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Transportation Mode Selection of UTHM Pagoh Students: an Analysis using Analytic Hierarchy Process

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Abstract

This study examines the transportation preferences and challenges students face at Universiti Tun Hussein Onn Malaysia (UTHM) Pagoh Campus, focusing on three academic faculties. Data were collected from 359 respondents through a survey to achieve three objectives: identifying preferred transportation modes, analysing barriers influencing these preferences, and evaluating decision factors using the Analytic Hierarchy Process (AHP). Findings reveal that private vehicles, including carpooling, are the most preferred mode of transportation, valued for convenience and efficiency. Buses are ranked second, recognized for their cost-effectiveness while walking and cycling are the least favoured due to safety concerns and infrastructure limitations. Safety emerged as the most critical barrier, followed by convenience, weather, travel time, and cost. The AHP analysis highlights the dominance of private vehicles for convenience and buses for affordability. These results underline the need for improved transportation systems, including enhanced parking facilities, more frequent bus services, and safer infrastructure for active transportation. The university can be better accommodating student mobility by addressing these challenges while promoting sustainability.

1. Introduction

Transportation mode preferences among students can be analysed from two perspectives: school and university students. In schools, travel choices are significantly influenced by socioeconomic status, urban characteristics, and distance to school. Higher-income households are more likely to use private cars, while lower-income families rely on public or non-motorised transport such as walking or cycling [1]. Urban built environments, including population density and the availability of walking and cycling facilities, further shape travel mode choices [2]. Similarly, university students' decisions are influenced by travel time, cost, convenience, safety, and environmental awareness. The built environment and infrastructural quality play a crucial role, with features such as adequate sidewalks and cycle tracks promoting active transportation [3].

For university students, the increasing reliance on motorised transport has led to several challenges, including higher traffic congestion, increased emissions, and reduced use of public and active transport modes. Studies highlight that students prefer public transportation or non-motorized options when these modes offer affordability, safety, and comfort [4] [5]. However, income, accessibility, and cultural norms often dictate their choices, in diverse contexts such as Medan City and Aizawl City [6] [7].

To address these challenges, researchers often rely on survey-based methods to analyse travel behaviour. Surveys provide critical data on preferences, perceptions, and constraints, enabling policymakers to develop informed strategies for improving transportation systems. Traditional surveys, combined with modern technologies such as GPS and Geographic Information Systems (GIS), allow for real-time monitoring of travel patterns and provide deeper insights into modal shifts and accessibility [8]. However, challenges such as response bias and sampling limitations highlight the need for mixed-method approaches to ensure representative and reliable data [9].

The primary aim of this study is to explore and analyse the transportation mode preferences of UTHM students, utilising both descriptive statistics and the Analytic Hierarchy Process (AHP). The specific objectives of this research are to determine the preferred modes of transportation among UTHM students using descriptive statistics, to identify the weightage of barriers influencing transportation choices using a pairwise comparison matrix and, to analyse students' transportation preferences based on influencing factors using the AHP method.

2. Materials and Methods

2.1 Data Description

The target population for this study comprises students from Universiti Tun Hussein Onn Malaysia (UTHM) at the Pagoh Campus. This population was chosen due to the diverse range of transportation modes students commute to campus for face-to-face classes. According to the UTHM website [10], there are currently 5,452 active students enrolled at the Pagoh Campus. To ensure broad participation, the survey was distributed to all students via the Google Forms platform, enabling convenient access and efficient data collection

The survey for this study was structured into four sections to address the research objectives systematically. The first section, Part A, collects demographic information about the respondents. Part B is aligned with the first objective, which investigates the transportation modes students prefer when commuting to campus. Part C addresses the second objective by identifying and evaluating the barriers influencing students' transportation choices. A pairwise comparison matrix will be applied to determine the relative importance of these barriers. Lastly, Part D relates to the third objective, focusing on students' transportation mode preferences based on the factors influencing their choices. The Analytic Hierarchy Process (AHP) will be employed to analyse and prioritise these preferences.

2.2 Sampling Method

Non-probability sampling methods, such as Convenience Sampling, are often employed when resources or accessibility are limited. These methods are more cost-effective but may introduce biases and limit the generalizability of findings [11]. Convenience Sampling, for example, selects participants who are easily accessible, which can lead to skewed results if the sample is not representative of the broader population. Despite these limitations, non-probability methods are practical for studying specific behaviours or hard-to-reach groups, especially in transportation research. Overall, selecting the right sampling method depends on the research objectives and the balance between accuracy and feasibility, with probability sampling offering more generalisable results. In contrast, exploratory studies often use non-probability methods [9].

2.3 Sample Size Determination

Sample size determination is critical in research, especially in health and biomedical studies, as it directly impacts the study's validity and reliability. It involves various considerations such as statistical analysis, precision levels, study power, confidence levels, and effect size, all of which are essential for making accurate inferences about a population from a sample [12]. For this study, based on [13] the sample size will be calculated by using equation (1) where from the calculation the sample size is 359 respondents.

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$$n = \frac{\frac{z^2 p(1-p)}{e^2}}{1+\frac{z^2 p(1-p)}{Ne^2}} = \frac{\frac{1.96^2(0.5)(1-0.5)}{0.05^2}}{1+\frac{1.96^2(0.5)(1-0.5)}{5452(0.05)^2}} = 358.87 \approx 359 \quad (1)$$

where, n is sample size, N is population size, Z is critical Value of the desired level of confidence, e is the margin of error/ desired level of precision and p is the maximum probability of variation in the distribution.

2.4 Descriptive Analysis

Descriptive analysis involves summarising and exploring data to identify trends, patterns, and relationships. It includes examining values for errors, visualising data through plots, calculating measures of frequency, central tendency, and variability, and utilising statistical models to find patterns and trends. This type of analysis is crucial in various fields, such as e-commerce, where it helps in making strategic decisions, enhancing organisational performance, and improving customer satisfaction [14]. In the context of car accidents in Washington, D.C., descriptive analysis was used to identify common causes of accidents and locations with high accident rates, aiding in developing strategies to reduce accidents [15].

Part A and Part B of the questionnaire are demographic profiles and the first objective is to determine the modes of transportation that students prefer. The measure of frequency will be used to calculate the frequency and percentage of gender, age, faculty, year of study, educational level, and modes of transportation. The data was analysed using simple graphics analysis using Microsoft Excel.

2.5 Analytic Hierarchy Process

The AHP is an analytic method for solving multistage decision problems; in this technique, decision problems are broken down into simpler sub-problems and arranged hierarchically. The process starts with the establishment of goal. This will create a hierarchy where the goal is at the top and then there are criteria and sub-criteria layers below the goal, and on the bottom, there are alternatives. In this approach, each criterion and sub-criterion is defined and compared against the other in turn to establish a rank order or priority, which will facilitate the decision-making process of a multi-dimensional problem by enabling the decision-makers to easily make trades between the various methods taking into consideration certain parameters such as cost, efficiency, scalability among others. Such comparisons are expressed in terms of the degree of importance on a ratio rank order scale, and the scale consistency is subjected to some tests for reliability [16]. The priorities hierarchy of three criteria (K1, K2, K3) for three alternative beers and relevant decision-making based on the AHP method developed by [17] is represented in Fig. 1.

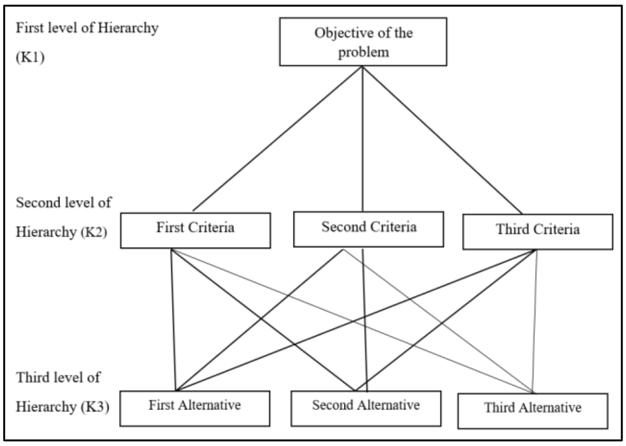

Fig. 1 Hierarchy of Analytical Hierarchy Process [17]

To avoid issues caused by excessively large or small values in the comparison matrix, the values are normalised using equation (2). This involves dividing each value in a column by the sum of all the values in that column. The resulting values form the normalised pairwise comparison matrix.

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad (2)$$

The elements of the eigenvector corresponding to the maximum eigenvalue, taking the average of the row elements of the normalised matrix is calculated as in equation (3).

$$w_i = \frac{\sum_{i=1}^{n} b_{ij}}{n} \tag{3}$$

The consistency of the matrix is assessed using the Consistency Ratio (CR). The CR is calculated as the ratio of the Consistency Index (CI) to the Random Consistency Index (RCI) for matrices of the same order. The consistency index can be calculated by using equation (4). Meanwhile, the consistency ratio is determined based on equation (5).

$$CI = \frac{(\lambda_{\max} - n)}{(n-1)} \tag{4}$$

$$CR = \frac{CI}{RI} \tag{5}$$

Regarding [22], RI clarifies that the CI of a matrix of comparisons is given by equation (5). The consistency ratio (CR) is obtained by comparing the CI with the appropriate one of the following numbers, each of which is an average RI. If CR is not less than 0.10, study the problem and revise the judgments. This determined the values of the RI based on the number of evaluated criteria, as reflected in Table 2.

Table 1 *The values of the random index (RI)*

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The Final Priority Vector (FPV) w(i,j) calculated in the AHP method is defined as:

$$w_{ij} = A_{ij} * C_{ij} \tag{6}$$

w_{ij} : Final Priority Vector (FPV)

A_{ij} : Matrix of normalised priority vectors of the alternatives

C_{ij} : Criteria eigenvector

3. Results and Discussion

3.1 Demography Analysis

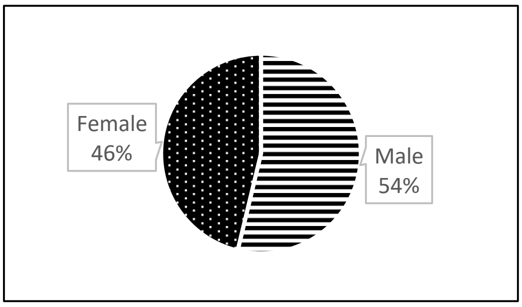

Fig. 2 The distribution of respondent by gender

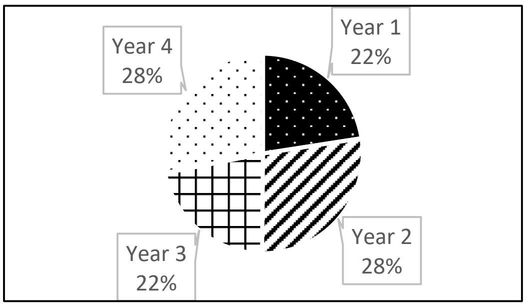

Fig. 3 The distribution of respondent by year of study

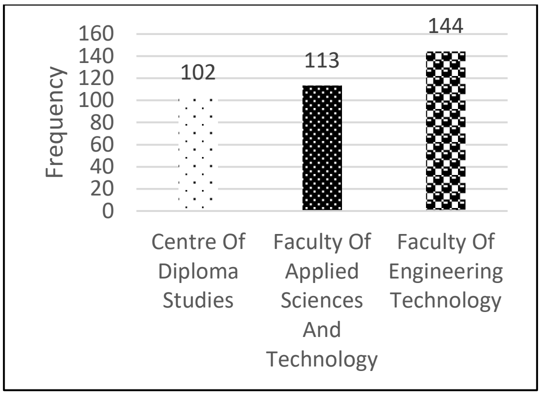

Fig. 4 The distribution of respondent by faculty

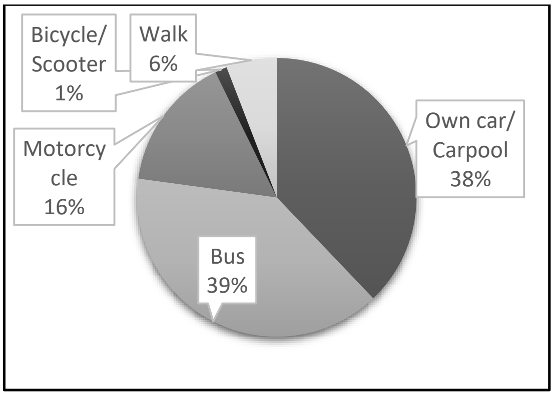

Fig. 5 The frequency of transportation mode distribution

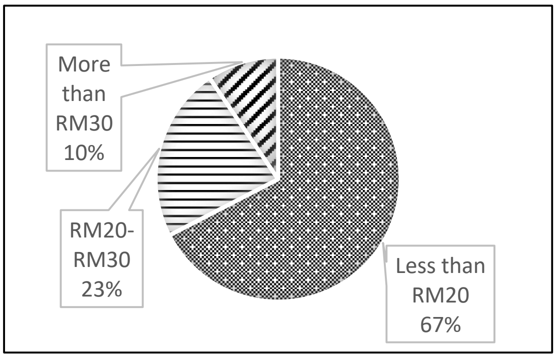

Fig. 6 Distribution of monthly transportation expenses

3.2 The Weightage for Barriers that Influence Students' Choice for Modes of Transportation to Campus by Using Pairwise Comparison Matrix Construction of References

Table 2 *Pairwise comparison matrix of criteria*

Criteria	Cost	Weather	Travel Time	Safety	Convenience
Cost	1	0.573414081	0.708994065	0.51815876	0.551404479
Weather	1.743940431	1	0.989587726	0.790648591	0.924875025
Travel Time	1.410449042	1.01052183	1	0.69021018	0.961335721
Safety	1.929910441	1.264784395	1.448834035	1	1.147071474
Convenience	1.813550739	1.081227163	1.040219331	0.871785257	1

A Pairwise comparison matrix normalised according to equation (2) was obtained as:

Table 3 *Normalized pairwise comparison matrix of criteria*

Criteria	Cost	Weather	Travel Time	Safety	Convenience
Cost	0.126616727	0.116312412	0.136669994	0.133863384	0.120270918
Weather	0.22081203	0.202841918	0.190758929	0.20425959	0.201731347
Travel Time	0.178586441	0.204976186	0.192766062	0.178311895	0.20968406
Safety	0.244358943	0.256551293	0.279286031	0.258344342	0.250196262
Convenience	0.229625859	0.219318191	0.200518984	0.225220789	0.218117413

Table 4 *Weightage for barriers that in influence students' choice for modes of transportation to campus*

No	Criteria	Criteria Weight	Ratio Vector
1.	Cost	0.1267467 **(5)**	5.006669
2.	Weather	0.2040808 **(3)**	5.007354
3.	Travel Time	0.1928649 **(4)**	5.008025
4.	Safety	0.2577474 **(1)**	5.007263
5.	Convenience	0.2185602 **(2)**	5.007323

Table 4 presents the weightage of various barriers that influence students' choice of transportation modes to campus. Among the factors considered, safety holds the highest weight at 0.2577474, indicating its critical importance in transportation decisions. This is followed by convenience (0.2185602), weather (0.2040808), and travel time (0.1928649), which also significantly impact students' choices. The cost factor, with a weight of 0.1267467, is the least influential barrier in comparison. This table highlights each barrier's varying degrees of influence on students' transportation preferences.

3.3 Factor That Influences Students' Choice of Transportation Mode by Using Analytical Hierarchy Process (AHP)

Table 5 *Weight of transportation alternatives based on cost*

	Own Car/ Carpool	Bus	Motorcycle	Bicycle/ Scooter	Walk
Alternative Weight	0.1610442 **(5)**	0.2928314 **(1)**	0.1820248 **(3)**	0.1728317 **(4)**	0.1912679 **(2)**
Eigenvalue			5.014973		
Consistency Index			0.003743152		
Consistency Ratio			0.0033421		

Table 5 evaluates the transportation alternatives based on cost. The analysis reveals that the "Bus" is the most cost-effective option, with the highest weight of 0.2928314. This is followed by "Walk", which ranks second with a weight of 0.1912679, and "Motorcycle", which comes in third at 0.1820248. "Bicycle/Scooter" ranks fourth, with a slightly lower weight of 0.1728317, while "Own Car/Carpool" is perceived as the least cost-effective option, with the lowest weight of 0.1610442. The eigenvalue is 5.014973, and the consistency ratio is 0.0037, confirming that the comparisons are consistent and reliable.

Table 6 *Weight of transportation alternatives based on weather*

	Own Car/ Carpool	Bus	Motorcycle	Bicycle/ Scooter	Walk
Alternative Weight	0.39745529 **(1)**	0.27134416 **(2)**	0.14489093 **(3)**	0.11644418 **(4)**	0.06986543 **(5)**
Eigenvalue			5.324067		
Consistency Index			0.08101669		
Consistency Ratio			0.07233633		

Table 6 assesses transportation alternatives based on weather conditions. The results show that "Own Car/Carpool" is the most preferred option, with the highest weight of 0.39745529, highlighting its reliability in varying weather. This is followed by the "Bus", which ranks second with a weight of 0.27134416, and the "Motorcycle", which takes third place with a weight of 0.14489093. "Bicycle/Scooter" is ranked fourth, with a lower weight of 0.11644418, while "Walk" is the least favourable alternative under this criterion, with the lowest weight of 0.06986543. The eigenvalue is 5.324067, and the consistency ratio is 0.07233633, confirming that the evaluations are consistent and reliable.

Table 7 *Weight of transportation alternatives based on safety*

	Own Car/ Carpool	Bus	Motorcycle	Bicycle/ Scooter	Walk
Alternative Weight	0.3879062 **(1)**	0.2588297 **(2)**	0.1398879 **(3)**	0.1072634 **(4)**	0.1061128 **(5)**
Eigenvalue			5.071404		
Consistency Index			0.01785109		
Consistency Ratio			0.01593847		

Table 7 evaluates transportation alternatives based on their safety. The results indicate that using "Own Car/Carpool" is perceived as the safest option, with the highest weight of 0.3879062. This is followed by "Bus", which ranks second with a weight of 0.2588297, reflecting a reasonable level of safety. "Motorcycle" comes in third with a weight of 0.1398879, indicating moderate safety concerns. "Bicycle/Scooter" is ranked fourth, scoring slightly lower at 0.1072634, while "Walk" is perceived as the least safe alternative, with the lowest weight of 0.1061128. The analysis is validated by a consistency index of 0.01785109 and a consistency ratio of 0.01593847, confirming that the judgments are consistent.

Table 8 *Weight of transportation alternatives based on travel time*

	Own Car/ Carpool	Bus	Motorcycle	Bicycle/ Scooter	Walk
Alternative Weight	0.33586527 **(1)**	0.14098985 **(4)**	0.27681532 **(2)**	0.16895217 **(3)**	0.07737738 **(5)**
Eigenvalue			5.340164		
Consistency Index			0.085041		
Consistency Ratio			0.07592947		

Table 8 assesses the transportation options based on their travel time. Once again, "Own Car/Carpool" is the most favourable choice, with the highest weight of 0.33586527, emphasising its efficiency. "Motorcycle" ranks second, with a weight of 0.27681532, reflecting their relatively fast travel times. "Bicycle/ Scooter" follows in third place, scoring 0.16895217, offering a balance of efficiency. "Bus" ranks fourth with a weight of 0.14098985, suggesting slower travel times than the top options. "Walk", unsurprisingly, is the least efficient mode of transport, weighing 0.07737738. The consistency index of 0.085041 and ratio of 0.07592947 confirm that the evaluation is reliable.

Table 9 *Weight of transportation alternatives based on convenience*

	Own Car/ Carpool	Bus	Motorcycle	Bicycle/ Scooter	Walk
Alternative Weight	0.38388059 **(1)**	0.18452814 **(3)**	0.21421204 **(2)**	0.12845329 **(4)**	0.08892595 **(5)**
Eigenvalue			5.07374		
Consistency Index			0.01843497		
Consistency Ratio			0.01645979		

Table 9 evaluates transportation alternatives based on convenience. The results reveal that "Own Car/Carpool" is the most convenient option, with the highest weight of 0.38388059, highlighting its overall ease of use. "Motorcycle" ranks second, with a weight of 0.21421204, suggesting they are also relatively convenient. The "Bus" ranks third, scoring 0.18452814, followed by "Bicycle/Scooter" at 0.12845329. "Walk" is the least convenient option, with the lowest weight of 0.08892595. The eigenvalue is 5.0780, and the consistency ratio is 0.01645979, indicating consistency in the comparisons.

Table 10 *Final scores and rankings for transportation alternatives*

	Own Car/ Carpool	Bus	Motorcycle	Bicycle/ Scooter	Walk
Final score	0.3501843	0.2267267	0.1889024	0.1339765	0.1002101
Rank	1	2	3	4	5

Table 10 presents the final scores and rankings for transportation alternatives based on the combined evaluation across all criteria. The final scores are calculated by multiplying the normalised criteria weights with the weight of the alternative using equation (6). The results indicate that owning a car or carpooling is the top-ranked option, with the highest final score of 0.3502, reflecting its overall superiority. The bus ranks second, with a score of 0.2267, followed by motorcycles, which take third place with a score of 0.1889. Bicycles or scooters are ranked fourth, scoring 0.1338, while walking is the least preferred alternative, with the lowest score of 0.1002101. These rankings reflect a comprehensive evaluation of all factors considered.

4. Conclusion

This study successfully achieved its objectives of exploring students' transportation preferences, identifying the barriers influencing these choices, and examining how various factors shape these preferences. Findings revealed that buses are the most popular mode of transportation among students, followed closely by car or carpooling, with affordability and convenience playing significant roles. Walking and cycling were the least preferred modes due to safety concerns and insufficient infrastructure. The analysis also highlighted safety as the most influential barrier affecting students' choices, followed by convenience, weather, and travel time, while cost was considered less critical. These insights indicate that students value secure and accessible transportation options above all. Additionally, the AHP identified buses as the most cost-effective option, while private vehicles like cars and motorcycles were favoured for their efficiency and convenience.

Based on these findings, several recommendations are proposed to improve the transportation system at UTHM. These include increasing the frequency of bus services, expanding parking spaces, enhancing cycling infrastructure, establishing ridesharing programs, and improving pedestrian pathways. However, it has some limitations. Data was collected through self-reported surveys, which may be subject to biases. The study's scope was limited to a single institution, limiting the generalizability of results. The lack of qualitative methods may have limited the depth of insights. Additionally, external factors during data collection were not fully accounted for. Despite these limitations, the findings comprehensively understand students' transportation behaviour and the factors shaping their choices. These insights offer valuable guidance for improving transportation systems and effectively supporting students' mobility needs.

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Conflict of Interest

The Authors declare that there is no conflict of interest regarding the paper's publication.

Author Contribution

The authors confirm their contribution to the paper as follows: ***study conception and design:*** *Nur Fatin Nadiah Mohd.Rashidi, Norziha Che Him;* ***data collection:*** *Nur Fatin Nadiah Mohd.Rashidi;* ***analysis and interpretation of results:*** *Nur Fatin Nadiah Mohd.Rashidi, Norziha Che Him;* ***draft manuscript preparation:*** *Nur Fatin Nadiah Mohd.Rashidi, Norziha Che Him, Noor Azliza Abd. Latif, Yusliandy Yusof. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Li, S., & Zhao, P. (2015). The determinants of commuting mode choice among school children in Beijing. Journal of Transport Geography, 46, 112–121. https://doi.org/10.1016/j.jtrangeo.2015.06.010

[2] Broberg, A., & Sarjala, S. (2015). School travel mode choice and the characteristics of the urban built environment: The case of Helsinki, Finland. Transport Policy, 37, 1–10. https://doi.org/10.1016/j.tranpol.2014.10.011

[3] Lee, C., Zhu, X., Yoon, J., & Varni, J. W. (2013). Beyond distance: Children's school travel mode choice. Annals of Behavioral Medicine, 45(SUPPL.1). https://doi.org/10.1007/s12160-012-9432-z.

[4] Nguyen-Phuoc, D. Q., Amoh-Gyimah, R., Tran, A. T. P., & Phan, C. T. (2018). Mode choice among university students to school in Danang, Vietnam. Travel Behaviour and Society, 13(June 2016), 1–10. https://doi.org/10.1016/j.tbs.2018.05.003

[5] Oubahman, L., Duleba, S., & Esztergár-Kiss, D. (2024). Analyzing university students' mode choice preferences by using a hybrid AHP group-PROMETHEE model: evidence from Budapest city. European Transport Research Review, 16(1). https://doi.org/10.1186/s12544-023-00626-w

[6] Oubahman, L., Duleba, S., & Esztergár-Kiss, D. (2024). Analyzing university students' mode choice preferences by using a hybrid AHP group-PROMETHEE model: evidence from Budapest city. European Transport Research Review, 16(1). https://doi.org/10.1186/s12544-023-00626-w

[7] Sabrina, L., Rakhmawati, F., & Husein, I. (2022). Implementation Of Decision Selection In The Selection Of Transportation Modes Among Workers And Students In Medan City Using Ahp And Electric Methods. ZERO: Jurnal Sains, Matematika Dan Terapan, 6(1), 24. https://doi.org/10.30829/zero.v6i1.12454

[8] Chen, C., & Ravulaparthy, S. (2014). Smartphone-based travel survey methods: A review and lessons learned. Transportation Research Part C: Emerging Technologies, 46, 74–88.

[9] Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). Internet, phone, mail, and mixed-mode surveys: The tailored design method (4th ed.). Wiley.

[10] UTHM. (2024, May). Universiti Tun Hussein Onn Malaysia. https://www.uthm.edu.my/en/join-us/admission

[11] Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. American Journal of Theoretical and Applied Statistics, 5(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

[12] Abebe, H. T. (2022). Determination of Sample Size and Errors. Promoting Statistical Practice and Collaboration in Developing Countries, 321–338. https://doi.org/10.1201/9781003261148-27

[13] Adhikari, & Prasad, G. (2021). Calculating the Sample Size in Quantitative Studies. Scholars' Journal, 4(December), 14–29. https://doi.org/10.3126/scholars.v4i1.42458

[14] De Jesus, N. M., & Buenas, L. J. E. (2023). Descriptive Analytics and Interactive Visualizations for Performance Monitoring of Extension Services Programs, Projects, and Activities. International Journal of Advanced Computer Science and Applications, 14(1), 660–668. https://doi.org/10.14569/IJACSA.2023.0140173

[15] Altukhi, Z. M., & Aljohani, N. F. (2023). Using Descriptive Analysis to Find Patterns and Trends: A Case of Car Accidents in Washington D.C. International Journal of Advanced Computer Science and Applications, 14(5), 257–264. https://doi.org/10.14569/IJACSA.2023.0140527

[16] Velmurugan, R., Selvamuthukumar, S., & Manavalan, R. (2011). Multi criteria decision making to select the suitable method for the preparation of nanoparticles using an analytical hierarchy process. Pharmazie, 66(11), 836–842. https://doi.org/10.1691/ph.2011.1034

[17] Saaty, T. L. (1970). Elements of decision making: An overview of the analytic hierarchy process. McGraw-Hill.

[18] Cheng, S. C., Chen, M. Y., Chang, H. Y., & Chou, T. Z. (2007). Semantic-based facial expression recognition using analytical hierarchy process. Expert Systems with Applications, 33, 86–95.

[19] Kadoić, N., Ređep, N. B., & Divjak, B. (2017). Decision making with the analytic network process. Proceedings of the 14th International Symposium on Operational Research, SOR 2017, 2017-Septe(September 2006), 180–186. https://doi.org/10.1007/0-387-33987-6