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The Effect of Human Engineering (HE) in Cockpit Design on Aviation Safety (AS)

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Abstract

The main objective of this study is to identify the concept of human engineering and its importance to shed light on the role of human engineering in the cockpit design in enhancing aviation safety. Quantitative analysis was carried out on data from (417) pilots in EgyptAir. The results revealed that human engineering in the cockpit design positively affects aviation safety. It was concluded that the application of human engineering in designing the aero plane cockpit is largely applied in EgyptAir. The study contributes to providing airlines with the pilots' feedback, complaints, and suggestions concerning the cockpit design with all its components with the aim of addressing any shortcomings to make the necessary cockpit design improvements to ensure pilot comfort and a higher aviation safety level.

Keywords: human engineering, aviation safety, cockpit design.

Introduction

According to Karwowski and Jamaldin (2000); Carayon (2011); and Carr (2021), human engineering (HE) is the scientific branch of science dealing with the understanding of interfaces between humans and other system elements, as well as the profession that applies principles, data, theory, and other methods to design in order to optimize human well-being and overall system performance. Human engineers help to design and evaluate environments, jobs, tasks, products, and systems to ensure that they are compatible with people's needs, abilities, and limitations. HE emphasized the value of designing and organizing the work environment to reduce the likelihood of the occurrence of errors and the impact of errors when they do occur. It's worth noting that "Human Engineering" isn't as directly about "humans" as the title suggests, however, it is a matter of understanding both human limitations and the design of the work environment and the equipment.

In its broadest sense, it is stated by both of Sanders and McCormik (1993) and Rahman et al.(2014) that the main aim of HE is to ensure that human beings and technology work in complete harmony, with the equipment and tasks aligned to human characteristics in order to achieve safe, productive, comfortable, and effective human use. HE also aims to figure out and create the best fit between people and the world where they live and work, particularly in terms of the features of both technology and physical design in their workplace.

Moreover, HE enhances people's lives by making technology work well for them. In general, it enhances interaction with systems and important for multiple reasons. Here are a few (Lee et al., 2017; Carr, 2021):

a) Safety: HE is able to reduce accidents, incidents, and damage to equipment;
b) Productivity: HE can increase efficiency, maximize quality and minimize errors;
c) Equipment reliability: HE helps minimizing system malfunction and maintenance cost;

d) Performance: HE enhances the user performance; and
e) Training: HE reduces the required training time.

Therefore, Wise et al. (2009) explicated that aviation HE focuses on studying the capabilities, limitations, and behaviour of humans, in addition to the incorporation of that knowledge into systems designed for the humans in order for improving the safety, performance, and overall well-being of the system's operators. Based on the above, this study aims to:

a) Indicate the dimensions of human engineering in the cockpit design.
b) Highlight the aspects of aviation safety.
c) Explore the effect of human engineering in the cockpit design on aviation safety.
d) Examine the effect of the dimensions of human engineering in the cockpit design (organizational regulations, working environment, seating posture, lighting, and displays, controls, and panels) on safety.

The problem of the study is that the badly-designed working environment with all its components can threaten the safety of people working in it and in turn, threaten the general safety. Egypt Air is chosen, as the national airline, with the purpose of improving its performance by providing the best fit working environment to its pilots, by using the study recommendations.

Literature review

Paulson (2012) shed light on the fact that in aviation's early days, the design of cockpits was as simple as possible, containing only a few pieces of equipment for the purpose of providing the pilot with the engine performance and aircraft-related information. The instruments and controls number in the cockpit increased, as did the requirement for growing pilots' roles. The pilot's interaction with the cockpit's instruments and controls was limited. The evolution of the design and layout of the aircraft cockpit is unavoidable; however, these changes must be consistent with the field of human engineering in order to achieve the best fit between pilots and their capabilities and limitations.

Holding the same point of view, Wiener and Nagel (1988) pointed out that the rates of the human error and the high levels of stress are caused by the complication of the performance and the instruments that display the systems of the aircraft. The design of the aircraft cockpit and the crew-related systems ignored the necessity to take into account the capabilities and limitations of the flight operators. Misinterpreted information, missed signals, and the flight crew's limited cognition of equipment are all considered as examples that emphasize this. Paulson (2012) added that in the aviation industry, as a formal discipline, the development of the field of human engineering is credited with the design development of the aircraft cockpit.

As demonstrated by Rune et al. (2008), ergonomic assessment for cockpit layout is also vital as it would harm pilots and cause aviation safety violation. Cockpits' reasonable layout, which enhances the comfortable piloting, reduces misplay, and pledges pilots in better circumstances, is a prerequisite for aviation safety improvement.

Following the same line, Strickland et al. (1996);Salas and Maurino (2010); Chen et al. (2014); and Shubham and Devendra (2017) confirm that during the flight, for operating the interactions between the flight and information, the cockpit of an aircraft is the primary location for pilots and when evaluating the performance of pilots, the ergonomic design of the cockpit of an aircraft cockpit is critical.

Cockpit Ergonomic Design Elements

Well-designed cockpits are critical to the achievement of system best performance and the highest level of pilot capacity. The aeroplane cockpit ergonomic design is critical to both flight safety and flight crew efficiency. In light of this, various critical elements, aeroplane system requirements, new generation cockpit features, aeroplane functional requirements, process of human-machine interfaces, and related standards and regulations perspectives must be examined (Zhang et al., 2014). As a matter of fact, the ergonomic design of the cockpit includes a number of elements. Zhang et al. (2014) categorized the cockpit design elements into four:

1-New generation cockpits

As Rao (2019) points out, the pilot-vehicle interaction and the cockpit are the two major areas where modern avionics have had a significant impact. The cockpit in the earlier aircraft, which was outfitted with a plethora of difficult-to-read electromechanics land mechanical equipment, increments the workload of pilots. The term "Glass Cockpit" refers to the availability of sensors-related information and aircraft systems-related ones, in modern avionics systems. Additionally, Mejdal and McCauley (2014) said that "Glass Cockpit" has come into existence. The terms "Multi-Function-displays" (MFDs) and "Glass Cockpit" (GC) are used synonymously or interchangeably.

2- Interface-related process

By monitoring the displays, sweeping the outside environment of the cockpit, and controlling the aircraft, pilots gain information concerning the conditions of the flight environment. As a result, the analysis of the interface process impacts the pilots' performance and comfort. Being broken into various phases, the flight contains seven. During these seven phases, starting from taxiing to finally landing, pilots have to make decisions depending on the environment of the flight with the purpose of controlling the aeroplane to make sure that the aeroplane is as safe as possible.

3- Ergonomic design elements

Zhang et al.(2014) stated these ergonomic design elements as follows: layout and arrangement which include (workspace, windows/inside/ outside visibility, controls reach ability, equipment such as seats, controls, marks, signs, and devices; displays which include display content, location and arrangement, and mode (brightness, contrast, colour, and display format); and environment which include temperature, humidity, pressure, noise, vibration, and lighting.

4-Standards and Regulations

There are some clauses that provide the airworthiness requirements, such as: shape of the control knob in the cockpit; pilot cockpit; cockpit controls' effects and motions; windows and windshields; view of the pilot cockpit; and cockpit controls. In addition to the ergonomic design of cockpit presented by Zhang et al. (2014), Shubham and Devendra (2017) suggested another cockpit ergonomic design element including the following:

a) Displays: reducing pilots' fatigue is considered as the primary goal of the ergonomic design of cockpit displays. There are two factors to be taken into account when ergonomically designing the cockpits' displays as follows:

- The clearness and legibility of the scale.
- The scale letters' size must be calculated as: $\textbf{Letter or number height} \geq \frac{\textbf{Reading distance}}{\textbf{200}}$

b) Controls: the ergonomic considerations of the design of the cockpit controls are: suitability of controls' size and shape to promote pilots to handle, exerting just the needed force, but not excessive force; conformity of the controls' portion which comes into contact with pilots' hand to the anatomy of human hands; appropriation of backgrounds’ and controls' colours for providing the desired psychological effect; frequently-used controls must be positioned close together, and vice versa; ease of access and logical position; and minimum smooth moments and energy (Cîmpian, 2011; Shubham and Devendra, 2017).

c) Working Environment: it has considerable impacts on the man-machine interface and the operators' efficiency and possibly health. The significant factors to be considered in the environments where operators work involve: noise, lighting, humidity, temperature, and air circulation.

d) Lighting: for being the focus of attention for pilots, the light intensity in the environment surrounding the pilots must be lower than that at the task area. Federal Aviation Administration (FAA) (2016) added that the gradation of lighting scheme, when changing from a mission area to another in the surrounding environment, will ensure that pilots will suffer from reduced fatigue.

e) Noise: there are many noise-caused issues which appear in the work environment. Equipment-related noise is inevitable for pilots. Therefore, pilots must be furnished with ear plugs if necessary, with the purpose of decreasing the noise to the least. Noisy work environment results in: nuisance, hearing damage, and work efficiency decrease.

f) Temperature: For ensuring efficiency, pilots must feel neither cold nor hot while carrying out their job because the deviation in temperature from the optimal needed decreases it. The work nature determines the optimal needed temperature.

g) Humidity: at optimal temperatures, another factor affecting the pilots' efficiency is humidity. Whereas reduced humidity can result in the dryness of nose and throat, increased humidity can result in the stuffiness and over sweating (FAA, 2016).

Furthermore, Rune et al. (2008) indicated that there are six elements to consider in the ergonomic design of the cockpit. These elements are as follows:

1-Pilot Seat: in accordance with human engineering principles, seats ought to be adjusted forward and upward in order to suit small pilot; backward and downward in order to suit moderate pilots as well as large ones.

2-Top Panel: there is a relation between the posture of the neck and the seat and the degree of visibility and reach ability of the top panel.

3-Stick: the improper position of the stick could lead to problems and pilot discomfort. These problems include the upper arm discomfort, unclear inner visual field, and abdomen extrusion.

4-Center Console: it is located on the pilot’s right side. Throttle is located at the middle of it. Emphasizing what has been said above, Simonean et al. (2003) and Xin et al. (2005) added that for avoiding the pilots' wrist ache, discomfort, and eventually disease, when the wrist ulnar deviation is large, the throttle's shape, journey, and position, as well as the controlling era, must not keep long.

5-Main flight panel and glare shield: these affect the inner visual field. For pilots' best visual, it must be 50 degrees up and down 50 from the pilot's horizontal line of sight.

6-Rudder pedals: the distance between the rudder pedals and the shinbone must provide maximum comfort for the pilot’s legs. If the rudders are outside the reach zone, this could result in serious consequences or aftereffects.

Aviation Safety

It is a right for all workers to get a work environment characterized by both safety and health (Wilhite, 2018a). Aviation safety is as complex and interconnected as the aviation system. The design of aircraft plays a role in aviation safety (Ausrotas et al., 2012). Penttinen (2014) stated that as a part of everybody's daily work duties and routines, both of safety and protection are considered in the work environment.

Simply put, Chrobak (2020) said that safety in the work environment is concerned with ensuring operators' physical, emotional, and mental well-being, so that they are safe, alert, healthy, and engaged in and out of the work environment. As a result, the design of a safe work environment enhances operators to be as best as possible or the best they can be.

A part of safety in the workplace is ensuring each employee feels safe (Wilhite,2018b). Historically, an unsafe environment was seen as caused primarily by human error (Dekker, 2002). Soekkha (1997) said that air transport industry greatly cares for the safety of its customers by devoting much effort to providing a smooth, efficient, and as effective as possible operation of daily air traffic services. Therefore, the importance of work environment safety can manifest itself in the following ways (Sharma, 2016; Bhasin, 2020; Goelitz, 2020): the prevention of unneeded workers’ illness and injury; preventing environment stress; encouraging a productive work environment; reducing employee absenteeism and turnover; and increasing workers’ satisfaction.

Methodology

Study Method

In order to achieve the objectives of the study, the researcher designed a questionnaire. It was distributed electronically via social networking, such as Facebook, E-mail, and Google Forms. It was distributed to pilots in EgyptAir from December 1, 2021 to May 30, 2022. The introduction of the questionnaire was explaining the concept of Human Engineering and its importance in the cockpit design and enhancing aviation safety. Participants were notified that their answers will be used for scientific aims only and will be collected confidentially.

A simple random sample of pilots was selected, only (314) questionnaires were valid for statistical analysis. The questionnaire in this study was divided into three sections: a)the first section deals with the demographic characteristics of the sample in terms of gender, age, years of experience, current position in the airline, b) the second section included forty nine items to measure the following variables; organizational regulations (OR) (6 items), working environment (WE) (10 items), seating posture (SP) (16 items), lighting (L) (6 items), and displays, controls and panels (11 items).These dimensions were extracted depending on the studies of Rune et al. (2008); Zhang et al. (2014); and Shubham and Devendra (2017)and were measured by utilizing forty nine statements. The statements were adopted from Goossens et al. (2000); Santos et al. (2009); and Alsamman and Mahmoud (2018). A 5-point Likert Scale anchored from (5) ‘Strongly agree’ to (1) ‘Strongly disagree’ was employed, as the respondents were asked to express to what extent they agree with the study constructs, c) the third section is concerned with the evaluation of both pilots’ safety and aviation safety. The fifty four statements of this section were retrieved from safety evaluation surveys carried out by ATSB (2004); IWH (2016); Weightman (2017); and Britton (2018).It contained three dimensions, organizational safety norms with twenty nine statements, work environment hard and soft safety norms with fourteen statements, and pilots’ performance safety norms with eleven statements. A (1-5) Likert scale degrees of agreement was used from (1) ‘Strongly disagree’ to (5) ‘Strongly agree’.

The results of demographic characteristics indicate that (98.7%) are males and (1.3%) are female. (57.3%) are captain pilot and (42.7%) are co-pilot. (10.2%) of them are aged from 20 to 29 years, (25.8%) are aged from 30 to 39 years, (33.4%) of them are aged from 40 to 49 years, and finally(30.6%) of them are aged 50 and over years. (20.4%) of pilots have work experience (30 years and over), followed by (24.8%) of pilots who have (20 to 29 years), then (33.8%) of pilots have (10 to 19 years), and finally (21%) of pilots who have (0 to 9 years).

Judgment sampling was applied in the pilot study to find out any required modifications to facilitate the easy and accurate completion of the questionnaire items. This pilot study resulted in the omission of some items due to the length of the questionnaire and the confusion that they created.

To get the findings of these analyses, the statistical package for social science (SPSS V. 24) and (AMOS V. 24) for Windows were used to test the study hypothesis: the (SPSS V.24) program was used to perform reliability test and descriptive analysis, including frequencies, percentages, means, and standard deviation. While (AMOS V.24) was used to conduct a path analysis to assess the effect of the independent variable on the dependent variable and to test the study hypothesis.

Results

Reliability Test

A high Cronbach's Alpha value reflects the reliability of scale and indicates cohesiveness among scale items. According to Nunnally (1978), a high Cronbach's Alpha is an indirect indicator of convergent validity. However, the validity needed to be confirmed by CFA. Table (1) indicates values of Cronbach's Alpha for all constructs. Based on the data presented in the table, there is sufficient evidence to suggest that the reliability of the constructs was acceptable, given that the Cronbach's Alpha value is >0.60 (Nunnally, 1978).

Table 1: Reliability Levels of Instrument – Cronbach's Alpha

	Cronbach's Alpha	No. of items
Human engineering in aviation industry (HEA)	.865	54
A- Human Engineering in Cockpit Design (HEC)	.748	49
Organizational regulations (OR)	.855	6
Working environment (WE)	.732	10
Seating posture (SP)	.814	16
Lighting (LG)	.881	6
Displays, controls, and panels (DC)	.755	11
B- Human Engineering in Safety (HES)	.892	54
Organizational safety norms (OS)	.887	29
Work environment hard and soft safety norms (HS)	.791	14
Pilots' performance safety norms (PP)	.802	11

As shown in the table, the scale, as well as each construct, has high levels of internal consistency and reliability, where Cronbach's Alpha values are >0.732. This leads to the conclusion that all the constructs and variables are built on well-established instruments with high reliability scores.

Descriptive Statistics

A) *Descriptive statistics for Human Engineering in Cockpit Design variables*

Table 2: Results Summary of Human Engineering in the Cockpit Design

	Mean	SD	Rank
Organizational Regulations	4.0033	.7091	2
Working Environment	3.8200	.5436	4
Seating Posture	4.0313	.7786	1
Lighting	3.5067	.7252	5
Displays, Controls, and Panels	3.9691	.4944	3
Human Engineering in the Cockpit Design	**3.8661**	**.4740**	

Table (2) represents the study sample’s responses to the human engineering in the cockpit design variable statements. The total mean came to (3.8661) with a standard deviation of (.4740). This mean indicates that the pilots in EgyptAir agreed that the various dimensions of HE are applied in the design of the cockpit.

B) Descriptive statistics for Aviation Safety variables

Table 3: Results Summary of Aviation Safety

	Mean	SD	Rank
Organizational safety norms	4.2566	.5977	3
Work environment hard and soft safety norms	4.3657	.5056	1
Pilots' performance safety norms	4.3364	.5368	2
Human engineering in safety	4.3195	.5038	

The results contained in Table (3) indicate that the total mean of the responses to Human Engineering in Aviation Safety amounted to (4.3195) with a standard deviation of (.5038). This mean signifies that the respondents strongly agreed that Human Engineering has an impact on Aviation Safety.

Path Analysis

A) Path Analysis from Human Engineering in Cockpit Design to Safety

Table 4: Model Fit for Path Analysis from Human Engineering in Cockpit Design to Safety

Indicators	Value
χ^2/df	1.822
Comparative Fit Index – CFI	.941
The Goodness of Fit Index – GFI	.937
Normative Fit Index – NFI	.952
Incremental Fit Index – IFI	.944
Tuker – Lewis Index – TLI	.928
Root Mean Square Error of Approximation – RMSEA	.029

According to Table (4), the value of chi-square is less than 5, reaching 1.822, making the model acceptable. The value of the (CFI) was 0.941, and this indicates the conformity of the model. The value of the (GFI) was 0.937, which indicates the conformity of the model. The value of the (NFI) was 0.952, and this indicates the conformity of the model. The value of the (IFI) was 0.944, indicating the conformity of the model. The (TLI) value was 0.928, which indicates the conformity of the model. Finally, the (RMSEA) value was 0.029, which is a value close to zero. This indicates the conformity of the model. Considering all the indicators, it becomes clear that the proposed model fitted the sample data.

Table 5: Results of path analysis from human engineering in cockpit design to safety

Path	Estimate	S.E.	C.R	P Value	Result
Human Engineering in Cockpit Design → Safety	.598	.102	5.863	.000	Supported

Table (5) indicates that the value of the standard estimate from human engineering in cockpit design to safety was 0.598, which is significant (p-value <.05), and this means that human engineering in cockpit design positively affects 59.8% of safety. The standard error was 0.102. The C.R. value was 5.863.

B) Path Analysis from Organizational Regulations to Safety

Table 6: Model Fit for Path Analysis from Organizational Regulations to Safety

Indicators	Value
χ^2/df	2.097
Comparative Fit Index – CFI	.974
The Goodness of Fit Index – GFI	.968
Normative Fit Index – NFI	.977
Incremental Fit Index – IFI	.948
Tuker – Lewis Index – TLI	.961
Root Mean Square Error of Approximation – RMSEA	.011

According to the Table (6), the value of chi-square is less than 5, reaching 2.097, thus making the model acceptable. The value of the (CFI) was 0.974, and this mirrors the conformity of the model. The value of the (GFI) was 0.968, which suggests the conformity of the model. The value of the (NFI) was 0.977, indicating the model conformity. The value of the (IFI) was 0.948, signifying the model conformity. The (TLI) value was 0.961, which is a sign of the model conformity. The (RMSEA) value was 0.011, which is a value close to zero. That indicates the conformity of the model. Considering all the above-mentioned indicators, it becomes clear that the proposed model fitted the sample data.

Table 7 Results of Path Analysis from Organizational Regulations to Safety

Path	Estimate	S.E.	C.R	P Value	Result
Organizational Regulations →Safety	.815	.110	7.409	.000	Supported

Table (7) indicates that the value of the standard estimate from organizational regulations to safety was 0.815, which is significant (p-value <.05), and this means that organizational regulations positively affect 81.5% of safety. The standard error was 0.110. The C.R. value was 7.409.

C) Path Analysis from Working Environment to Safety

Table 8: Model Fit for Path Analysis from Working Environment to Safety

Indicators	Value
χ^2/df	1.780
Comparative Fit Index – CFI	.969
The Goodness of Fit Index – GFI	.987
Normative Fit Index – NFI	.947
Incremental Fit Index – IFI	.976
Tuker – Lewis Index – TLI	.961
Root Mean Square Error of Approximation – RMSEA	.002

Table (8) shows that the value of chi-square is less than 5, reaching 1.780 and making the model acceptable. (CFI) value was 0.969, and this indicates the conformity of the model. The value of the (GFI) was 0.987, an indication of the conformity of the model. The value of the (NFI) was 0.947, and this assures the model conformity. The value of the (IFI) was 0.976, which indicates the conformity of the model. The (TLI) value was 0.961, which suggests the conformity of the model. The (RMSEA) value was 0.002, which is a value nearing zero. This indicates the conformity of the model. Depending on all the previous indicators, it can be concluded that the proposed model fitted the sample data.

Table 9: Results of Path Analysis from Working Environment to Safety

Path	Estimate	S.E.	C.R	P Value	Result
Working Environment → Safety	.758	.120	6.317	.000	Supported

Table (9) indicates that the value of the standard estimate from working environment to safety was 0.758, which is significant (p-value <.05), and this means that working environment positively affects 75.8% of safety. The standard error was 0.120. The C.R. value was 6.317.

D) Path Analysis from Seating Posture to Safety

Table 10: Model Fit for Path Analysis from Seating Posture to Safety

Indicators	Value
χ^2/df	1.992
Comparative Fit Index – CFI	.990
The Goodness of Fit Index – GFI	.974
Normative Fit Index – NFI	.979

Incremental Fit Index – IFI	.958
Tuker – Lewis Index – TLI	.980
Root Mean Square Error of Approximation – RMSEA	.003

As mentioned in Table (10), chi-square value is less than 5, reaching 1.992, therefore the model is accepted. Since the values of (CFI), (GFI), (NFI), (IFI), and (TLI) were respectively0.990, 0.974, 0.979, 0.958, and0.980, they signify the conformity of the model. The (RMSEA) value was 0.003, which is a value close to zero. This indicates the conformity of the model. In light of all the above-mentioned indicators, it becomes clear that the proposed model fitted the sample data.

Table 11: Results of Path Analysis from Seating Posture to Safety

Path	Estimate	S.E.	C.R	P Value	Result
Seating Posture → Safety	.781	.129	6.054	.000	Supported

Table (11) indicates that the value of the standard estimate from Seating Posture to safety was 0.781, which is significant (p-value <.05), and this means that seating posture positively affects 78.1% of safety. The standard error was 0.129. The C.R. value was 6.054.

E) Path Analysis from Lighting to Safety

Table 12: Model Fit for Path Analysis from Lighting to Safety

Indicators	Value
χ^2/df	2.114
Comparative Fit Index – CFI	.974
The Goodness of Fit Index – GFI	.958
Normative Fit Index – NFI	.976
Incremental Fit Index – IFI	.934
Tuker – Lewis Index – TLI	.955
Root Mean Square Error of Approximation – RMSEA	.032

Table (12) shows that the value of chi-square is less than 5, reaching 2.114, and making the model acceptable. Since the values of (CFI),(GFI),(NFI), (IFI), and (TLI) were respectively 0.974, 0.958, 0.976, 0.934, and 0.955, they show the conformity of the model. The (RMSEA) value was 0.032, which is a value close to zero. This indicates the conformity of the model. All the indicators mentioned above suggest that the proposed model fitted the sample data.

Table 13 Results of Path Analysis from Lighting to Safety

Path	Estimate	S.E.	C.R	P Value	Result
Lighting → Safety	.497	.071	7.000	.000	Supported

Table (13) indicates that the value of the standard estimate from lighting to safety was 0.497, which is significant (p-value <.05), and this means that lighting positively affects 49.7% of safety. The standard error was 0.071. The C.R. value was 7.000.

F) Path Analysis from Displays, Controls, and Panels to Safety

Table 14: Model Fit for Path Analysis from Displays, Controls, and Panels to Safety

Indicators	Value
χ^2/df	2.158
Comparative Fit Index – CFI	.977
The Goodness of Fit Index – GFI	.937
Normative Fit Index – NFI	.958
Incremental Fit Index – IFI	.981
Tuker – Lewis Index – TLI	.961
Root Mean Square Error of Approximation – RMSEA	.024

Table (14) shows that the value of chi-square to be under 5, reaching 2.158, and therefore the model is accepted. The values of (CFI), (GFI), (NFI), (IFI), and (TLI) was respectively 0.977, 0.937, 0.958, 0.981, and 0.961, they reflect the conformity of the model. (RMSEA) value is 0.024. This indicates the conformity of the model. After considering all the mentioned indicators, it becomes clear that the proposed model fitted the sample data.

Table 15 : Results of Path Analysis from Displays, Controls and Panels to Safety

Path	Estimate	S.E.	C.R	P Value	Result
Displays, Controls and Panels → Safety	.515	.109	4.725	.000	Supported

Table (15) demonstrates that the value of the standard estimate from displays, controls and panels to safety was 0.515, which is significant (p-value <.05), and this means that displays, controls and panels positively affects 51.5% of safety. The standard error was 0.109. The C.R. value was 4.725.

Recommendations

The study presented the following recommendations:

1. The working space in the cockpit must be sufficient to provide pilots with the required space for moving easily.
2. The cockpit pressure, temperature, illumination, noise, ventilation must be adaptable to provide pilots with the best working conditions.
3. The controls in the cockpit must be allocated in the best place which provides pilots with the best response in a timely manner and helps pilots avoid the cross-hands problems.
4. The displays and panels and their lighting and colours must be designed to provide pilots with easy-to-read flight information.

5. A seat massage should be available to avoid back and neck pain for the pilot in long-time flights.

Conclusion and further research

The study contributed to highlight the essential role of Human Engineering in enhancing aviation safety. Human Engineering and its dimensions are vital to improving the pilots' comfort and safety by designing a working environment "cockpit" which provides pilots with high levels of comfort and required facilities. The study targeted EgyptAir pilots as the study population and used the questionnaire as a data collection tool. The study was based on the one main hypothesis that the ergonomic cockpit design positively affects aviation safety. The study put forward a number of recommendations concerning cockpit designers. As for further research, it is recommended to study different models of cockpits to show the advantages and disadvantages of each of them to identify the optimal design that ensures the highest levels of pilots' comfort and aviation safety.

The study also reached a number of results that clearly showed that:

1. EgyptAir performs in accordance with organizational regulations, as a part of human engineering, which are set and applied in an optimal way to enhance the pilots' comfort, performance, and safety.
2. In EgyptAir, working environment is well-designed, safe to work in, and positively affects pilots.
3. Seating posture in EgyptAir is optimal and seats enhance pilots' comfort and performance during flight time to operate a safe flight.
4. Lighting in cockpit, displays, controls, and panels are all adequate. This provides pilots with a high level of feeling of comfort.
5. The cockpit displays, controls, and panels are well-designed and best-located and arranged.
6. Organizational regulations positively affect safety.
7. Working environment positively impacts safety.
8. Seating posture affects safety in a positive way.
9. The effect of lighting on safety is a positive one.
10. Displays, controls, and panels have a positive effect on safety.

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أثر الهندسة البشرية في مقصورة القيادة على السلامة الجوية

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الملخص العربي:

تتمثل الأهداف الرئيسية لهذه الدراسة في تحديد مفهوم الهندسة البشرية وأهميتها وذلك لإلقاء الضوء على دور الهندسة البشرية في تصميم مقصورة القيادة وتعزيز السلامة الجوية. وقد تم إجراء تحليل كمي على البيانات التي تم جمعها من عدد 417 طيار ينتمون إلى شركة مصر للطيران. وقد كشفت النتائج أن تطبيق الهندسة البشرية في مقصورة القيادة يؤثر إيجابياً على السلامة الجوية. وقد تم التوصل إلى أن تطبيق الهندسة البشرية عند تصميم مقصورة القيادة بالطائرة تُطبق بشكل كبير في مصر للطيران. وتُسهم الدراسة في تزويد شركات الطيران بالتغذية المرجعية للطيارين بما يتضمن شكواهم ومقترحاتهم فيما يتعلق بتصميم مقصورة القيادة بكل مشتملاتها وذلك بهدف التعامل مع نواحي القصور من أجل القيام بالتحسينات الضرورية في تصميمها لضمان راحة الطيار وضمان مستويات أمان أعلى.

الكلمات الدالة: الهندسة البشرية، السلامة الجوية، تصميم مقصورة القيادة.