and subjective measures. Study experience; show that 3D visualization produced no more headaches, eye strain, or other side effects than 2D visualization. Also it's providing clear technique to implement critical tasks, so all the Participants overwhelmingly preferred 3D visualization [25].

### **3D visualization in multimedia applications for science learning**

This study aims to specify whether the utilization of specific kinds of visualization (3D animation, interactive 3D animation, and 3D illustration) integrated with text and narration, contributes to the learning method of 13- and 14- years-old students in various science courses. The study held out with 212 8th grade students in Greece. Structured visualization skills different based on the various levels of difficulty: 1- Spatial visualization 2-Spatial orientation 3-Spatial relations [26]. This exploratory research use three various versions of an interacting multimedia application named "methods of separation of mixtures", every one differing from the other two in a kind of visuals.

The multimedia application was generated from scratch. The steps were as follow drawing and producing of all constant 3D illustrations, generating of 3D animations, and also interactive 3D animations with the suitable programming, then adding of the text and sound speech, at last, the precise connection of all of above components in the final format of the multimedia application, utilizing the most appropriate authoring programmer. The results show that multimedia applications with interactive 3D animations like with 3D animations do actually, raise the interest of students and make the material more attractive to them.

The results also propose that the most obvious and primary benefit of constant visuals (3D illustrations) was that they left the control of learning time to the students and reduced the cognitive load [27].

### **3D Visualization on mobile devices**

In this research [28], were discussing the present status and current advancements of 3D graphics on mobile platforms and describe open issues about its usage in multiple applications. They have treated two specific application fields. Firstly, they treated

with problems of visualization of sophisticated data structures on different mobile devices. The employment of a 3D visualization renderer on the Symbian program for various mobile devices was coded as a C++ application and depends on the Diesel Engine just like a rendering engine. 3D visualization of data was created in the form of a (VRML) Virtual Reality Modeling Language file sense that any type of 3D element written in VRML file format could be rendered on like a device. It was the result of a project the objective of that was to supply a user interface on a mobile platform presenting a visualization of hierarchical grid control data. Secondly, they described the system which brought face animation to established platforms. Face animation is supposed to be one of the strict tasks in computer animation nowadays and its delivery to mobile platforms conduct probability for the development of advanced innovative and granular services for the mobile market.

[29] explained that Three-dimensional visualizations implementing traditional input and output methods have well-known limitations, natural interaction techniques, Immersive technologies and current improvement in data physicalization could help to overcome those concerns. Due to this situation, they were specifically concerned with the use of spatial interaction within mobile devices for developed 3D visualizations. To gain a better understanding of that interaction kind, they performed example visualizations on a spatially-tracked tablet and examined their use and potential. In this study, they reported on a qualitative survey comparing spatial reaction with in-place 3D visualizations to classic tap interaction based on ideal visualization operations, comparison of individual data objects, navigation of unknown datasets, and the realization and memorization of construction in the data. They identified many distinct use patterns and deduced recommendations for utilizing spatial interaction in 3D data visualization [29].

#### **Interactive and static 3d visualization – a pilot study**

[30], specified in their study that in recent applications like Google Earth and Virtual Earth and different others, were created a considerable extending of the third dimension with multiple spaces just as the cartographic and geoinformatics scopes. Interactive 3D visualization of spatial data is recently used for different applications and various issues. 3D visualization of spatial data utilized in crisis and emergency handling, urban planning, noise mapping, geography learning or virtual tourism.

Visualization was discussed within the scope of human factors in more concentration. Many researchers, like [31], discussed that 3D visualization can provide a large amount of complex data to larger audiences, containing those with few or no Cartographic or GIS literacy. The pilot study presented in this study aims to confirm the above-mentioned statement.

[32] described the common advantages of the 3D Visualization of spatial data. The main benefits are the presence of more space for displaying extra data variables, which resolving issues concerned with hidden symbols, and access to a more familiar vision of space. Also, [32], [33], express out possible concerns that might arise through 3D visualization. Those contained the obstruction of objects in a 3D view, the presence of variable scales within the only view, perspective distortion and unequalled geometries of objects. Furthermore, there are various solutions for the disadvantages and the generality mentioned was the interactive movement in 3D view. In the researcher's notation, interactive 3D visualization, which permits virtual movement and navigation, was various to static perspective views on 3D data, that the users utilize, induce entirely various working strategies and cognitive operations. This study aimed to detect the differences in user performance and interactive 3D visualization, and constant perspective views Unique experimental instruments depend on web technologies that were used for that test. They firstly analyzed the speed and accuracy of the user's performance. Moreover, the movement and the interactions in the virtual environment were registered within the interactive Visualization. [30].

[34] was determine weight and center of gravity based on electrical signals as he described that the Aircraft Weight and Balance computer apparatus procedure sensor outputs to create an electrical signal which is relative to aircraft total weight at the time take-off thrust is firstly implemented to the aircraft on the runway and frequently updates the weight signal when airborne to calculation for burn off of fuel or another weight reduction and also supplies a measure of the position of the aircraft center of gravity location. This is done by computing the aerodynamic power on the aircraft in its longitudinal plane and the thrust that produced by the engines and relating this calculation to the corresponding acceleration elements measured by a pair of direct accelerometers which in this longitudinal plane are mounted orthogonally [34].

## CHAPTER 3

### DESIGN AND METHODOLOGY

This chapter explains the methods used in this study in order to achieve the proposed thesis objectives, this thesis displays the work done to implement advanced virtual computational tools and methods concentrate on aircraft virtual design sizing and optimization, which provided new training method in the aviation sector by employing E-Learning technology. Those tools have been applied to provide the trainer with modern and powerful demonstration tools that will increase the effectiveness and quality of the training course.

Aircraft Weight and Balance course provided by the Iraqi Airways in the airline training center in Baghdad to qualify employees to be a load sheeter (loadmaster), where all the selected trainees are coming from the same background and have the same knowledge and experience about aircraft weight and balance course. While the current methods in the Iraqi Airways training center in teaching the aircraft weight and balance course are still quite traditional and mostly experimental.

The old way is to extrapolate information's through using a traditional learning way, where the instructor uses a plastic airplane of 0.5m height and explains the course topics and methods on that plastic airplane model. Eventually, this will lead to several difficulties as stated below:

1. Less familiarity and visualize of aircraft parts and airport tools related to load and balance process for the trainees.
2. Low familiarity with different aircraft types for the trainees.
3. Trainees suffering from a boring learning class.
4. Difficulty in receiving the information for the trainees.
5. Trainees taking a long time to get used to making the right loading decision quickly and automatically.
6. Low in mastering aviation codes and audio communications in the load and balance process.

## 7. Big effort spent on the explanation and information delivery from the trainer.

This thesis contributes by providing a developed technical solution for the course training aircraft weight and balance, which creates computerized training methodology comprises a system, method, and computer program product that providing 3D visualization model, which will be explained as a part of E-learning training. The usage of 3D visualization is to provide a tool that facilitates the explanation of the subject and facilitates its understanding for students in a way that they are more competent, knowledgeable, and imagining and understanding the goals of training.

The proposed online application allows instructors and students to access it from anywhere worldwide, the instructor will explain the course by using a 3D aircraft virtual model, which will provide a complete ability to explain all load and balance topics by using a 3D model with designed drawings, photos, text, and videos on that computerized model.

The rest of the chapter is structured as four partitions after the final data collection procedures:

- (1) Design the website (includes the reasons for choosing design instruments with a description of the design steps and procedures).
- (2) Comparing the two methods of education for aircraft weight and balance course (virtual versus traditional) by depending on exam scores results.
- (3) Design a simple satisfaction survey (for the students).
- (4) Arrange an interview with the aircraft weight and balance course instructor.

### **3.1 Design methodology (Computer-Aided Design)**

#### **3.1.1 The main problem**

The traditional method provides difficult and weak explanation tools and lacks a precise clarification mechanism. Where a general 0.5m height aircraft model has been used in the training, where there are different types of aircraft, where the properties and loading documents of each aircraft are different, yet the same model

will be used in all the courses. The usage of the previously mentioned model requires a big effort from the trainer in the explanation. The lack of content where a few photos and not enough demonstration tools are used.

### **3.1.2 The main Solution**

The proposed approach using modern technology presented by 3D visualization helps the trainer to deliver the information in an easier and more effective mechanism. Which will provide trainees with an understandable, interesting and rememberable content.

### **3.1.3 The design**

The first idea was to develop an application that works on Android OS, using Android visual studio but the obstacle was that it might not be working on another operating system. The most effective idea was to develop an online web page as a learning environment, which can be accessed by many operating systems using desktop, laptop, mobile, and tablet.

The proposed approach to use HTML, JAVASCRIPT, and CSS to design and develop the website, as it gives the ability to virtualizing and visualize the targeted content.

### **3.1.4 Course design requirements**

Several meetings were arranged with the instructor of the Aircraft Weight and Balance course, some of those meetings are held in the training center (location of the training in Baghdad). Face to face meetings was held, which need several domestic flights between two cities. The researcher needs to communicate by phone call, video call, WhatsApp video, and voice calls for more additional details.

In the first meetings, the trainer requirements were investigated and analyzed in order to be visualized and detect the problems or barriers while the course being educated, then it has been decided what the suggested solutions could be. Eventually, with trainer support, a conceptualization for the proposed solutions has been reached.

The features and functions for the virtual system and the selected tools by the trainer from the proposed system are stated below:

**First:** aircraft model with 360 rotational, must include these main features:

A - An aircraft model that can be rotated 360 degrees.

B - Annotations, drawings, on the aircraft 360-degree model.

C - Text, and virtual photos on some parts of the airplane.

D - Attached buttons, includes photos and videos when needed.

**Second:** a page for aviation Alphabets.

A- Buttons labeled with the letters with its aviation shortcut code.

B- When specified button clicked, a clear voice record played, for the specified letter with its aviation shortcut.

**Third:** A page for the aviation codes.

A-Several buttons labeled with Aviation codes shortcuts.

B-When the buttons clicked, alert that explains the meaning of the shortcut appears.

**Forth:** A simulator for a general loading document.

A - Sliders with arrows that guide the movement.

B - Alert, when the slider moves to the wrong side.

C - Alert, when the loading is more than the threshold allowed in the slider.

D- The sliders are connected sequentially.

E- Loading result is shown as two red lines dropped on the specified sheet.

**Fifth:** Several 3D aircraft models with explanation tools.

A - The 3D aircraft model object can be controlled by a mouse or touch screen devices.

B- Ability to freeze the aircraft 3D model.

C- After freezing the aircraft 3D model, the ability to draw and write on the model.

**Sixth:** Several 3D aircraft models attached to the loading document for each aircraft type with explanation tools. The 3D model includes the following features and functions:

A - The 3D aircraft model object can be controlled by a mouse or touch screen devices.

B- Ability to freeze the aircraft 3D model.

C- Ability to show the loading document while the model is frozen.

D- Make the loading document transparent and control its transparency degree.

E- After freezing the aircraft 3D model, the ability to draw and write on the model.

**Seventh:** A page simulates the communications to get the final load of the aircraft:

A- Multiple buttons that include different communication scenarios.

B- A button to start the communication.

C- A press and hold button to answer during communications.

After obtaining sufficient information about the problems of the old design, as well as obstacles facing the trainer during the process of explaining the basic concepts and key processes in the aircraft weight and balance course. The shape and functions of the design were determined.

The next step was modeling the course through a direct explaining, supervision, and directions given by the trainer.

**A.** A small aircraft model used to determine the required part and its annotations to design the 360-degree rotation virtual aircraft model with annotations. Stickered scraps used on the small aircraft model, each of them labeled with an index number, which written in a notebook followed by the definitions and explanations of each part.

**B.** The same small aircraft model used to explain the parts on the small-sheet to design the loading document simulator.

C. Communication scenarios, and the aviation alphabet recorded under the supervision of the trainer.

### **3.1.5 System design and modeling**

In this research, the developed online website includes virtualized procedures for aircraft weight and balance course. Designed and developed system will support the aircraft weight and balance trainer, which will facilitate the process of explanation vital and important points, as it will provide near-realistic and clear scenes for the actual operations being processed, so the trainees will receive high-quality techniques in the learning and training process, and most of the core tasks will be easy to learn and implement.

The proposed approach provides a visual and semi-realistic design of a real aircraft, rather than the old plastic model, which represented one aircraft that was used to explain all the other aircraft types, with the hardness to move it, also, without ability to write or draw on it and hardness to matching it clearly to the loading documents of different aircraft types. Eventually, it will help the trainees, and refine their skills by linking the theoretical with the practical.

This design provides a 3D model to each aircraft type in the airline company, with tools to write and draw on each aircraft, and with the ability to move it easily with visible loading document attached to each aircraft type, with writing and drawing tools on the loading document also.

The system design provides simple interfaces, the first one to learn the aviation codes in an interesting way. While the second interface to learn the aviation letters with the record for each letter to simplify the training on listening and memorizing it, as they are important during the communication and for aircraft zoning figures and aircraft registrations.

The system design provides a simple communications simulator to practice listening and responding during communications, which leads to mastering the real communications scenarios.

The system provides a general loading document simulator, to exercise on taking the correct loading instructions and understanding the loading document details, where alerts appear if mistakes occurred.

### **3.1.6 User interface and virtual environment**

This part will show the functionality of the online virtualized course website for the user (trainer/trainee) includes the website creating, requirements of the system, access to the web, access to the content and user controls.

#### **3.1.6.1 Website creating**

The domain name is chosen and booked from **GODADDY** co international domain provider. Then the web host is created on the Linux server, and the domain is linked to the server via DNS, creating a database "MySQL" on a web host, then Word-press PHP script is installed, which is used with "MySQL" database to manage the content of the website. Eventually, the general theme of the website is chosen and designed, the pages are created and connected to the teaching system, that is designed and developed by utilizing JavaScript, HTML, and CSS.

#### **3.1.6.2 Website access and system requirements**

The system requirements for aircraft weight and balance online course are:

1. Moderate Internet connection.
2. Internet Explorer, (Firefox, google chrome, opera, safari).
3. Touch screen, keyboard with CTRL button for mobile.
4. Mouse, keyboard for laptop and desktop.
5. Microphone and speakers.

**First:** The end-user needs to open the internet explorer, and write the website address, just as www.....com.

**Second:** The user should choose the aircraft weight and balance course page for the trainer.

**Third:** The trainer should enter the trainer password to reach the content. The students (trainees) can reach their page by click on the trainee/student and enter the password to reach the content.

### **3.1.6.3 User interface and controls**

The interface used in this website is simple and clear to both trainer and trainee, at the main aircraft weight and balance page a vertical list of course sections, which cover the whole important virtual content of the course.

In the sections of "Holds & Compartments, ULD, Bay, Net Section & Loading, Cabin & Cabin sections, Basic weight, dry operating weight & traffic load, Maximum take-off/landing weight & zero fuel weight, The Four Forces of Flight, Datum, Arm, Moment Arm, and CG, and Aircraft registration" a 360-degree rotation aircraft which can be controlled and move 360 degree using a designed control slider through dragging the mouse on it or by one click on it then control it by left and right keyboard directions, some drawings, and annotations will appear during the rotation, with on-click buttons which contain videos and photos contain definitions and examples. Figure 3.1 shows the aircraft drawings and annotations during the rotation.

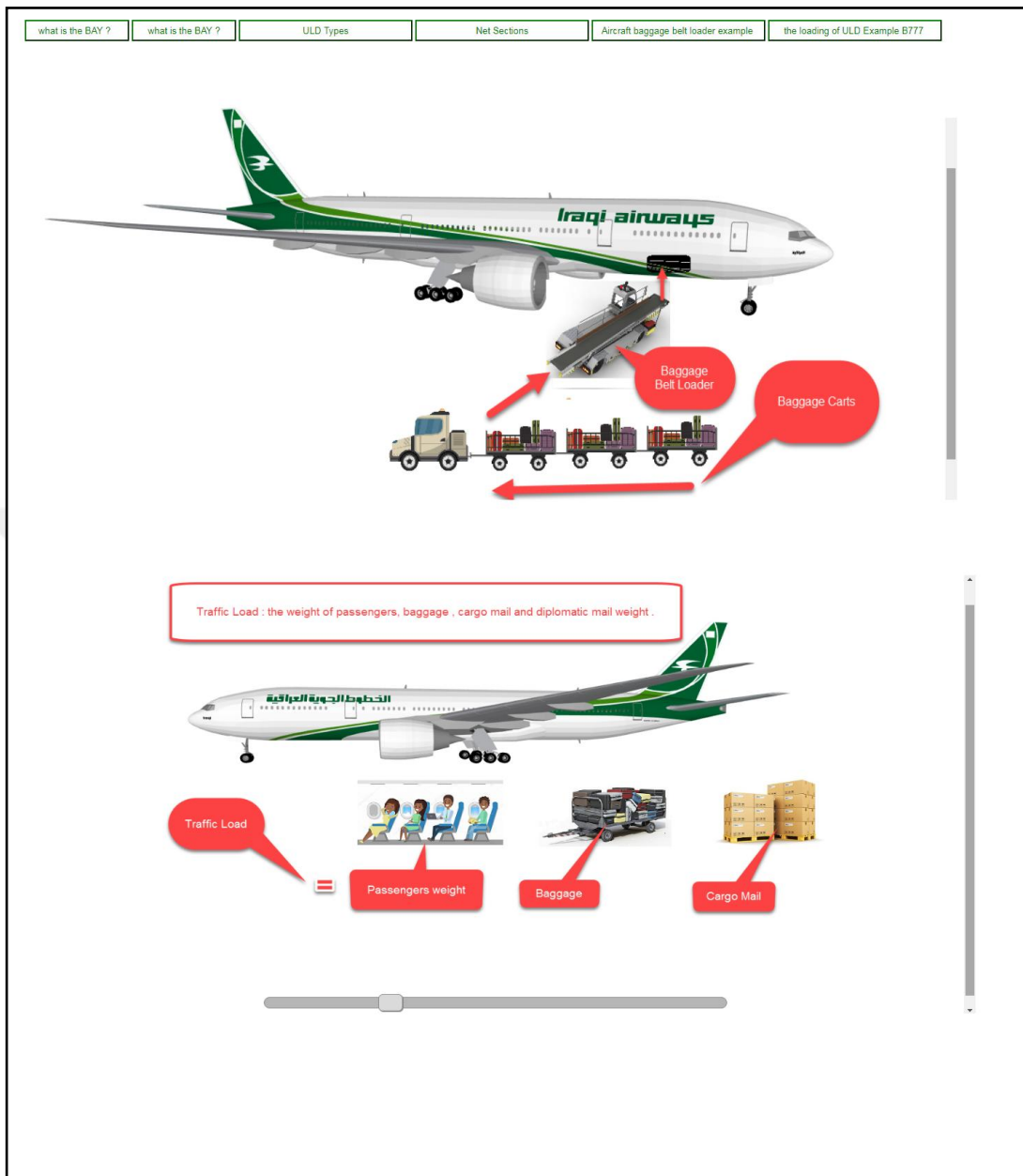


Figure 3.1 Aircraft drawings and annotations during the rotation.

The codes of aircraft rotation 360-degree: In this section, a 360-degree rotational aircraft.

- 50 to 60 images taken to an aircraft object from several sides around, with annotations and drawings on some of it.

The idea of the code is collecting those images to load and view it in order(sequence)and match it to a slider which gives the ability to move it as one object.

An HTML image tag was added with the id imgg, and the width and height were set, then an HTML input tag was added to create a range (slider), with a specific value(the starting image), minimum value and maximum value of the slider, with id imgrange as shown in figure 3.2.

```
<img src="" width="1250" height="800" id="imgg" />
<input type="range" value="1" min="1" max="62" id="imgrange">
```

Figure 3.2 HTML tags and slider.

A function getimg() was added to load all the images after opening the page, so the rotation can be faster as shown in figure 3.3.

```
<script>
    function getimg()
    {
        URLs = new Array(62);
        for (let i = 0; i <= 61; i++) {
            URLs[i] = "/s2/photos/" + (i + 1) + ".png";
        }

        URLs.map(function (URL) {
            var img = new Image();
            img.src = URL;
            return img;
        });

        setInterval(function() {imgfun()},100);
        function imgfun()
        {
            var imgvalu=document.getElementById("imgrange").value;
            document.getElementById("imgg").src="/s2/photos/"+imgvalu+".png";
        }
    }
</script>
```

Figure 3.3 Getimg function.

SetInterval method calls the function imgfun() every 100 milliseconds to check the value of the slider continuously. Then a variable that gets the value of the slider is defined, then the name of the image with the value of the slider is matched as shown in figure 3.4.

```
setInterval(function() {imgfun()},100);  
}  
function imgfun()  
{  
var imgvalu=document.getElementById("imgrange").value;  
document.getElementById("imgg").src="/s2/photos/"+imgvalu+".png";  
}
```

Figure 3.4 SetInterval method.

When loading of the page finished, the function getimg() was called as shown in figure 3.5.

```
<body onload="getimg()">
```

Figure 3.5 Calling getimg function.

The script of buttons and photos will give the ability to click on the button and view the image inside it, and at the same time, by clicking any another button it will show the image of it instead of the first image. Figure 3.6 shows the script.

```

<script>
    var imgs = ["img1", "img2", "img3", "img4"];
    function showImage(imgid) {

        for (let i = 0; i < imgs.length; i++) {
            if (imgs[i] !== imgid) {
                var img = document.getElementById(imgs[i]);
                img.style.display = 'none';
            } else {
                var currentimg = document.getElementById(imgs[i]);
                if (currentimg.style.display === 'inline') {
                    currentimg.style.display = 'none';
                } else {
                    currentimg.style.display = 'inline'
                }
            }
        }
    }
</script>

```

Figure 3.6 The script of buttons and photos.

The section of the "Codes" includes a clear distributed designed clickable buttons which labeled with the code name, and after clicking the button the code name will appear in the designed alert message, figure 3.7 shows the codes page.



Figure 3.7 Codes page.

1 - In this section, several buttons were created with alerts to appear on-click.

2 – From **github.io** SWAL alert style, used to show the alert with the required text.

Swal alert shown in figure 3.8.

```
<script src="swal.js"></script>

<center>

<input type="button" value="A/C" onclick="swal.fire(' Aircraft') " style="background-color:white;
border-color:green; color:green; height:30px ;width:150px" />
```

Figure 3.8 SWAL style.

The section of the "Aviation alphabet" includes a clear distributed designed clickable buttons, which labeled with the English letter with the aviation shortcut of it, after the click, a clear voice record of the English letter with the aviation shortcut of it will be played. Figure 3.9 shows the aviation letters page.



Figure 3.9 Aviation letters page.

The author has recorded each English letter with its aviation shortcut into 26 sound files. in this code, the script control pausing and playing the sound file from the beginning. Then buttons are matched to sound files, the buttons will play the sound file inside it once, by clicking on it. As shown in figure 3.10.

```

<script>
var snd= new Audio('./audio/B - BRAVO.m4a');
function playS(b) {
snd.pause();
snd.currentTime = 0;
snd = new Audio(b);
snd.play();
}
</script><button class="btnCls" type="button" onclick="playS('./audio/A- ALPHA.m4a')">
<div align="center">
<table border="0" cellspacing="0" width="100%" bordercolor="#000000" cellpadding="0">
<tr>
<td width="41px">
</td>
<td style="text-align:center;">A- ALPHA</td>
<td width="41px">&nbsp;</td>
</tr>
</table>
</div>
</button>

```

Figure 3.10 The script of aviation letters.

The section of "Trim sheet simulator – loading instructions decisions", includes a list of designed sliders connected with each other from the first one to the last to simulate the loading document, with loading counter and arrows guide of the sliders.

The sliders can be controlled by mouse dragging or keyboard right and left directions, with an alert message in the case of moving to the wrong direction, then the result will be visible via two red lines on a photo for real trim sheet. As shown in Figure 3.11.

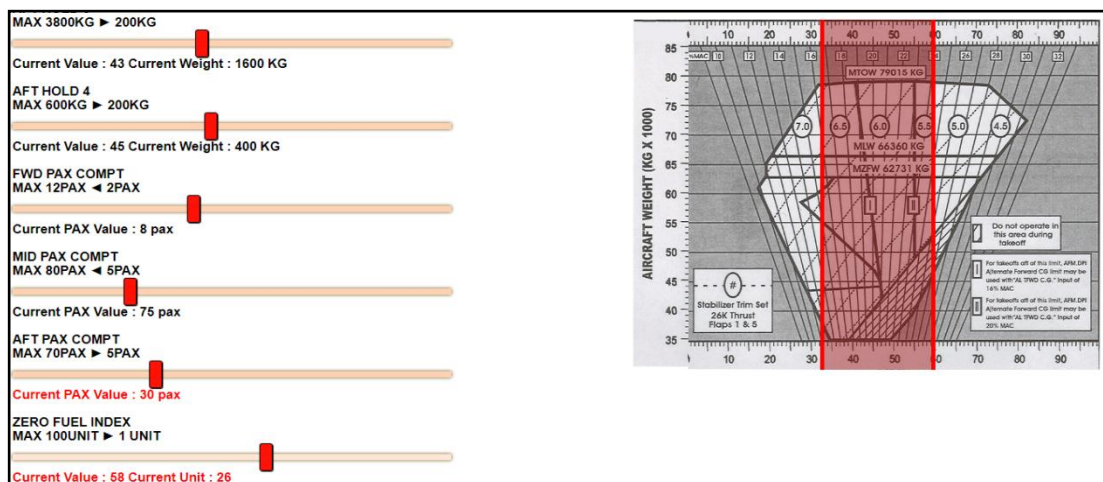


Figure 3.11 Trim sheet simulator.

Eight sliders used and matched together. From the final value of the last two sliders, a two lines will be dropped on a real trim sheet image, which divided in two images named r.png and bd.png, to control and set the limit of the two lines, which will

cover only the image bd.png, while the other image r.png is to complete the trim sheet image. As shown in figure 3.12.

```

<div class="mxdiv">
  

  <div class="Xdiv">
    <div style="height:100%;width:20%;float:left;"></div>
    <div id="Rd" class="Rdiv"></div>
  </div>
</div>

```

---

```

.Xdiv{
  height:500px;
  width:500px;
  background-image:url (bd.png) ;
  background-size:100% 100%;
  float: right;
}

```

Figure 3.12 Two red lines setting.

Eight sliders created, with setting onchange event, to call a function named oc(). As shown in figure 3.13.

```

</head><body><span class="inf" id="inf1">
  FWD HOLD 1 <br>
  MAX 800KG ◀ 200KG
</span><br>
<input type="range" id="r1" min="0" max="100" onchange="oc(1)
" value="40"><br><span id="cv1" class="cv">Current Value : 40</span><br><br>
<span class="inf" id="inf1">
  FWD HOLD 2 <br>
  MAX 2600KG ◀ 200KG
</span><br>
.
.
.
.
.
.
.
.
<input type="range" id="r7" min="0" max="100" onchange="oc(7)
value="40"><br><span id="cv7" style="color:red" class="cv">Current Value : 40</span><br><br>
<span class="inf" id="inf1">
  ZERO FUEL INDEX <br>
  MAX 100UNIT ▶ 1 UNIT
</span><br>
<input type="range" id="r8" min="0" max="100" onchange="oc(8)"
value="100"><br><span id="cv8" style="color:red" class="cv">Current Value : 100</span><br>

```

Figure 3.13 The 8 sliders creating.

The oc() function matched the sliders with each other's, through the ID of the slider. The oc() function used to give " out of the range " alerts when the slider moves to the wrong direction or excess a specified limit, using an IF statement, with the ID of the sliders. Figure 3.14 shows the function.

```
function oc(x) {  
  
var tx=document.getElementById("r"+x);  
var nx=document.getElementById("r"+(x+1));  
switch(x) {  
case 1:  
if(tx.value>40 || tx.value<36){  
alert("out of range");}  
if(nx.value>tx.value) {nx.value=tx.value;}  
break;  
case 2:  
var bx=document.getElementById("r"+(x-1));  
if(tx.value>bx.value || tx.value<(bx.value-13)){  
alert("out of range");}  
if(nx.value<tx.value) {nx.value=tx.value;}  
break;  
. . .  
case 8:  
var bx2=parseInt(document.getElementById("r7").value);  
  
if(tx.value<bx2 ) {  
//alert("out of range");  
}  
break;  
}  
cv();  
}
```

Figure 3.14 The oc function.

The result of this matching, each slider starts from the end of the previous one (the starting value (0) of the slider is, at the position of last value of the previous slider). The cv() function uses the ID of the sliders to calculate the value of the slider and view the result with its unit (KG, PAX and Unit ) as text. Figure 3.15 shows the function.

```

function cv(){
var tx1=document.getElementById("r1").value;
var tx2=document.getElementById("r2").value;
var tx3=document.getElementById("r3").value;
var tx4=document.getElementById("r4").value;
var tx5=document.getElementById("r5").value;
var tx6=document.getElementById("r6").value;
var tx7=document.getElementById("r7").value;
var tx8=document.getElementById("r8").value;
document.getElementById("cv1").innerHTML="Current Value : "+tx1+" Current Weight : "+((40-tx1)*200)+" KG";
document.getElementById("cv2").innerHTML="Current Value : "+tx2+" Current Weight : "+((tx1-tx2)*200)+" KG";
document.getElementById("cv3").innerHTML="Current Value : "+tx3+" Current Weight : "+((tx3-tx2)*200)+" KG";
document.getElementById("cv4").innerHTML="Current Value : "+tx4+" Current Weight : "+((tx4-tx3)*200)+" KG";
document.getElementById("cv5").innerHTML="Current PAX Value : "+((tx4-tx5)*2)+" pax";
document.getElementById("cv6").innerHTML="Current PAX Value : "+((tx5-tx6)*5)+" pax";
document.getElementById("cv7").innerHTML="Current PAX Value : "+((tx7-tx6)*5)+" pax";
document.getElementById("cv8").innerHTML="Current Value : "+tx8+" Current Unit : "+((tx8-tx7))+ " ";
}

```

Figure 3.15 The cv function.

To create the two red lines, a Div. created id="Rd", in the CSS Style, left and right borders were added for that div. As shown in figure 3.16.

```

.Rdiv{
height: 91.4%;
width:58%;
background: #99000069;
border-right: 5px solid red;
border-left: 5px solid red;
position: relative;
right: 0%;
left: 40%;
}

```

Figure 3.16 Red borders creation.

The ID of the sliders with the id of the Div used to drop the two red lines from the last two sliders. As shown in figure 3.17.

```

var ee=parseInt(tx8);
var ede=parseInt(tx7);

document.getElementById("Rd").style.width=cr+"%";

if(ede>=ee){
document.getElementById("Rd").style.right=ede+"%";
document.getElementById("Rd").style.left=ee+"%";
}else{
document.getElementById("Rd").style.right=ee+"%";
document.getElementById("Rd").style.left=ede+"%";
}
}

```

Figure 3.17 Matching and drop two red lines.

These sections are available for both, the trainer and trainee pages.

Next sections are for the trainers to use it to explain and annotations:

The sections of "Boeing 777 3D sample, Boeing 737 3D sample, Boeing 747 3D Sample, Boeing 767 3D sample, Boeing 787 3D sample, Boeing 747 IA 3D sample, Airbus 320 3D sample, Airbus 380 3D sample, Challenger 604 3D sample, and CRJ 3D sample" includes a 3d aircraft object which can be controlled by mouse click and dragging/touch for the mobiles phones, and with the ability to zoom in /out by mouse scroll or touch screens two fingers zoom in/out movement.

This page gives the ability of moving the aircraft to the wanted side of it then, by clicking "Ctrl" on the keyboard the photo will be fixed and a tools bar will appear which includes a line, text, and eraser and those tools can be used on the clicked part of the fixed photo, the user can choose the size and colors of the line and text also, figure 3.18 shows the page.



Figure 3.18 Drawing on the aircraft 3d model.

The sections of "CRJ with Trim sheet, A320 with Trim sheet, A321 with Trim sheet, A330 with Trim sheet, B737 with Trim sheet, B747 with Trim sheet and B777 with Trim sheet" includes a 3D aircraft object which can be controlled by mouse click and dragging/touch for the mobile phones, and with the ability to zoom in /out by mouse scroll or touch screens two fingers zoom in/out movement.

This page gives the ability of moving the aircraft to the wanted side of it then, by clicking "Ctrl" on the keyboard the photo will be fixed and a tools bar will appear which includes a line, text, and eraser and those tools can be used on the clicked part of the fixed photo, the user can choose the size and colors of the line and text.

A button will appear with slider, by clicking the button a trim sheet will appear and moving the slider from left to the right will control the transparency of it (the fixed aircraft side or photo will still appear in the background regarding to the transparency determined degree by the slider ) with the same ability to write or draw on it using the tools in the tools bar, as shown in figure 3.19.

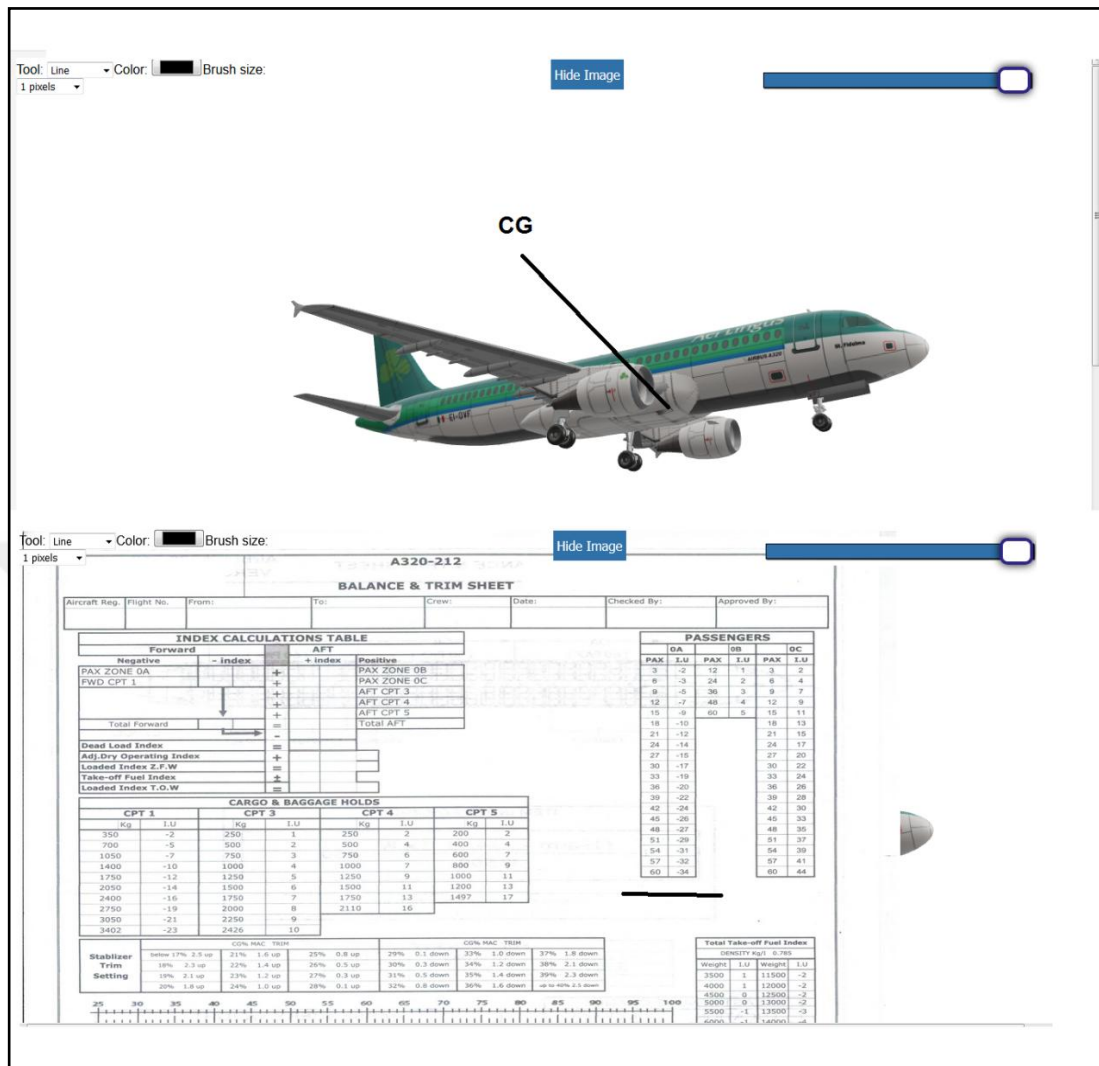


Figure 3.19 3D aircraft model with loading document.

In those sections, a script from Google library was used to view the objects, the type of object should be GLB or Gltf. Several objects have been used, some objects were converted to GLB or Glft to use it, the second script that was used in those sections is a script which provides paint tools, from [codepen.io](https://codepen.io). Then the script is modified by removing some unwanted tools provided by the script from its code. The author has added an event to the script to show and hide the paint tools by pressing the "Ctrl" key. As figure 3.20 shows.

```

document.addEventListener('keydown', function (e) {
  if (e.ctrlKey) {
    if (appDiv.getAttribute("style").includes("display: none;")) {
      appDiv.setAttribute("style", "display: block;");
      slide.style.visibility = "visible";
      show_image.style.visibility = "visible";
    } else {
      cx.clearRect(0, 0, paintWidth, paintHeight);
      appDiv.setAttribute("style", "display: none;");
      slide.style.visibility = "hidden";
      image_paint.style.visibility = "hidden";
      show_image.style.visibility = "hidden";
    }
  }
});

```

Figure 3.20 Code of show/hide paint tools.

The author added function to the script to show and hide an image and to control the opacity of the image. Figure 3.21 shows the function.

```

slide.onchange = function () {
  image_paint.style.opacity = this.value;
};

function showImage() {
  if (image_paint.style.visibility === "hidden") {
    image_paint.style.visibility = "visible";
    show_image.innerText = "Hide Image";
  } else {
    image_paint.style.visibility = "hidden";
    show_image.innerText = "show Image";
  }
}

```

Figure 3.21 The function of show/ hide image and control opacity.

The section of "Communication Simulator" includes several buttons with flight numbers, each button contains a call for the loadmaster engaged to the appointed flight number.

When the button is pressed, the communication starts with a question if the loadmaster is ready to copy the final figures, then passing the final figures for the appointed flight.

The "Communication Simulator" includes a button to start the communication, the name of it "start ", and a button to answer in the communication the name of it " press and hold ".

The first step: a click on the button with the flight number, the second step: click on the "Start" button, the communication will start by "calling the loadmaster of the flight", and the third step: clicking and hold on the button " press and hold " to answer.

The user should answer with "go ahead", there is a question if the user is ready to get the final figures, the answer should be one of these 3 choices:

A - "stand by": the communication will stop.

B - "come again": the question will be repeated.

C - "go ahead": passing the final figures will start.

When passing figures end :

A- if the user answer "copied thank you " an alert will appear to confirm that the communication is correct.

B- if the user answer "come again": passing the final figures will start again. Figure 3.22 shows the communication simulator page.

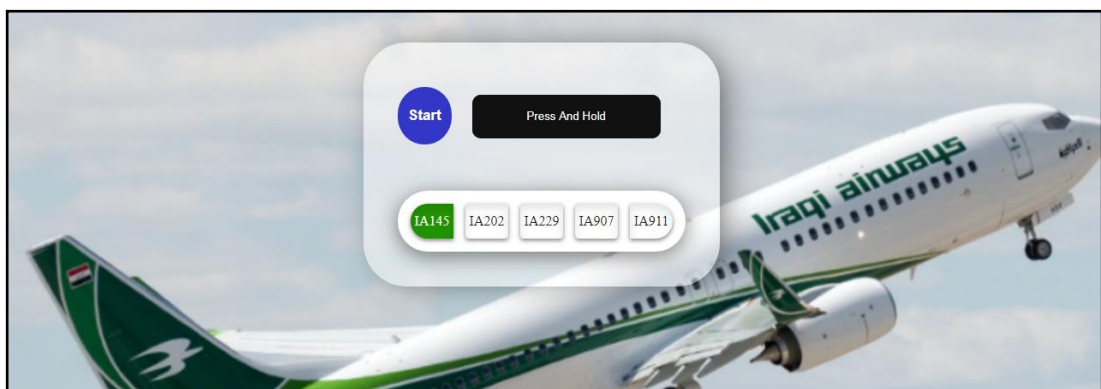


Figure 3.22 Communication Simulator page.

Several communication scenarios recorded under the trainer's supervision, using a microphone with moderate quality to simulate real communication. In the beginning, five HTML pages were created, each page is referring to a (dominated flight number). Each page contains a list of links of that 5 pages, on each page in the list of links, the class name of it, named "Active". As shown in figure 3.23.

```
<li><a id="page1" class="active" href="#">IA145</a></li>
<li><a id="page2" href="index2.html">IA202</a></li>
<li><a id="page3" href="index3.html">IA229</a></li>
<li><a id="page4" href="index4.html">IA907</a></li>
<li><a id="page5" href="index5.html">IA911</a></li>
```

Figure 3.23 Creating 5 HTML pages.

The script beginning with requesting permission to use the microphone, as figure 3.24 shown.

```
navigator.mediaDevices.getUserMedia({audio: true})
  .then(function (stream) {
    console.log('mic is available !');
  })
  .catch(function (err) {
    console.log('mic is not available!')
  });
```

Figure 3.24 Requesting permission to use the microphone.

Two main variables were defined for the path of the sound files, If-statements was used, to check if the class name of one of the list elements is "active" then it will call the sound files which are related to that element. As figure 3.25 shows.

```
var callPath = 'sounds/Calling145.m4a';
var finalPath = 'sounds/Final145.m4a';

if (document.getElementById("page1").className === "active") {
    callPath = 'sounds/Calling145.m4a';
    finalPath = 'sounds/Final145.m4a';
} else if (document.getElementById("page2").className === "active") {
    callPath = 'sounds/Calling202.m4a';
    finalPath = 'sounds/Final202.m4a';
} else if (document.getElementById("page3").className === "active") {
    callPath = 'sounds/Calling229.m4a';
    finalPath = 'sounds/Final299.m4a';
} else if (document.getElementById("page4").className === "active") {
    callPath = 'sounds/Calling907.m4a';
    finalPath = 'sounds/Final907.m4a';
} else if (document.getElementById("page5").className === "active") {
    callPath = 'sounds/Calling911.m4a';
    finalPath = 'sounds/Final911.m4a';
}
```

Figure 3.25 Calling the sound files.

After writing the code of the voice recognition setting, which supported by JavaScript, (for loop) is used to get the text from the speech, to use it in several if statements. The author defined a variable recognition type to control the sequence of the conversations (set the texts with the sound file, which should be played before/after recognizing that text). As figure 3.26 shown.

```

let calling = new Audio(callPath);
let ready = new Audio('sounds/ready.m4a');
let final = new Audio(finalPath);
var recognitionType = 1;
var isSpeechRun = false;

window.SpeechRecognition = window.webkitSpeechRecognition;
let recognition = new window.SpeechRecognition();
recognition.interimResults = false;
recognition.lang = 'en-US';
recognition.continuous = true;

recognition.onresult = (event) => {

  for (let i = event.resultIndex, len = event.results.length; i < len; i++) {
    let transcript = event.results[i][0].transcript.toLowerCase().trim();
    if (event.results[i].isFinal) {
      console.log(transcript);

      if (recognitionType === 1) {
        if (transcript === "go ahead") {
          playAudio(ready);
          recognitionType = 2;
        }
      } else if (recognitionType === 2) {
        if (transcript === "go ahead") {
          playAudio(final);
          recognitionType = 3;
        } else if (transcript === "stand by") {
          recognition.stop();
        } else if (transcript === "come again") {
          playAudio(ready);
          recognitionType = 2;
        }
      } else if (recognitionType === 3) {
        if (transcript.includes("thank you")) {
          alert("Correct ã");
          recognition.stop();
        } else if (transcript === "come again") {
          playAudio(final);
        }
      }
    }
  }
};

```

Figure 3.26 Getting text from voice recognition.

By pressing the (START) button, startVoice() function called to play the first audio file . and by pressing and holding (Hold and Press) button, startReco() function called to start the voice recognition. By drop (Hold and Press) button, stopReco() function called to stop the voice recognition. As shown in figure 3.27.

```

recognition.onend = function () {
    isSpeechRun = false;
    console.log("Speech Stop");
};

recognition.onstart = function () {
    isSpeechRun = true;
    console.log("Speech Start");
};

function startVoice() {
    recognitionType = 1;
    playAudio(calling);
}

function startReco() {
    if (!isSpeechRun)
        recognition.start();
}

function stopReco() {
    if (isSpeechRun)
        recognition.stop();
}

// play Audio from beginning
function playAudio(audio) {
    audio.currentTime = 0;
    audio.play();
}

```

Figure 3.27 Start and stop voice recognition.

### 3.2 Methods of analyzing system effectiveness

The proposed methods for analyzing the effectiveness of the computerized virtual system.

After completing design of the application, it was activated, and then it actually used by the instructor, where this course was used computerized application in the theoretical and practical explanation of the trainees, where the instructor used this computerized system in two consecutive weight and balance courses, the effectiveness of the computerized virtual application will be assessed in three ways:

- 1- Comparing the average of the results of two exams for the trainees 43 trainees, they were trained and examined according to the traditional method versus 43 trainees, they were trained and tested on the computerized virtual application.

2- Simple and quick trainees satisfaction survey after the trainees have passed the course exam (both parts, theoretical and practical), in order to obtain valuable feedback from trainees.

3- Interview with Mr. Ahmed Sami Hasan, the trainer and the supervisor of the course who is responsible for the theoretical and practical training for the trainees in each stage, in the "Iraqi Airways Training Center".

### **3.2.1 Comparing the two methods of education**

The comparison between two methods of training, for aircraft weight and balance courses (virtual versus traditional) according to the exam scores results.

The course is given within 6 weeks, it is given in the Iraqi airways training center, all selected trainees (employees) who took the course are from the same scientific background.

Comparison is done in order to compare the outcome of two learning methods (traditional vs virtual), in order to analyze the effectiveness of the computerized virtual system, it is done by comparing the results of the trainees' scores, by measuring the difference between the average scores for the course students who have learned in traditional way, and then comparing it with the average scores for the students who have learned and practiced within the virtualized application.

The trainer, who gave the course in the old traditional way, is the same trainer who gave the virtual course to 43 students from the same scientific background.

The comparison between the average scores of the previously mentioned group which took their training in the previous training session and another 43 new trainees in a new training session using the experimental method.

The (experimental group with 43 trainees) will take the course in the new virtual online web method, their exam results will be taken to calculate the average scores.

On the other side, the (comparison group with 43 trainees) who took the course previously in the old traditional method, their exam results will be taken to calculate the average scores, which is obtained from the Iraqi Airways Training Center. it should be noted that all exams (traditional vs virtual) were held in the same year.

Both experimental and comparison have taken the course within 6 weeks, two hours per each day.

By utilizing the new virtual online web method, their exam results were generally high for most students, and the average score for the 43 trainees was 88.20%.

While the comparison group who took the course previously in the old traditional method, the average score for the 43 old trainees was 79.53%.

T-test used to compare the difference between the two groups, the result was 8.67% for the computerized virtual application, which is considered as high success rate.

### **3.2.2 Quick trainees' satisfaction survey**

After completing the exam, a quick satisfaction survey was distributed to the trainees, in order to measure the trainee's satisfaction, and determined positivity and effectiveness of computerized application by counting positive or negative points. Figure 3.28 shows the survey questions.

Measuring the trainees' satisfaction					
	Satisfied	Very Satisfied	neutral	Dissatisfied	Very dissatisfied
1. Virtual Application give me the real vision for the aeroplane dimensions and main parts.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. virtual application is easy to access and interact	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I have the ability to make my first flight Confidently	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. virtual application offer positive engagement during the course.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. The virtual application saves my time and effort during the course	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. It was easy to understanding calculations, communication, annotations and Aviation alpha bet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. I encourage using the Virtual Application in The course training.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. The course was visually attractive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 3.28 Satisfaction survey.

After retrieving the results of the survey, the author has computed the Net Promoter Score (NPS),

Net Promoter Score (NPS), which is an index ranging from -100 to 100, which measures the willingness of customers (the trainees) to support a company's products (computerizing virtual application for aircraft weight and balance courses) or services to others.

It is utilized as a proxy for gauging the customer's overall satisfaction with a specific company's product or any type of service and the customer's loyalty to such a brand [35].

As shown in figure 3.29. There are 8 detractors (dissatisfied and very dissatisfied), 5 are passives (neutral), and 30 are promoters (satisfied and very satisfied). The percentages represented in figure 3.30.

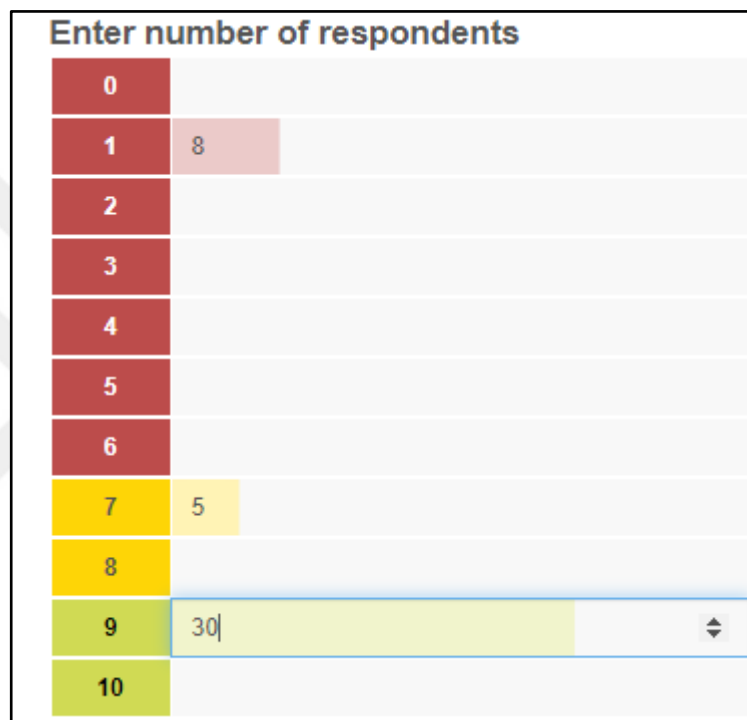


Figure 3.29 Survey`s results analysis.

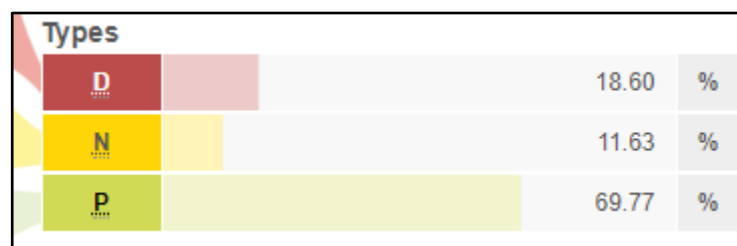


Figure 3.30 Survey results percentages.

To calculate the Net Promoter Score, the percentage of detractors was subtracted from the percentage of promoters. As shown in figure 3.31.

69.77-18.60 =51

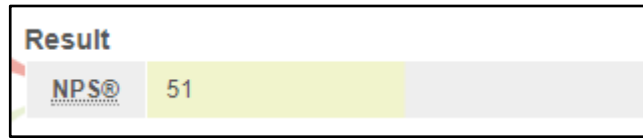


Figure 3.31 NPS's results.

### 3.2.3 Interview with the course trainer

Aircraft weight and balance course provided by the "Iraqi Airways Training Center", The traditional and virtual courses were given in the same year of the study.

The trainer and the supervisor of the course who is responsible for the theoretical and practical training for the trainees in each stage, Mr.Ahmed Sami Hasan supported the study by providing the required data to the system.

The trainer explained the obstacles of the traditional training method from his own experience, with clarifying a lot of critical points about the process of aircraft weight and balance, which helped to avoid the drawbacks of the traditional method in the new system and virtual design.

Some meetings were held to learn the trainer on how to use the system, how to access to his page, and how to access to the student's pages, some changes have been applied on the system upon to the request of the trainer.

It was necessary to hold an Interview with the trainer, after completing the activation for the application, and after it has been used by the trainer, where the instructor explained the content of the course using the computerized virtual application within the designed system, to determine to what extent has proved effectivity in the education and training of students, by employing this application in the explanation to the trainees.

In order to obtain valuable feedback from the trainer about the system, the last interview with the trainer was held, the interview was unstructured, it included some questions about the benefits of the computerized system. Interview questions are shown in table 3.1.

Q number	The question
Q1	How easy it was to handle and interact with the application?
Q2	The most important positive aspects that benefited from them as a trainer?
Q3	The most important observations about the response of trainees with the application?
Q4	Do you support the adoption of the Iraqi Airways for this application?

Table 3.1 Interview questions.

## CHAPTER 4

### RESULTS AND DISCUSSION

This study came to developed the process of teaching and training Aircraft Weight and Balance course in Iraqi Airways Training Center, which are given in the Iraqi Airways, in line with the technical development that covered all areas of life, especially the spread of E-learning in the areas of learning and training.

Therefore, it has become necessary to measure the performance effectiveness for the virtual system by examines the effect of E-learning on both the trainer and the trainees.

This was done by analyzing the learning outcomes in three ways:

The first: by measuring the average test results of the trainees who used the virtual application and compare it with the average test results for former trainees who used the old traditional method and then compared their average results.

The second: analyzing trainee's satisfaction survey results by measuring Net Promoter Score (NPS).

The third: interview with Mr. Ahmed Sami Hasan, the trainer and the supervisor of the Aircraft weight and balance course.

#### **4.1 Exam results and discussion**

The experimental group (after applying the virtual application): included 43 trainees, that have taken the course within 6 weeks, two hours per each day, the average score for those 43 trainees was 88.20 points.

The comparison group (applying traditional method): included 43 previous trainees, their average score was 79.53 points.

Hypothesis Testing: The Difference between two population mean

**1 Data:** Determine the variable, sample size (n), sample means, and sample standard deviation (s) for each group.

**2. Assumptions:** Population is normally or approximately normally distributed with unknown variance.

**3. Hypotheses:** Test that the mean for the first population is different from the second population mean.

The Null Hypothesis is:  $H_0: \mu_1 = \mu_2 \rightarrow \mu_1 - \mu_2 = 0$

The Alternative Hypothesis:  $H_A: \mu_1 \neq \mu_2 \rightarrow \mu_1 - \mu_2 \neq 0$

**4. Test Statistic: t-test**

$$T = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

**5. Decision Rule:**

If  $H_A: \mu_1 \neq \mu_2 \rightarrow \mu_1 - \mu_2 \neq 0$

Reject  $H_0$  if  $T > t_{1-\alpha/2, (n_1+n_2-2)}$  or  $T < -t_{1-\alpha/2, (n_1+n_2-2)}$

Or

Reject  $H_0$  if P-Value  $< \alpha$  and Accept  $H_0$  if P-Value  $> \alpha$ .

**6-Conclusion:**

Reject  $H_0$ , since T-test = 3.03 > 1.96

Or

Reject  $H_0$ , since P-Value = 0.004 < 0.05

In many research situations, it is necessary to test whether the difference between two independent groups of individuals is statistically significant. The null hypothesis for this test is that the groups have equal means or that there is no significant difference between the average scores of the two groups in the population. The alternative hypothesis states that the two means are significantly different.

When data come from two random samples or two groups in a randomized experiment, the difference between the sample means  $\bar{x}_1 - \bar{x}_2$  is the best estimate of the difference between the population means ( $\mu_1 - \mu_2$ ). In other words, since the population means ( and ) are unknown, the sample means ( $\bar{x}_1$  and  $\bar{x}_2$ ) must be used to make inferences. The inferences that are being made are based on the differences between the sample means:  $\bar{x}_1 - \bar{x}_2$ .

In the research experiment, the goal is to make an inference about the difference between two groups (virtual and traditional) based on their performance on a t-test. To make inferences about each population as a whole, a random sample from the population of virtual and a random sample from the population of traditional must be selected.

Since the p-value is 0.004, which is less than the alpha level of .05, the null hypothesis should be rejected. According to these results, the alternative hypothesis should be accepted. The difference between the two group means is statistically significant.

In table 4.1, the test statistic t is (3.03) greater than the critical value (1.96). Therefore, the null hypothesis should be rejected.

Are there statistically significant differences at the level ( $\alpha = 0.05$ ) between the virtual and traditional groups?, To answer the question, arithmetic means, and standard deviations for the performance of virtual individuals as well as members of a traditional group were calculated, and a t-test was applied for independent samples. As table 4.1 shows the arithmetic means and standard deviations for the two groups virtual and traditional, and (t-test) for independent samples to find the significance of the difference between them.

Group	N	Mean	Standard Deviation	Difference	95% Confidence Interval for Difference		T-Test Value	P-Value
Virtual	43	88.20	8.41	8.67	2.96	14.39	3.03	0.004
Traditional	43	79.53	16.8					

Table 4.1 T-test results.

- Statistically significant difference at the level (0.05)

It is noted from table 4.1 that the average for the members of the virtual group is 88.20. while the average for the traditional group is equal to 79.53, indicating that there is an increase of 8.67 on the average, and with a probability of 95%, the average increase of the scale as a result of the virtual training method, is not less than 2.96 and not more than 14.39, and the previous table stated that the value of (T) reached (3.03), at the level of significance (0.004), which indicates the presence of a statistically significant difference between the averages of the two groups virtual and traditional, and the difference was in favor of the virtual group whose average reached (88.20) because it is higher than the average of the traditional group which averaged (79.53), and this indicates that the virtual group that used the virtual training method benefited in increase the measurement, which means the presence of a significant difference between the two groups. Figure 4.1 shows the t-test.

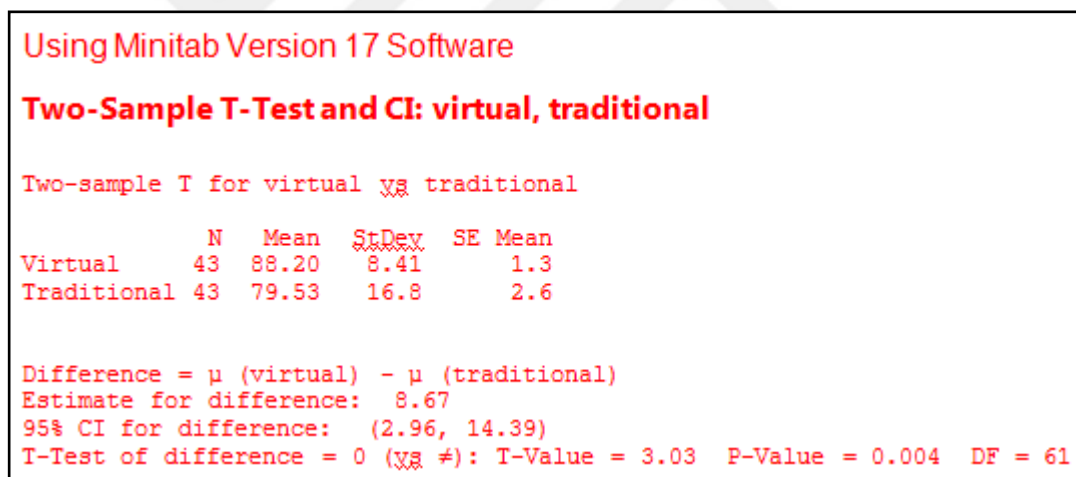


Figure 4.1 T-test.

The significant difference between the two groups using the T-test and the 8.67 means difference result was a valuable outcome, as examined and showed by [19] and [21] where their comparison showed that virtual learning was more effective than traditional learning. since at the time of conducting this study, the Iraqi Airways Training Center students had no previous experience with virtual learning.

#### 4.2 Trainee's satisfaction survey result and discussion

The results of the trainee's satisfaction survey present 8 Detractors that classified as dissatisfied and very dissatisfied, this showed that they are not particularly thrilled by the virtualized application and its service, 5 are the Passives that classified as neutral, they are somewhat satisfied, but they are not enthusiastic enough about virtual E-learning application and its services, to actually promote them, and 30 Promoters that classified as satisfied and very satisfied, they love and accept the virtual E-learning application and its services, they are the repeat users, are the enthusiastic evangelist who recommends the virtual application and services to other potential students. As shown in figure 4.2.

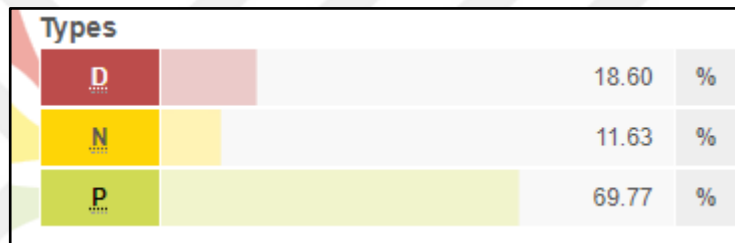


Figure 4.2 Survey's results.

NPS record 51%, which indicates the satisfaction of trainees to the E-learning utilizing the virtual application in Iraqi airways training center students. As figure 4.3 shows.

$$69.77 - 18.60 = 51$$

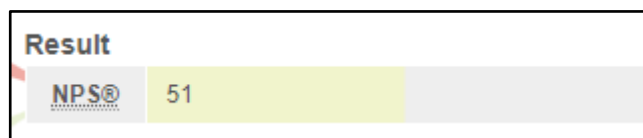


Figure 4.3 NPS final result.

NPS scores 51% is considered as desirable, where this result was consistent with [30] outcomes.

#### 4.3 Interview with course trainer results and discussion

Different meetings were held with the trainer and the supervisor of the course who is responsible about the theoretical and practical training for the trainees, in each stage,

Mr. Ahmed Sami Hasan, in order to obtain valuable feedback from the trainer about the system, last interview with the trainer was held, the last interview was unstructured, it included some questions about the effectiveness and the importance of the virtualized application, the answers were listed as bellow:

**Q1.** How easy it was to handle and interact with the application?

**A1.** From a different point of view, the trainer Mr. Ahmed Sami Hasan explain that the virtual system was designed to make interacting with it easy, the user interface was friendly and easy to use, controls were very simple and practical, the website login requires only a simple registration process, the navigation between pages was available, the website was very friendly, and it worked perfectly without any fail, stop or delay during the time of using it.

**Q2.** The most important positive aspects that benefited from them as a trainer

**A2.** The trainer saw that he was taking a lot of time and effort in the process of explaining the Aircraft Weight and Balance Course compared to the time and effort he needed now, he benefited in the explanation process, as there was clarity for the purpose which he desires to explain to the trainees as [25] experience, which display that proficiency depends on objective and subjective measures.

Using a 3D model was very easy to explain, as [27] suggested in their study, with the ability to write and draw on the desired part, on the contrary, the old plastic model that cannot be drawn on, with the high flexibility in using the virtual 3D model much more than the old plastic model of the aircraft.

The attached documents of each aircraft with the ability to write and draw on it made a huge positive difference in ease the explaining.

**Q3** The most important observations about the response of trainees with the application?

**A3.** Making the rightest loading decision became faster, as former students took more time to determine the correct loading decisions [20] showed in their study result.

-The trainees became more familiar with the trim-sheet, the directions of movement in the paper based on the shares and determining the amount of loading allowed in each part.

-In the practical stage, the trainees started with high confidence, and clearly, they appeared that they already got a full visualizing for important aspects and actual environment of the work, through training using the virtualized course as [20] and [27] proved.

-The trainees quickly accustomed to using the application, they have more confidence in applying what they have learned actually, they need less time to link the theoretical part to the practical part during the training and implementation.

-The trainees were highly able to interact and understand the aviation alphabet and aviation codes, the method of displaying alphabet and codes was very smart, which led to great mastery by the trainees.

-The communication training method for coping flight Final figures was motivating and fun.

-Existence of important concepts for working on the aircraft, with the possibility of rotating 360-degrees, gave a complete and almost realistic vision to the trainees about the important aircraft's parts which are related to the course, and knowing their exact entire locations, the pictures and videos added strong support for this visualization distinctively.

-Having a page for the trainees, making their review of the content easy, and retraining on their own through the relevant pages.

**Q4.** Do you support the adoption of the Iraqi Airways for this application?

**A4.** Through my personal experience, and according to the results I noticed by myself, my evaluation as a trainer for the Aircraft Weight and Balance course, and Based on using the computerized course website, I found adopting such application is very effective as it is in line with the era of technology.

It greatly contributes to supporting trainees in theoretical and practical learning as [22] result study displayed, as it achieves quick understanding, short task completion, and support the training process.

I encourage the Iraqi Airways company to adopt and support this computerized application within its plans for the future.

**Other comments:**

I look forward to using the website for all subsequent training courses in more than one place in our stations to enrich the learning process.

I encourage using the online virtual environment courses in other aviation courses training.

Results for this study largely agreed with the results presented for the previous related studies that were presented during the research as [29], deduced recommendations for utilizing spatial interaction in 3D data visualization.

## CHAPTER 5

### CONCLUSION AND RECOMMENDATIONS

#### Conclusion

Based on the findings of this study the designed virtual learning system was more effective than traditional lecture-based training with only one general plastic aircraft model (0.5 m), which used to teach all the aircraft types in that airline company, with a simple presentation, most of it consists of texts, with very limited number of photos.

The main results showed how it easy it was, to handle and interact with the virtual system, as it was designed to make interacting with it easy, the user interface was friendly and easy to use, the controls were simple and practical, the website login require only a simple registration process.

The most important positive aspects that trainer benefited from the virtualized system in addition to saving time and effort using the 3D model was very easy to explain, with ability to write and draw on the desired part, while the most important observations about the response of trainees to the application were, a higher level of confidence and visualizing, while the ability to automatically making the rightest loading decision became faster, and the trainees became more familiar with the trim-sheet in short time, and they were higher to interact and understand communications simulator, aviation alphabet and aviation codes, as the method of displaying alphabet and codes was very smart, and more advantages the trainer and the trainees have gained from 3D virtualized system which mentioned in the previous chapter.

A comparison of the mean knowledge score of both groups using a t-test shows a presence of significant difference in the favor of the virtual training group, which displays that virtual training was more effective and successful than traditional training with effect size = 8.67, which considered as a valuable result.

## **Recommendation**

Study experience in designing this technique could be regarded as the starting point for the use of the virtual learning program in the Iraqi airways training center.

-Work on creating a new learning environment for other important courses in the aviation field.

-Work on developing the website by adding more operations.

- Carry out more comprehensive studies for using the virtual environment in e-learning in the aviation field



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