Journal of Aeronautics, Astronautics and Aviation, Vol. 57, No. 3S, pp. 295 – 307 (2025)
https://doi.org/10.6125/JoAAA.202503_57(3S).02

Establishment of Seat Pitch and Seat Tray Table's Height as Significant Factors for Aircraft Passengers' Flight Comfort Through Triangulation Method

Salim Mkubwa Salim, Fairuz Izzuddin Romli *, Mohammad Yazdi Harmin, Norkhairunnisa Mazlan, Dayang Laila Abang Abdul Majid

Department of Aerospace Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.

ABSTRACT

In-flight comfort has become one of the main considerations for aircraft passengers in choosing their air travel options. It is therefore imperative for airlines to be able to provide a good flying cabin comfort to their passengers throughout the flight in order to be more competitive in the air transportation market. As indicated in several previous studies, one of the primary aspects of in-flight comfort can be related to the ease of passengers in performing in-flight activities while being seated. It is believed that the passengers' comfort during the in-flight activities is highly affected by the seat pitch and the height of seat tray table. To establish the influence of these two factors on aircraft passengers' comfort while performing their in-flight activities, triangulation approach is applied in this study. Three different data collection methods are conducted, which are online survey, focus group session and group discussion conducted at aircraft cabin mock-up. The collected data is then triangulated to reach the conclusion on effects of height of seat tray table and seat pitch to aircraft passengers' comfort during in-flight activities. All in all, results of the data triangulation indicate that current aircraft cabin is not comfortable for all aircraft passengers, particularly for them to do their typical in-flight activities. The ease and comfort to perform in-flight activities has been noted as crucial for aircraft passengers and this affects their overall flying comfort. Both seat pitch and height of seat tray table have been cited as influential factors that affect the comfort and ease of passengers in doing in-flight activities.

Keywords: Flight comfort, Seat pitch, Seat tray table height, Flight activities, Data triangulation

I. INTRODUCTION

Exponential growth in air travel, fueled by the ascent of many low-cost airlines, has spurred a market expansion that is reaching the previously underserved segments [1, 2]. For instance, numerous studies like those in India have shown a discernible shift from rail transport to low-cost air travel, highlighting the influential role of affordable flight fares [3]. As the air transportation passengers' market gets bigger, the competition between airlines has also become more intense since there are more airlines that offer flight services now and they are competing against each other to capture the same pool of passengers. Facing with the high competitions, airlines have been actively searching for the effective market strategies that can differentiate their flight services and win the passengers market. It should be noted that, while flight ticket price is a significant consideration for many aircraft passengers, it is not the only main factor. In fact, despite their great success in attracting passengers with much cheaper ticket prices, most low-cost airlines are having issues to retain and build loyal passengers base [4]. On the other hand, it is found that many aircraft passengers are willing to pay more for better flight service quality and

Manuscript received, May 6, 2024, final revision, July 6, 2024
* To whom correspondence should be addressed, E-mail: fairuz_ir@upm.edu.my

comfort level [5]. Unsurprisingly, flight comfort has long been used as one of the major competitive means between airlines and comfortable flight services have been linked to increased numbers of passengers for airlines [6]. Flight comfort has been highlighted as the most important aspect for aircraft passengers in selecting their air travel options [7] and its importance is also supported and highlighted by several other studies [8-10].

In general, there is no standard definition for comfort. Comfort used to be taken as a state without discomfort [11] but it has been argued that there are times when people feel uncomfortable even in the absence of any discomfort [12]. Another definition of comfort used by researchers views it as a "the pleasant state or relaxed feeling of a human being in reaction to its environment" [13]. It should be noted that the complexity in defining comfort can be attributed to its subjectivity where different people react differently under similar circumstances or conditions. Nevertheless, despite different opinions or definitions, it has been widely agreed that comfort can be related to physical, physiological and psychological factors [14]. This means that it will depend on the environment the person is reacting to, the emotional state of the person himself and also the body functions of the person. In the context of aircraft passengers, in-flight comfort can therefore be linked to the cabin environment and the passengers' state of mind and body functions. The latter can be further related to in-flight activities that the passengers do as that will dictate their body movement and posture. Thus, it is essential for the aircraft cabin design to enable passengers to easily and comfortably perform their activities while being seated as this will affect their overall flight comfort.

Different in-flight activities in current aircraft cabin has been shown to correspond to different level of comfort among aircraft passengers [15]. Apart from the passengers' psychological factors, this state is believed to be caused by inadequacy of current cabin design to accommodate their physiological aspects. Passenger seat design is one of the most cited factors for flight discomfort [16], in addition to limited knee space or legroom due to low seat pitch setting used in current cabin seating arrangement [17]. There are many complaints on lack of available space at the seat for passengers to move about and adopt better sitting postures, which in turn is causing them to have body aches and pains, leading to flight discomfort [18]. Clearly such restrictions will affect their ability to easily do their in-flight activities as well, which is highlighted in Figure 1.

Figure 1 Small legroom can lead to difficulty for aircraft passengers to do their in-flight activities [17]

Moreover, it is observed that most in-flight activities by aircraft passengers at their seat involve the usage of the seat tray table. It should be noted that the current seat tray table in many aircraft cabins is fixed in height. A study has found that this fixed height may not be suitable for aircraft passengers as many had issues in using the seat tray table since it is largely too low for their comfort. The improper height led to bad neck postures and discomfort when they used it for their in-flight activities [19]. Similar finding is demonstrated in another study where perceived passengers' comfort level during several in-flight activities was shown to vary with different heights of the seat tray table [8].

In order to support and establish seat pitch and height of the seat tray table as significant factors for passengers' flight comfort, triangulation approach is used in this study. Three different methods of data collection are carried out: online survey, focus group and also group discussion at the aircraft cabin mock-up. The findings from these different methods are then analyzed and triangulated to establish on the significance level of effects by seat pitch and height of seat tray table on the comfort of aircraft passengers during flight by easing their in-flight activities.

II. METHODOLOGY

The triangulation method is often applied to increase the credibility and validity of findings from data collection process [20]. This helps to eliminate any inherent biasness of a single method and provide more balanced explanation for the complex human behavior through the use of several different methods [21]. For this study, three data collection approaches are used: online survey, focus group study and group discussion at the aircraft cabin mock-up.

2.1 Online Survey

Conducting survey is a widely-accepted as one of the ideal methods for data collection, particularly in gathering and documenting information of general perception, belief, attitude and knowledge from the public or target groups of people regarding particular topics [22]. For instances, this survey method has been used to gather data on importance of English language for aviation maintenance [23], fatigue among aircrew [24] and also passengers' view on current aircraft systems or services like onboard carry-on luggage handling [25] and safety briefing materials [26]. For this study, the survey is conducted in the online mode and it is focused on establishing the significant cabin design factors in commercial transport aircraft that can affect the comfort of passengers while they are doing their in-flight activities.

The first task in conducting a survey is to develop the appropriate survey instrument or questionnaire. Based on gathered information in literatures with regards to aircraft passengers' comfort and their in-flight activities, questions for the survey are tailored to the interested information that is to be collected from the respondents. The initial draft of the survey questionnaire is put through a test run among a small group of people. This is done to ensure that all of the questions in the survey meet their goals in extracting the right type of answers from the survey participants by being correctly worded and easy to understand. Feedbacks from this test run are then used to improve the survey instrument

before it is finalized. As previously mentioned, the conduct of the survey is done through online mode. This choice of online survey is primarily due to ongoing circumstances of COVID-19 pandemic at the time of data collection process for this study. In this study, the online survey is conducted using the Google Forms platform for the duration of three months. Public invitations for survey participants are made through various social media outlets such as Facebook and WhatsApp. Note that the target participants for this survey are people who have previous flying experiences with the commercial airlines.

Furthermore, it is essential to ensure that the number of survey respondents is adequate to derive representative conclusions from the collected data. In this study, it is hard to accurately quantify actual population size for all aircraft passengers. However, it has been shown that, as the target population size increases, the increase rate in the number of the required sample size for good statistical analysis is actually reduced and eventually, the required sample size becomes constant regardless of how big the population is [27]. It is found that, when target population size is bigger than 250,000 as can be expected for the aircraft passengers, the required sample size remains as 384 for standard 95% confidence level and 5% error level (or significance level). A total of 410 survey responses have been collected in this study, which is more than required. The collected survey responses are then analyzed to establish significant factors to provide better comfort for the passengers in performing their in-flight activities.

2.2 Focus Group Study

Since flight comfort is principally a subjective matter, it is important to qualitatively capture all unique personal experiences, perceptions, beliefs and also meanings from the aircraft passengers. Focus group study has been one of the approaches regularly used to achieve this as it enables a direct engagement with the target groups during the data collection process [28]. For instances, this data collection method has been used in various aerospace-related studies such as for gathering opinions on reduction in numbers of pilots [29] and future in-flight virtual reality entertainment [30]. In this study, the focus group sessions are conducted in online mode due to ongoing situations with COVID-19 pandemic at that particular time. Screenshot for one of the conducted sessions is depicted in Figure 2.

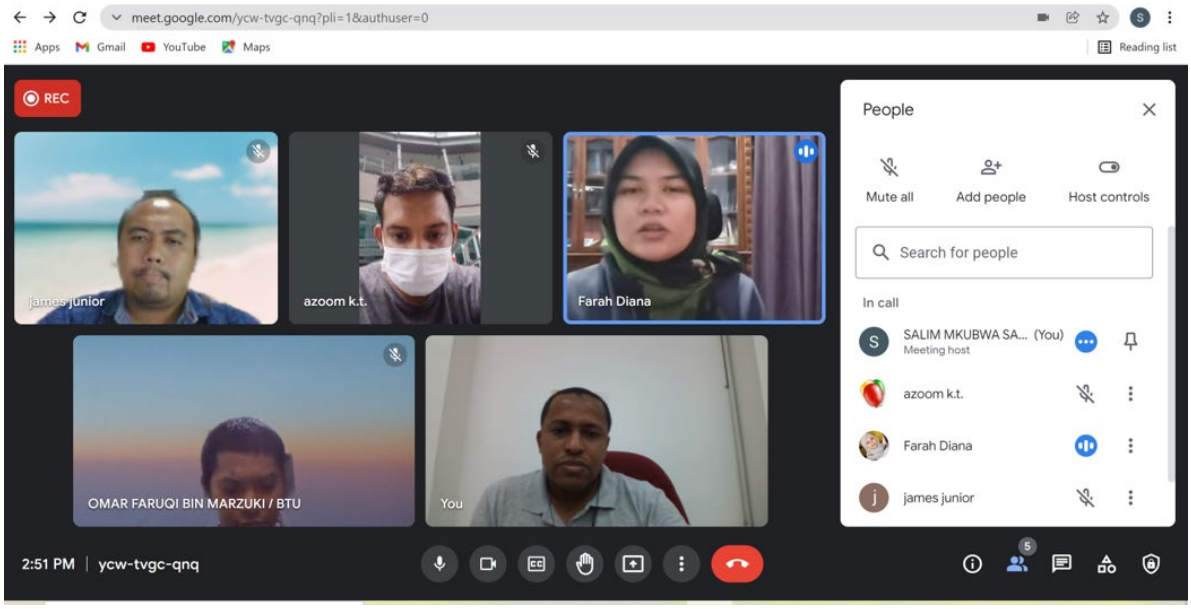

Figure 2 Online focus group session in this study

To ensure the effectiveness of conducted focus group sessions, standard practice guideline used in other research works is referred [31,32]. For the focus group in this study, the primary target participants were those who already had flying experience on any commercial airlines. This ensures that the participants have familiarities with travel comfort inside the cabin of the current passenger transport aircraft to provide critical feedbacks. Public calls for participation in the focus group session are made through circulation in few social media outlets such as Facebook and WhatsApp. Based on the obtained responses, only those who matched with the selection criteria were shortlisted and invited to join the conducted focus group sessions.

Prior to conducting the focus group, the guideline for questions to be asked during the session is prepared, which are tailored to the intended information to be elicited from the participants. Table 1 presents the discussion guideline that is used in this study. Nevertheless, it should be noted that the focus group session is conducted in semi-structure way, meaning that the guideline of the prepared questions serves only as a reference and the session is flexible based on the situation.

A total of nine participants have been chosen for the focus group, which is conducted in three online sessions. The background details of the participants are tabulated in Table 2. It should be noted that by the third online session, the findings have become greatly similar and repetitious to

the other two previous sessions. This situation can be taken to imply that information gathered from these focus group sessions is already adequate to make a sensible conclusion for the collective perspective of all participants regarding air travel comfort on current commercial aircraft [33]. The analysis of findings from all three focus group discussions is done through the content analysis technique of recorded video of the sessions [34], which enables the identification of shared experiences and also general perceptions of this group of participants in terms of in-flight cabin comfort.

Table 1 Discussion guide for the focus group

General perceptions on comfort level in conducting common in-flight activities inside the current cabin
- What are the common in-flight activities that you often engaged in during flight at your seat?
- How easy or comfortable it is to perform those in-flight activities with the current cabin arrangement?
- Do you think the current seat pitch and also seat tray table's height are properly set for your comfort to perform those in-flight activities? Please briefly discuss your reasoning for saying so.

Personal experiences regarding comfort level in performing the in-flight activities
- Have any of you experience any discomfort in performing your in-flight activities during flight? It can be either you yourself or you saw your fellow passengers having the discomfort or difficulty. Please explain.
- Have any of you experience any issues with the current seat pitch and tray table's height? Or seen it for your fellow passengers? Please explain.
- What cabin design factors that seem to negatively affect your comfort while doing your in-flight activities at your seat that can be improved? Please explain.

Table 2 Background of focus group participants

Volunteer	Gender	Age	Frequency of Air Travel	Common Reasons of Air Travel
1	Male	32	Frequently	Business
2	Female	24	Occasionally	Leisure
3	Female	29	Frequently	Business & Leisure
4	Male	27	Occasionally	Leisure
5	Male	31	Occasionally	Business & Leisure
6	Male	24	Frequently	Business
7	Male	23	Frequently	Business
8	Male	26	Frequently	Leisure
9	Male	29	Frequently	Business

2.3 Group Discussion at Aircraft Cabin Mock-up

In addition to the traditional focus group sessions that are conducted in this study, few volunteers who answered the call for participants group have been asked to join the group discussion session. The group discussion is done at the aircraft cabin mock-up, which is located at Department of Aerospace Engineering, Universiti Putra Malaysia. By having the group session at the aircraft cabin mock-up, the participants have the opportunities to test their comfort in conducting the activities with varying seat pitch and also height of the seat tray table in real time. Therefore, instead relying solely on their perception that has been probably shaped through their previous flying experiences, they are able to experience themselves how their comfort level will be affected by the different settings of seat pitch and seat tray table's height in real time during the discussion.

The conduct of this group discussion is started with explanation and briefing of the main goal for conducting the focus group study to all of the participants. Next, each of the participants took turns in the aircraft cabin mock-up where they experienced the actual situation in performing their common in-flight activities with different settings of seat pitch and height of the seat tray table. Once everybody completed their turns at the aircraft cabin mock-up, a short group discussion is conducted using the same guideline of focus group discussion as presented in previous 1. Lastly, after the discussion session has ended, each participant is asked to fill up a short questionnaire. Unlike focus group discussion that is more general in nature, the questionnaire is specifically tailored to the experiences during individual session at the aircraft cabin mock-up. The list of questions is tabulated in Table 3 while Figure 3 shows some pictures taken during the discussion at the aircraft cabin mock-up.

Five volunteers have participated in the group session at the aircraft cabin mock-up and their background details is tabulated in Table 4.

Table 3 Questionnaire for group discussion at aircraft cabin mock-up

1. In general, your opinion on the comfort level inside the aircraft cabin?
2. What type of activities that you normally do during flight?
3. Is it comfortable for you to do this activity? If not, what are the reasons for the discomfort?
4. Do you think the tray table height and the seat pitch contribute to the comfort level while performing these activities?
5. What is your opinion on the current seat pitch? – Adequate space at the seat?
6. What is your opinion on the current tray table height? – Improve sitting posture?
7. Suggestions to improve the comfort of inflight activities – eating, reading, working etc.

(a) Session at the aircraft cabin mock-up

(b) Group discussion

Figure 3 Conducted group discussion session at the aircraft cabin mock-up

Table 4 Background of group discussion participants

Volunteer	Gender	Frequency of Air Travel	Common Reasons for Air Travel
1	Male	Frequently	Business
2	Male	Occasionally	Leisure
3	Male	Frequently	Business & Leisure
4	Female	Frequently	Leisure
5	Female	Frequently	Business & Leisure

2.4 Triangulation of the Collected Data

Triangulation method is applied to derive conclusions from two or more data sources. It is also often performed as a form of validation for findings from different methods used such that it ensures correct interpretations have been made from the collected data [35].

Table 5 Triangulated data types

Types	Description
Same story, same meaning	Participants gave similar answers and indicated similar interpretations or assigned a similar meaning to the asked questions
Same story, different interpretation	Participants gave similar answers to a question but indicated that they had a different understanding or assigned a different meaning to their answers
Missing pieces	Information provided by one participant that was needed to understand and complete the story, which was not included in another participant's response
Unique information	A response that was uniquely provided by one participant only, which was not shared with other participants
Illuminating	Responses that are different but not contradictory, which may vary due to different personal perspectives and situations

As in previous sections, the data in this research study has been collected through three different approaches: survey, focus group and group discussion at the aircraft cabin mock-up. A comparative analysis is then done on the collected data to identify five types of triangulated data [36], which are listed in Table 5 for this particular study. Based on the obtained results of the comparative analysis, the triangulated findings that are convergent, complementary and also dissonant can then be identified and derived as the overall conclusion from the collected data [37].

III. STRATEGIC OBJECTIVES AND SIGNIFICANCE OF THIS RESEARCH

The online survey enables the engagement of general public who are also aircraft passengers in this study. In the survey, they are essentially asked to share their experience during their flight trips. Their responses will help to further highlight on significant cabin design factors that can affect their comfort while performing in-flight activities. Table 6 tabulates the summary of background characteristics and also flying history for the survey participants. It should be noted that the total number of participants for this online survey is recorded as 410.

Table 6 Demographic information and flying history of survey participants

Variable		n (%)
Gender	Male	285 (69.5)
	Female	125 (30.5)
Age (years)	≤ 20	18 (4.4)
	21 – 30	94 (22.9)
	31 – 40	210 (51.2)
	41 – 50	44 (10.7)
	≥ 51	44 (10.7)
Nationality	Malaysian	213 (51.9)
	Others	197 (48.1)
Flying Frequency with Commercial Airlines	Seldom	50 (12.2)
	Occasionally	164 (40.0)
	Often	99 (24.2)
	Frequent	79 (19.2)
	Highly Frequent	18 (4.4)
Type of Airlines Usually Flown With	Low Cost Airlines	153 (37.3)
	Full Service Airlines	69 (16.8)
	Both Types of Airlines	188 (45.9)

It can be seen from Table 6 that there are more male respondents for the survey with 69.5% than female respondents with 30.5%. Moreover, it is noted that the largest age group of survey respondents is between 21 to 40 years old, which matches with the age group for the majority of aircraft passengers in Malaysia as could be implied from several previous survey studies [38-40]. This realization adds to the credibility of the findings from this survey. Furthermore, the nationality of survey respondents is roughly equally split between Malaysians and also non-Malaysians. On positive aspect, this generalizes the survey findings across various countries and cultures, which adds value to understand the aircraft passengers' comfort from global perspective. In addition, the good adequacy of this pool of survey respondents is also reflected by the fact that most of them have ample flying experiences. Only a small percentage, or just 12.2%, of the respondents, declared that they seldom use air transportation. Passengers of both low-cost and full-service airlines are well represented among the survey respondents. All in all, demographics and also flying experiences of the survey respondents indicate that they can provide a good representation for the population of aircraft passengers in this study.

The survey respondents are asked regarding their past flying experiences inside passengers' cabin of commercial transport airlines. In this case, the survey respondents have rated their agreement level on several statements regarding cabin comfort based on their previous flying experiences. According to their responses, which are tabulated in Table 7, vast majority of the survey respondents believed that the current aircraft cabin arrangement is mostly adequate for their flight comfort. Nevertheless, there are still a notable percentage of respondents who felt that the current cabin arrangement could be improved to enhance their comfort, with close to 22% of the total survey respondents. In fact, only about 6% of the total respondents strongly agree on the provision of comfort level by the current aircraft cabin arrangement. This is taken to imply that there is definitely room for improvement to improve current flight comfort of aircraft passengers.

When queried whether the current cabin arrangement is comfortable for them to perform their in-flight activities, the number of respondents who disagreed has increased to 30%. This strengthens the notion that current aircraft cabin arrangement may not be proper to accommodate the needs of many aircraft passengers for their in-flight activities at their seat. Focusing further on the in-flight activities, it is important for aircraft passengers to be able to comfortably perform their activities and this significantly affects their overall flying comfort. This is agreed by a whopping 86% of respondents, which ultimately supports the underlying motivation of this study that intends to relate overall flying comfort of aircraft passengers to their ability to perform their in-flight activities with ease. Furthermore, in regards to the comfort level in doing their in-flight activities, close to 46% and 73% of the respondents stated that current seat pitch and height of seat tray table, respectively, are not set properly and this situation disables them to comfortably do the activities. The inadequacy of the current seat pitch and seat tray table's height used in most of the current aircraft cabin is also indicated by through the following responses of the survey participants: 81.6% stated that current seat pitch is inadequate for them to easily change their seating position and 53.9% indicated that seat tray table's height

is either too low or too high for them to comfortably use it for their in-flight activities. Additionally, 22.2% of them had issues in performing their in-flight activities due to the low legroom caused by the small seat pitch while 49.8% contributed the difficulty to do the activities on improper tray table's height.

Table 7 Flying experiences in terms of comfort

Situation	Response	n (%)
Current aircraft cabin arrangement provides adequate flying comfort for me	Highly Agree	25 (6.1)
	Agree	294 (71.7)
	Disagree	71 (17.3)
	Highly Disagree	20 (4.9)
Current aircraft cabin arrangement enables me to perform my common in-flight activities with ease and comfort	Highly Agree	25 (6.1)
	Agree	263 (64.1)
	Disagree	102 (24.9)
	Highly Disagree	25 (4.9)
It is important for me to be able to perform my common in-flight activities in order to have good flying comfort	Highly Agree	125 (30.4)
	Agree	227 (55.4)
	Disagree	38 (9.3)
	Highly Disagree	20 (4.9)
Current seat pitch used in the cabin provides ample and comfortable space at my seat	Highly Agree	45 (10.9)
	Agree	170 (41.5)
	Disagree	168 (40.9)
	Highly Disagree	27 (6.7)
Current tray table height is comfortable for me to use during my in-flight activities	Highly Agree	18 (4.4)
	Agree	92 (22.4)
	Disagree	258 (62.9)
	Highly Disagree	42 (10.3)
Experienced yourself or watched fellow passengers having trouble to change seating position because the available legroom is inadequate	Yes	335 (81.6)
	No	75 (18.4)
Experienced yourself or watched fellow passengers having trouble to change seating position while using the tray table because the height is too low or too high	Yes	221 (53.9)
	No	189 (46.1)
Experienced yourself or watched fellow passengers having trouble to perform common in-flight activities (such as eating and using laptop) because the legroom is too small	Yes	91 (22.2)
	No	318 (77.8)
Experienced yourself or watched fellow passengers having trouble to perform common in-flight activities (such as eating and using laptop) because the tray table's height is too low or too high	Yes	204 (49.8)
	No	206 (50.2)

In addition, survey respondents have been also asked about the cabin design factors that they felt affecting their comfort level and also the common in-flight activities that they normally do during flight. Their responses are shown in Figure 4 and Figure 5, respectively. Figure 4 highlights that both seat pitch and seat tray table's height are selected by a large number of respondents as the main cabin factors that affect their overall comfort level and the ease of their in-flight activities. This solidifies the significance of these two factors for passengers' flying comfort. Meanwhile, it can be observed from Figure 5 that the top three common in-flight activities are eating, writing and using a laptop. It can easily be noted that all of these three in-flight activities greatly involve the use of seat tray table and thus placing big emphasis on adequacy of its height for good provision of passengers' comfort while using it to support their in-flight activities.

On the whole, based on collected survey responses, it can be established that seat pitch and seat tray table height have big influence in providing proper comfort for aircraft passengers while engaging in their in-flight activities. The proper setting of these two cabin design factors can help to enhance flying comfort of passengers by enabling them to comfortably do their in-flight activities at their seat with ease.

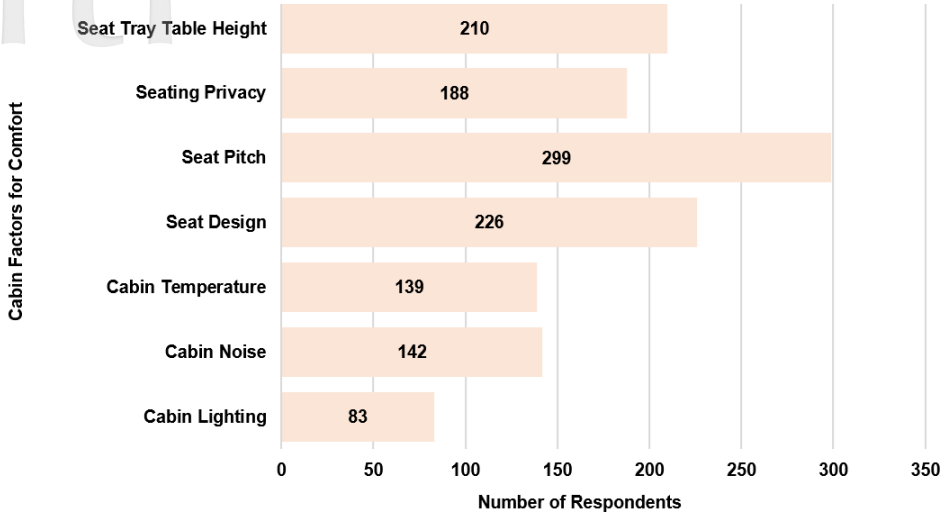

Figure 4 Cabin design factors for comfort

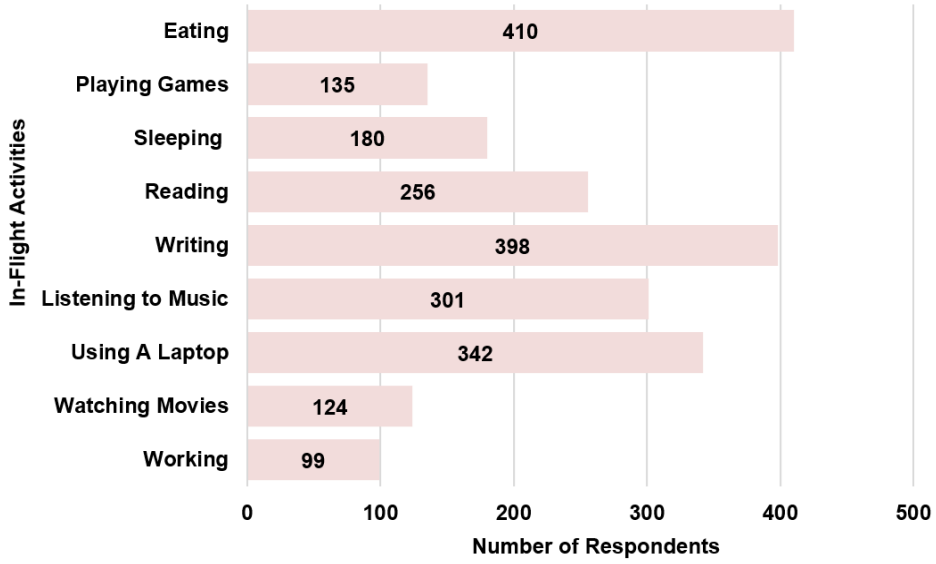

Figure 5 Common in-flight activities

Meanwhile, based on the responses of participants in conducted focus group sessions, the findings are presented in three major themes that emerged from the discussions. The first theme is their general perceptions on the in-flight activities. The general consensus among the participants in all three focus group sessions is that in-flight activities are currently not easy and comfortable to do. Two main causes that are raised by them are seat pitch and tray table's height, or the combination of both. The overarching sentiment is that the current cabin arrangement poses challenge to their flying comfort since it creates difficulties for them to enjoy and do their typical in-flight activities. For instances, this sentiment is clearly visible through the following selected quotes from the participants of the focus group sessions:

Writing is crucial for my work but the limited space and tray table height can be quite inconvenient.

Laptop use is common for work but the tight seating and tray table height can strain my neck and wrists

.

I often work during flights and the limited space makes it difficult. A bit more room and an adjustable tray table would be great.

Eating is something we all do but the setup is not always comfortable. The trays are not as convenient as they could be.

Writing is a part of my routine and I feel cramped. A more ergonomic design would make a significant design.

All in all, it should be noted that the findings from the focus group sessions underscore the need for measures to

enhance aircraft passengers' comfort during their in-flight activities. It appears unanimous that the participants feel that current aircraft cabin can be improved to provide more optimal environment. Additionally, it is also good to note that the participants had consistently expressed their desire for a better setting of seat pitch and tray table's height that enables their ability to perform in-flight activities, which is perfectly in line with the driving motivation of this study.

The second theme used to aptly describe the findings from the focus group sessions is the influence of seat pitch and height of the seat tray table. In general, the participants in all focus group sessions agreed that seat pitch and seat tray table's height can have a significant influence on their perception of the overall flying comfort. The participants are mostly dissatisfied with current seat pitch as it provides limited legroom at their seat, which causes discomfort to them during flight, especially for long flights. For instance, one participant echoed the sentiment by stating:

The seat pitch is quite tight, especially on longer flights. It gets uncomfortable and you cannot stretch out properly.

Meanwhile, consistent with established sentiments in previous theme, participants believed that the current fixed seat tray table height might not be suitable for all their in-flight activities. The improper height of the seat tray table can cause inconveniences to them to comfortably enjoy the in-flight activities. This particular sentiment is reflected by the following quoted statement by one of the participants:

The tray tables are not adjustable and it is a problem. They are too low for comfortable laptop use and sometimes too high for eating.

All things considered, the overall consensus from all focus group sessions is that the limited legroom caused by improper seat pitch and the lack of adjustability in height of the seat tray table contribute towards aircraft passengers' discomfort, especially when doing their common in-flight activities. Most of current seat pitch and tray table's height used by the airlines today are largely inadequate and need to be enhanced to provide better flying comfort. These are evident from following quotes taken from the focus group sessions:

I am not particularly tall but even for me, the seat pitch feels cramped. I cannot imagine how uncomfortable it must be for taller passengers.

The tray table height is fixed and it is not always convenient. Sometimes it is too low and other times it is too high. Adjustability would make a big difference.

Last but not least, the third theme to group together findings from the focus group sessions is the importance of passengers' ability to comfortably do in-flight activities. The participants of all focus group sessions were in good agreement that the ability to do their in-flight activities in a comfortable manner and at ease will affect their overall flying comfort. This highlights the high importance of in-flight activities in shaping comfort experience of aircraft passengers. The following is a quote from a participant of the focus group sessions:

For me, the ability to work or relax during a flight is a make-or-break factor. It is not just about getting from A to B; it is about how comfortable and productive you can be in between.

The importance of the capability to perform their in-flight activities is also emphasized by other participants. It should be noted that the nature of these in-flight activities can be a mix of business and leisure but it is undoubtedly vital for aircraft passengers to be provided with the ability to do them with ease and comfort. Other relatable quotes from the participants of focus group sessions that further highlights such sentiment are as follow:

Being able to work on my laptop is crucial for me. If the setup is uncomfortable, it affects my productivity and the whole flight experience becomes less enjoyable.

I travel for both business and leisure. Regardless of the purpose, being able to comfortably eat, read or work makes a huge difference in how I perceive the flight.

On the other hand, selected voluntary participants had been provided the chance to explore the different settings of seat pitch and seat tray table's height at the aircraft cabin mock-up. They were given the chance to experience sitting inside the cabin and perform their in-flight activities with the normal setting of seat pitch and seat tray table height, and they could change the setting of both cabin parameters to their liking and experienced the differences. It should be mentioned that the participants' real experience in aircraft cabin mock-up has allowed them to acquire great valuable insights in terms of their perception of flying comfort and ability to perform their in-flight activities.

Some of the key findings from the discussion and the responses of the questionnaire are listed as follow:

- In general, the participants expressed mixed opinions on the adequacy of the typical seat pitch and seat tray table height used in current cabin of commercial transport aircraft. While some found it acceptable, several others believed that the situation can be improved to enhance their flying comfort. It should be noted that the different opinions may be affected by their different body anthropometry whereby participants with smaller-built body dimensions may feel that the current settings are already adequate for them compared to those with bigger body size.
- In terms of the common in-flight activities, the participants indicated that they normally engaged in activities such as working on their laptop, reading, writing and also eating throughout the duration of their flight. Their comfort level while doing these activities may vary and this is contributed to the cabin arrangement that leads to inadequate space or sitting posture. Among others, the participants stated their discomfort when using their laptop and also eating.

- The majority of participants is in a good agreement that the setting of the tray table height and seat pitch has a big influence on their comfort while doing their in-flight activities. All of them are in consensus that the current seat pitch used is often inadequate and they strongly expressed the need for more legroom to enhance their comfort. In the meantime, the participants also agreed that the height of the seat tray table dictates their sitting posture during their in-flight activities and the current fixed height may not be suitable for all of their activities.
- After experiencing the adjustable seat tray table height feature in the aircraft cabin mock-up, the participants seem to like such idea very much as it helps to improve their comfort level and enable them to do their activities with ease. They also suggested better seat ergonomics and more legroom as among the improvements they like to see for better flying comfort.

On the whole, the participants seem to agree that the currently used seat pitch and seat tray table's height might not be ideal for all passengers and even for the same person, he/she might need different settings when doing different types of in-flight activities. Thus improvement is required to ensure that aircraft passengers are given the appropriate chance to have good flight comfort and flying experience.

Using the findings from the different data collection approaches as presented previously, the data triangulation is done to derive a solid conclusion. Table 8 highlights the comparison between the findings from the three different approaches based on the essential themes to this study. It can be noted that there is strong indication that the current aircraft cabin arrangement might be inadequate to support the in-flight activities for many passengers. About 30% of the survey respondents indicated that they felt discomfort while doing their in-flight activities.

Table 8 Comparative analysis for different data collection approaches

Theme of Findings	Derived Conclusion from Collected Data	
	Mode	Findings
Current Comfort for Passengers' In-Flight Activities	Online Survey	About 30% of the respondents disagreed that it is comfortable to do their in-flight activities in current aircraft cabin.
	Focus Group	The participants strongly indicated that current in-flight activities are not easy and comfortable to do.
	Discussion at Cabin Mock-Up	The participants expressed some discomfort in doing certain in-flight activities in the current aircraft cabin.
Significance of Seat Pitch and Tray Table Height to In-Flight Activities	Online Survey	22.2% and 49.8% of the respondents indicated that they experienced or seen the difficulties to do in-flight activities due to small legroom and improper seat tray table height, respectively.
	Focus Group	The participants agreed that improper seat pitch and height of seat tray table contribute to aircraft passengers' comfort in doing their common in-flight activities.
	Discussion at Cabin Mock-Up	Majority of participants agreed that the setting of the tray table height and seat pitch influences their comfort while doing their in-flight activities.
Significance of In-Flight Activities to Overall Passengers' Cabin Comfort	Online Survey	About 86% of the respondents agreed that their ability to perform their common in-flight activities is important for having a good flying comfort.
	Focus Group	Consensus among participants is that the ability to do in-flight activities in comfortable manner and at ease will affect their overall flying comfort.
	Discussion at Cabin Mock-Up	The participants indicated that their flying comfort is also affected if they are unable to comfortably do their in-flight activities with ease.

On the other hand, the participants from focus group sessions strongly expressed their difficulties in doing their in-flight activities in current aircraft cabin while participants of group discussion at the cabin mock-up have also raised similar issues. The limited available legroom due to small seat pitch and unsuitable seat tray table's height have been quoted among the main factors that lead to discomfort among aircraft passengers in conducting their in-flight activities. This can be taken to highlight the importance of these two cabin design factors in enabling the comfort and ease for the passengers in their activities at their seat during flight. Last but not least, the impact of the ability to comfortably and easily perform in-flight activities to the overall perception of flight comfort has been strongly indicated in findings from all three data collection methods. Majority of participants in focus group

sessions and group discussion at the aircraft cabin mock-up have indicated this, which is further supported by close to 86% of the survey respondents who indicated the same sentiment.

Furthermore, subsequent to this comparative analysis, the resultant triangulation of these findings is presented in Table 9. On the whole, it can be concluded that both seat pitch and seat tray table's height have influential effects on aircraft passengers' comfort during their in-flight activities.

Table 9 Triangulation results from the collected data

Theme of Findings	Conclusion from Data Triangulation
Current Comfort for Passengers' In-Flight Activities	The passengers' comfort while performing their in-flight activities can be improved and the current aircraft cabin may cause discomfort for many passengers in their activities.
Significance of Seat Pitch and Tray Table Height to In-Flight Activities	Seat pitch and seat tray table height have significant impact in enabling the aircraft passengers to comfortably perform their in-flight activities with ease.
Significance of In-Flight Activities to Overall Passengers' Cabin Comfort	It is essential for the aircraft passengers to be able to do their in-flight activities with proper comfort and ease in order for them to have an overall positive flying comfort experience.

IV. CONCLUSIONS

Flight comfort is one of the major considered factors by aircraft passengers in choosing among available flight services. From the viewpoint of the passengers, a good and comfortable flying experience can make them inclined to repeat the services of the same airlines. There seems to be a lack of studies on assessing flight comfort by considering passengers' in-flight activities, which is a crucial gap that has to be addressed for better and more holistic provision of cabin comfort. It can be observed that the types of in-flight activities that aircraft passengers usually do mostly involve the use of the seat tray table. In this case, proper height of the seat tray table can be a significant factor to ease passengers to do these in-flight activities and increase their comfort level. Moreover, the available legroom based on the setting of the seat pitch will also influence the ease and comfort of aircraft passengers in performing their in-flight activities. To establish the significance of seat pitch and seat tray table height for the comfort of passengers' in-flight activities, three different data collection methods are conducted, which are online survey, focus group and group discussion at aircraft cabin mock-up, and collected data is then triangulated to arrive at a cohesive conclusion.

All in all, results of data triangulation have indicated that the current aircraft cabin is not comfortable for all of the passengers, particularly for them to do the common in-flight activities. The capability to comfortably and easily perform in-flight activities has been noted as essential for aircraft passengers and this affects their overall perception of their flying comfort. Seat pitch and height of seat tray table have been cited as influential factors that can affect the comfort and ease of passengers during their in-flight activities. Improper seat pitch setting leads to inadequate space and legroom at the passengers' seat while the current fixed height of the seat tray table is deemed inappropriate to cater for the different in-flight activities since it causes inappropriate sitting postures of passengers while using it. Both of these cabin factors need to be properly studied and analyzed to come to their optimal settings.

ACKNOWLEDGMENTS

The authors acknowledge that this research has been funded by Ministry of Higher Education Malaysia through their Fundamental Research Grants Scheme (FRGS) with the project number: FRGS/1/2018/TK09/UPM/2/1 and the vot number: 5540074.

REFERENCES

[1] Murugan N, "Influence of socio demographic factors in the choice of airline between Air Asia and Malaysia Airlines," Proceeding of ASEAN Tourism Research Conference, 2017.

[2] Romli FI, Asmadi AN, Dasuki N, "Ergonomics study of vertical seat design for standing cabin concept in commercial transport aircraft," *International Review of Aerospace Engineering*, Vol. 8, No. 3, 2015, pp. 101-106. https://doi.org/10.15866/irease.v8i3.6246

[3] Nithiyanandam N, Sivathanupillai S, Rajendran S, Jayasankar S, Muthusamy S, "Impact of low cost airlines on upper class rail transport for long-haul travel in India," *International Journal for Traffic and Transport Engineering*, Vol. 10, No. 1, 2020, pp. 61-68. http://dx.doi.org/10.7708/ijtte.2020.10(1).06

[4] Rajaguru R, "Role of value for money and service quality on behavioural intention: A study of full service and low cost airlines," *Journal of Air Transport Management*, Vol. 53, 2016, pp. 114-122. https://doi.org/10.1016/j.jairtraman.2016.02.008

[5] Balcombe K, Fraser I, Harris L, "Consumer willingness to pay for in-flight service and comfort levels: A choice experiment," *Journal of Air Transport Management*, Vol. 15, No. 5, 2009, pp. 221-226. https://doi.org/10.1016/j.jairtraman.2008.12.005

[6] Dumur E, Barnard Y, Boy G, "Designing for comfort," Human Factors in Design, D. de Waard, K. A. Brookhuis, C. M. Weikert, Eds., Maastricht, the Netherlands, Shaker Publishing, 2004, pp. 111-127.
[7] Ergun O, Capuk S, "The effects of perceived service quality for customer loyalty in airlines," Proceeding of International Scientific Conference on Economic and Social Development, 2016.
[8] Hamil MHF, Romli FI, Shafiq Reincastle MSR, "Effects of seat tray table height and body anthropometry dimensions on passengers' in-flight comfort," *International Journal on Engineering Applications*, Vol. 11, No. 3, 2023. https://doi.org/10.15866/irea.v11i3.22685
[9] Walia S, Sharma D, Mathur A, "The impact of service quality on passenger satisfaction and loyalty in the Indian aviation industry," *International Journal of Hospitality and Tourism Systems*, Vol. 14, No. 2, 2021, pp. 136-143.
[10] Habibillah NHA, Ismail NH, Romli FI, "Influence of seat pitch and body anthropometry parameters on aircraft passengers' seating comfort," *Journal of Aeronautics, Astronautics and Aviation*, Vol. 54, No. 3, 2022, pp. 241-250. https://doi.org/10.6125/JoAAA.202209_54(3).01
[11] Helander MG, Zhang L, "Field studies of comfort and discomfort in sitting," *Ergonomics*, Vol. 40, No. 9, 1997, pp. 895-915. https://doi.org/10.1080/001401397187739
[12] Vink P, Brauer K, Aircraft Interior Comfort and Design, Boca Raton, Florida, CRC Press, 2011.
[13] De Looze MP, Kuijt-Evers LFM, Van Dieen J, "Sitting comfort and discomfort and the relationships with objective measures," *Ergonomics*, Vol. 46, 2003, pp. 985–997. https://doi.org/10.1080/0014013031000121977
[14] Ahmadpour N., Robert JM, Lindgaard G, "Aircraft passenger comfort experience: Underlying factors and differentiation from discomfort," *Applied Ergonomics*, Vol. 52, 2016, pp. 301-308. https://doi.org/10.1016/j.apergo.2015.07.029
[15] Bouwens J, Tsay WJJ, Vink P, "The high and low comfort peaks in passengers' flight," *Work*, Vol. 58, No. 4, 2017, pp. 579-584. https://doi.org/10.3233/WOR-172637
[16] Ahmadpour N, Lindgaard G, Robert JM, Pownall B, "The thematic structure of passenger comfort experience and its relationship to the context features in the aircraft cabin," *Ergonomics*, Vol. 57, No. 6, 2014, pp. 801-815. https://doi.org/10.1080/00140139.2014.899632
[17] Vink P, Van Mastrigt S, "The aircraft interior comfort experience of 10,032 passengers," Proceeding of Annual Meeting of Human Factors and Ergonomics Society, 2011.
[18] Cascioli V, Heusch AI, McCarthy PW, "Does prolonged sitting with limited legroom affect the flexibility of a healthy subject and their perception of discomfort?" *International Journal of Industrial Ergonomics*, Vol. 41, No. 5, 2011, pp. 471-480. https://doi.org/10.1016/j.ergon.2011.06.003
[19] Wang L, Yu S, Chen D, Li W, Chu J, Fan H, "Effects of aircraft tray table height and neck posture on passenger comfort: A study of the economy class cabin," *Work*, Vol. 75, No. 1, 2023, pp. 287-302. https://doi.org/10.3233/WOR-220043
[20] Cohen L, Manion L, Morrison K, Research Methods in Education, Milton Park, Oxfordshire, Routledge, 2002.
[21] Noble H, Heale R, "Triangulation in research with examples," *Evidence-based Nursing*, Vol. 22, No. 3, 2019. https://doi.org/10.1136/ebnurs-2019-103145
[22] Paradis E, O'Brien B, Nimmon L, Bandiera G, Martimianakis MA, "Design: Selection of data collection methods," *Journal of Graduate Medical Education*, Vol. 8, No. 2, 2016, pp. 263-264. https://doi.org/10.4300/JGME-D-16-00098.1
[23] Ahmad Shukri S, Romli FI, Wan Badaruddin WTF, Mahmood AS, "Importance of English language in aviation maintenance: A Malaysia case study," *Journal of Aeronautics, Astronautics and Aviation*, Vol. 53, No. 2, 2021, pp. 113-120. https://doi.org/10.6125/JoAAA.202106_53(2).02
[24] Taneja N, "Fatigue in aviation: A survey of the awareness and attitudes of Indian air force pilots," *The International Journal of Aviation Psychology*, Vol. 17, No. 3, 2007, pp. 275-284. https://doi.org/10.1080/10508410701343466
[25] Romli FI, Ariffin NH, "Malaysian public survey on the current carry-on luggage handling onboard commercial transport aircraft," *International Journal of Engineering & Technology*, Vol. 7, 2018, pp. 14-17. https://doi.org/10.14419/ijet.v7i4.13.21321
[26] Hsu YL, "A study on the comprehensibility of airline safety card pictorials and pictograms," *Journal of Aeronautics, Astronautics and Aviation*, Vol. 42, No. 1, 2010, pp. 31-37. https://doi.org/10.6125/JoAAA.201003_42(1).04
[27] Krejcie RV, Morgan DW, "Determining sample size for research activities," *Educational and Psychological Measurement*, Vol. 30, No. 3, 1970, pp. 607-610. https://doi.org/10.1177/001316447003000308
[28] Sim J, "Collecting and analysing qualitative data: issues raised by the focus group," *Journal of Advanced Nursing*, Vol. 28, No. 2, 1998, pp. 345-352. https://doi.org/10.1046/j.1365-2648.1998.00692.x
[29] Stewart N, Harris D, "Passenger attitudes to flying on a single-pilot commercial aircraft," *Aviation Psychology and Applied Human Factors*, Vol. 9, No. 2, 2019, pp. 77-85. https://psycnet.apa.org/doi/10.1027/2192-0923/a000164
[30] Williamson JR, McGill M, Outram K, "Planevr: Social acceptability of virtual reality for aeroplane passengers," Proceeding of the CHI Conference on Human Factors in Computing Systems, 2019.
[31] Krueger R, Casey M, Focus Groups: A Practical Guide for Applied Research, Thousand Oaks,

California, Sage Publications, 2000.
[32] Hennink MM, Focus Group Discussions, Oxford, Oxford University Press, 2013.
[33] Cossrow NH, Jeffery RW, McGuire MT, "Understanding weight stigmatization: A focus group study," *Journal of Nutrition Education*, Vol. 33, No. 4, 2001, pp. 208-214. https://doi.org/10.1016/S1499-4046(06)60033-X
[34] Stemler S, "An overview of content analysis," *Practical Assessment, Research, and Evaluation*, Vol. 7, No. 17, 2001. https://doi.org/10.7275/z6fm-2e34
[35] Bans-Akutey A, Tiimub BM, "Triangulation in research," *Academia Letter*s, Vol. 2, 2021, 3392. https://doi.org/10.20935/AL3392
[36] Sands RG, Roer-Strier D, "Using data triangulation of mother and daughter interviews to enhance research about families," *Qualitative Social Work*, Vol. 5, No. 2, 2006, pp. 237-260. https://doi.org/10.1177/1473325006064260
[37] Perlesz A, Lindsay J, "Methodological triangulation in researching families: making sense of dissonant data," *International Journal of Social Research Methodology*, Vol. 6, No. 1, 2003. https://doi.org/10.1080/13645570305056
[38] Mohd Suki N, "Passenger satisfaction with airline service quality in Malaysia: a structural equation modelling approach," *Research in Transportation Business and Management*, Vol. 10, 2014, pp. 26-32. https://doi.org/10.1016/j.rtbm.2014.04.001
[39] Shin KM, Hon YK, Rajendran SD, "A study on passengers perspective towards in-flight food delivery and waste collection services," *E3S Web of Conferences*, Vol. 136, 2019, 04091. https://doi.org/10.1051/e3sconf/201913604091
[40] Ishak FD, Romli FI, Abdul Rahman K, "Public survey on new in-flight food delivery and waste collection system," *Journal of Mechanical Engineering*, Vol. SI5, No. 4, 2018, pp. 142-152. https://ir.uitm.edu.my/id/eprint/40117