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Role of Design Thinking Approach on Sustainable Transport: A Study on Commuters Experience of Public Transport

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KEYWORDS

Design thinking, sustainable transport, efficiency, ideation, prototyping

ABSTRACT

Purpose: Design Thinking approach helps to improve sustainable transport systems by emphasizing the innovation of the design as well as the needs of the user. This approach cultivates creativity and effective collaboration towards better public transport services that are user oriented and beneficial to commuters. The Design Thinking approach to sustainable transport further developed in the next sections.

Understanding that commuter adoption is vital for sustainability, the study applies human centred principles to glean insights into commuters' challenges, opportunities, and perspectives. The research aims to understand commuters' unfulfilled needs through quantitative methods to come to some observations for sustainable urban transportation systems.

1. INTRODUCTION

India has a documented history of ancient transportation systems since the Indus Valley Civilization, with great empires such as the Guptas and Mauryas Guptas constructing roads and postal networks for trade and administration.

Nevertheless it is now suffering from a great challenge owing to too many vehicles on road as well as multiple constructions of residential and commercial complexes everywhere. The transport infrastructure development in Mumbai Metropolitan Region has not been upto the mark with the demand (Shaban, 2023). Statistics showed that in 2020, around 18% of the Indian population depends on public transport with around 30 million passengers commuting on daily basis (Sahu et. Al., 2022). Further, there are reports that forecast a significant growth in the public transport market in the near future. Also, the number of people using public transport in India is expected to reach 1.20 bn by 2029.

Human-centered mobility puts the user directly at the heart of design and decision making (D. Mitchell et al. / Engineering 2 (2016) 33–36). Sometimes solutions are obtained by techniques of ideation like bringing together different stratas and encourage ideas through brainstorming with a goal of improving customer satisfaction. In 2022, BEST had around 3000 plus buses for transport. At present there are around 2800 buses. Review of Literature:

2. REVIEW OF LITERATURE

(Dervilla Mitchell, 2016) The paper discusses the need for a human-centered approach in urban transport systems to address challenges posed by rapid urbanization. It emphasizes the importance of integrating different modes of transport to create efficient, seamless journeys for users. The authors highlight advancements in technology and innovative practices, such as electric buses and real-time information systems, to enhance the transport experience. Additionally, they outline case studies demonstrating successful gradual changes in transport infrastructure. Ultimately, the paper advocates for prioritizing people's needs in designing future transport solutions.

(Jo Kuys 1, 2022) The study investigates the development of a sustainable bus system for Kuala Lumpur, Malaysia, using Human-Centred Design principles. It employs user observations and a questionnaire survey with 102 participants to identify key issues faced by public transport users, such as access and comfort. Findings reveal that a significant number of potential users avoid the bus system due to concerns over frequency and safety. The analysis highlights critical areas for improvement, providing a foundation for enhancing the existing bus services. Overall, the research aims to inform the design of an effective electric bus system tailored to user needs.

(SHNEIDERMAN) The author proposes 15 recommendations for HCAI development, focusing on translating ethical principles into practical guidelines. These recommendations span three levels: reliable systems via software engineering, safety culture through management strategies, and trustworthy certification by external review. The paper emphasizes the importance of diverse expertise and user-centric design to enhance human performance and experience with AI systems. Ultimately, the goal is to create HCAI systems that empower users, foster creativity, and promote responsible social participation

(Yingli Wang) This paper presents a systematic literature review of blockchain technology's application in supply chains. It identifies four key themes: provenance and traceability, supply chain finance, supply chain operations, and integration and security. The review analyzes existing research to understand blockchain's potential benefits and challenges in supply chain management. Key findings highlight blockchain's ability to enhance transparency, security, and efficiency in various supply chain processes. The paper concludes with a research agenda, suggesting future research directions to further explore blockchain's transformative potential in supply chains.

(Sigala1) This paper explores the growing role of customer involvement in sustainable supply chain management within the tourism industry. It proposes a framework for understanding customer involvement in SSCM, encompassing motivating factors, degree of involvement, management strategies, and outcomes. The framework highlights how social media empowers customers to actively participate in and support sustainable practices. Using examples from the tourism sector, the paper demonstrates how customers contribute to sustainability across various supply chain stages. The study emphasizes the importance of integrating customer perspectives and actions to achieve comprehensive and effective SSCM in tourism.

(O. M. Zagurskiy, 2020) The study investigates the optimization of transport processes within supply chains, focusing on minimizing the environmental impact of logistics. It emphasizes the growing importance of green supply chain management due to increasing environmental awareness and regulations. The authors propose a model for consolidated cargo transportation that aims to balance economic and environmental concerns. Key technologies for reducing environmental impact include optimizing transport routes, utilizing local resources, and employing energy-efficient vehicles.

The study in (Madani et al., 2024) is about a systematic review of sustainable supply chain network design. It analyses existing research on incorporating economic, environmental, and social sustainability into supply chain models. The review identifies key trends in optimization approaches and discusses the limitations of current research. A significant focus is on the integration of sustainability factors into the design of supply chain networks. The study highlights the increasing importance of resilience and vulnerability considerations, particularly in light of recent global disruptions. Finally, it suggests future research directions to address existing gaps in the field.

The paper (Mehmood et al., 2024) examines successful supply chain management in transport infrastructure projects. It explores the complex relationships between supply chain roles and project performance, emphasizing the need for nuanced models. The study highlights the practical implications of managing supply chains in TIPs, including improved efficiency, cost savings, and risk mitigation. It also underscores the importance of sustainability, technology integration (especially BIM), and stakeholder collaboration. The research identifies key areas for improvement, such as optimizing resource allocation and promoting environmentally friendly practices. Finally, it advocates for an interdisciplinary approach, merging supply chain management with construction, transportation, technology, and sustainability.

The paper (Wang, 2023) explores future urban public transport service design using the double diamond model. It focuses on a human-centred approach, addressing user needs in the context of evolving technology like autopilot systems. The study emphasizes the importance of community involvement and iterative design processes to create more user-friendly and efficient public transport. Key themes include convenience, consideration, constructiveness, and inclusivity in design interventions. The research aims to improve the quality and availability of public transport, contributing to urban efficiency and sustainability. It envisions future scenarios where physical and digital aspects of transport are intertwined, particularly in the context of autopilot systems.

The paper (Cohen et al., 2017) details a user-centred design approach for developing a mobile transportation app. The study emphasises the importance of understanding user needs and habits in public transport to create effective and user-friendly apps. It employs a mixed-methods approach, combining qualitative and quantitative data collection methods to gather comprehensive insights. The research focuses on discovering user requirements and adapting them to the specific constraints of transportation research. The findings contribute to a better understanding of how to design mobile transportation apps that meet user needs and improve the overall public transport experience.

The paper (Saputro et al., 2024) discusses the development of a mobile app called "Go-Bus" to promote sustainable public transportation, specifically the Trans Banyumas bus system. It uses a design thinking approach, focusing on user needs and incorporating gamification to encourage bus usage. The app aims to address challenges in motivating users to shift from private vehicles to public transport. User satisfaction testing and single ease question evaluations showed positive results, indicating user-friendliness and satisfaction. The study highlights the potential of gamification and design thinking in promoting sustainable transport solutions

3. RESEARCH GAP:

Extensive research and studies have been done on the customer experience and satisfaction with respect to logistics and efficiencies in supply chains. However, the human-centric approach of design thinking remains unexplored as it is a relatively new concept. Hence there is relatively low empirical evidence on direct or indirect relationship of design thinking with efficiency and customer experience. The transportation authorities and policymakers must also focus on improving the financial stability and enhancing the customer's trust in the public transportation system (Sahu et. Al., 2022).

4. OBJECTIVES OF THE STUDY:

a) To study the impact of a design thinking applications on the operational efficiency of public transport systems.

b) To evaluate the impact of design thinking applications on the sustainability of transport operations.

c) To examine the role of design thinking parameters in improving transport supply chain performance.

d) To study the role of demographic factors in design thinking applications

5. HYPOTHESIS OF THE STUDY:

- H1: The design thinking application has a significant positive impact on the operational efficiency of the public-transport supply chain.
- H2: The design thinking application has a significant positive impact on the sustainability of public transport operations.
- H3: The Iterative prototyping have a positive significant impact on transport supply chain performance.
- H4: The application of a human-centered design thinking significantly differ across different age groups
- H5: The application of a human-centered design thinking significantly differ across different mode of transportation

6. RESEARCH METHODOLOGY:

6.1 Data Collection:

The study utilized a quantitative methodology by gathering primary data from over 150 commuters of public transport across Mumbai. Variables measuring the design thinking principles and its impact on efficiency and sustainability were administered. Likert-scale questions were employed to quantify the thoughts.

Also, secondary data would be collected for 10 major routes of Mumbai to understand their current statistics and gather insights to add to the study.

6.2 Sample Size:

Quantitative sample was 150 commuters.

The other sample was the 10 busy routes of Mumbai.

6.3 Sampling Technique:

Purposive sampling was used to include responses of commuters from various parts of Mumbai.

6.4 Statistical Analysis Technique:

Descriptive statistics was used to summarize the survey data. Further Levene's test of equality was used to interpret the demographic impact of commuters and modes of transport used by them. Regression analysis was used to study the impact of Design thinking on operational efficiency and sustainability.

6.5 Statistical tool:

SPSS software was used for all the analysis in the study.

7. DATA ANALYSIS ON INTERPRETATION:

H1: The Design Thinking Application (DTA) has a significant positive impact on the Operational Efficiency (OE) of the public-transport supply chain.

Findings:

Descriptive Statistics			
	Mean	**Std. Deviation**	**N**
OE	4.2730	.49142	150
DTA	4.1720	.42222	150

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.506[a]	.256	.251	.42518	1.081
a. Predictors: (Constant), DTA					
b. Dependent Variable: OE					

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	9.228	1	9.228	51.049	.000[b]
	Residual	26.755	148	.181		
	Total	35.983	149			
a. Dependent Variable: OE						
b. Predictors: (Constant), DTA						

The overall model was significant, $F = 51.049$, $p < .001$, indicating that the model significantly predicts the outcome variable. The model explained approximately 25% of the variance in OE, Adjusted $R^2 = .251$. Furthermore, The Durbin-Watson statistic was 1.081, indicating no autocorrelation in the residuals.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.814	.346		5.244	.000
	DTA	.589	.082	.506	7.145	.000

a. Dependent Variable: OE

Results- In the regression model, DTA ($\beta = .506$, $t = 7.145$, $p = .000$) were significant predictors OE. Therefore, hypothesis H1 supported.

Interpretation:

The public transport authorities should consider incorporating design thinking in the strategic frameworks as it will lead to improved service delivery outcomes.

H2: The Design Thinking Application (DTA) has a significant positive impact on sustainability (ST) of public transport operations.

Findings:

Descriptive Statistics

	Mean	Std. Deviation	N
ST	3.9664	.34745	150
DTA	4.1720	.42222	150

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.454[a]	.206	.201	.31056	1.758

a. Predictors: (Constant), DTA

b. Dependent Variable: ST

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.714	1	3.714	38.509	.000[b]
	Residual	14.274	148	.096		
	Total	17.988	149			

a. Dependent Variable: ST

b. Predictors: (Constant), DTA

The overall model was significant, $F = 38.509$, $p < .001$, indicating that the model significantly predicts the outcome variable. The model explained approximately 20% of the variance in OE, Adjusted $R^2 = .201$. Furthermore, The Durbin-Watson statistic was 1.758, indicating no autocorrelation in the residuals.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.406	.253		9.524	.000
	DTA	.374	.060	.454	6.206	.000

a. Dependent Variable: ST

Results- In the regression model, DTA ($\beta = .454$, $t = 6.206$, $p = .000$) were significant predictors ST. Therefore, hypothesis H2 is supported.

Interpretation:

As design thinking is focussed on understanding user needs, it will enhance the environmental and economic sustainability of the system.

H3: Iterative Prototyping (PT) has a positive significant impact on Transport Supply Chain Performance (TSCP).

Findings:

Descriptive Statistics

	Mean	Std. Deviation	N
TSCP	4.1394	.31609	150
PT	4.1889	.42025	150

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.229[a]	.053	.046	.30872	1.207

a. Predictors: (Constant), PT

b. Dependent Variable: TSCP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.782	1	.782	8.202	.005[b]
	Residual	14.105	148	.095		
	Total	14.887	149			

a. Dependent Variable: TSCP

b. Predictors: (Constant), PT

The overall model was significant, F = 8.202, p =.005, indicating that the model significantly predicts the outcome variable. The model explained approximately 5% of the variance in TSCP, Adjusted R^2 = .046. Furthermore, The Durbin-Watson statistic was 1.207, indicating no autocorrelation in the residuals.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.417	.253		13.489	.000
	PT	.172	.060	.229	2.864	.005

a. Dependent Variable: TSCP

Results- In the regression model, PT (β = .229, t = 2.864, p = .005) were significant predictors TSCP. Therefore, hypothesis H3 is supported.

Interpretation:

Step by step implementation of design thinking with monitoring and feedback systems in place will lead to more effective transport operations.

H4: The application of a human-centered design thinking significantly differ across different age groups

Findings:

Univariate Analysis of Variance

Descriptive Statistics

Dependent Variable: DTA

Age	Mean	Std. Deviation	N
18-24	4.3750	.48329	8
25-34	4.0259	.46952	54

35-44	4.2246	.36659	57
45-54	4.2774	.35281	31
Total	4.1720	.42222	150

Levene's Test of Equality of Error Variances[a]

Dependent Variable: DTA

F	df1	df2	Sig.
1.992	3	146	.118

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Age

Levene's Test for Equality of Variances was not significant, F (3, 146) = 1.992, p = .118, indicating that the assumption of homogeneity of variances was met."

Tests of Between-Subjects Effects

Dependent Variable: DTA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	1.984[a]	3	.661	3.928	.010	.075	11.785	.822
Intercept	1477.900	1	1477.900	8778.944	.000	.984	8778.944	1.000
Age	1.984	3	.661	3.928	.010	.075	11.785	.822
Error	24.579	146	.168					
Total	2637.400	150						
Corrected Total	26.562	149						

a. R Squared = .075 (Adjusted R Squared = .056)

b. Computed using alpha = .05

Result- DTA was found to significantly differ across different age groups ($p \leq .05$). Therefore, hypotheses H_4 was supported.

Interpretation:

Different demographic groups have different perceptions. Regular feedbacks will help in understanding and incorporating the requirements for better transport experience.

H5: The application of a human-centered design thinking significantly differ across different mode of transportation

Findings:

Univariate Analysis of Variance

Descriptive Statistics

Dependent Variable: DTA

transportMode	Mean	Std. Deviation	N
bus	3.2000	.	1
Train	3.7600	.33166	25
Auto	4.2230	.41328	61
Metro	4.3016	.34243	63
Total	4.1720	.42222	150

Levene's Test of Equality of Error Variances[a]

Dependent Variable: DTA

F	df1	df2	Sig.
1.413	3	146	.241

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + transportMode

Levene's Test for Equality of Variances was not significant, F (3, 146) = 1.413, p = .241, indicating that the assumption of homogeneity of variances was met."

Tests of Between-Subjects Effects

Dependent Variable: DTA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	6.405[a]	3	2.135	15.463	.000	.241	46.388	1.000
Intercept	223.611	1	223.611	1619.591	.000	.917	1619.591	1.000
transportMode	6.405	3	2.135	15.463	.000	.241	46.388	1.000
Error	20.158	146	.138					
Total	2637.400	150						
Corrected Total	26.562	149						

a. R Squared = .241 (Adjusted R Squared = .226)

b. Computed using alpha = .05

Result- DTA was found to significantly differ across different modes of transport ($p<.01$). Therefore, hypotheses H_4 was supported.

Interpretation:

There are different demographic groups commuting via different public transports. Each feedback and grievance will need to be handled differently for having future sustainable transport systems.

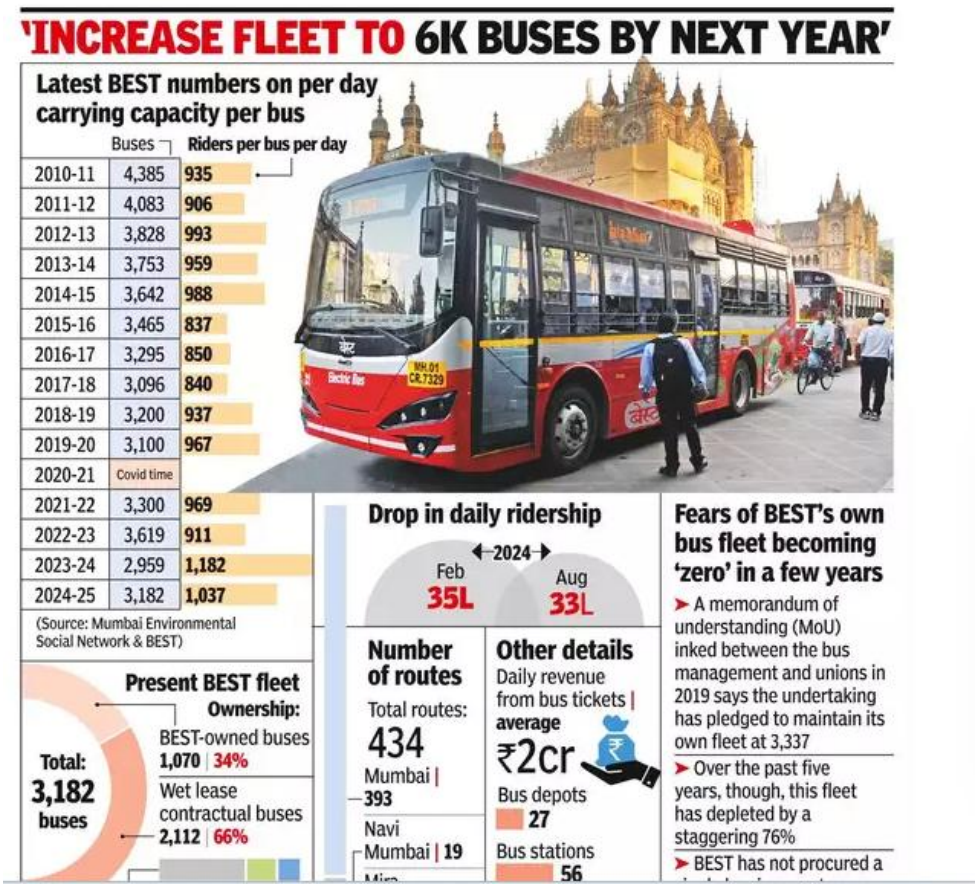
Secondary Data Analysis:

The milestones mentioned on the BEST website was last updated in 2016 as shown below. There are few tabs which are not working. A major re-vamping needs to be done and the communication should be made more user-friendly. This maybe due to plans for deploying more of EV vehicles too.

2000	All Luxury Buses Discontinued w. e. from 1/12/2000
2003	Low Floor Bus Introduced, as a Pilot Project
2004	Exclusive Bus Lane for BEST Buses from Mumbai-C.S.T to Mantralaya (approx 3.5 Kms)
2010	**Bus Pass Scheme with RF-ID based SMART CARD's is introduced.**
2011	Electronic Ticket Issuing Machines (ETIM) introduced on all the buses.
2014	Commissioned Malad Bus Depot from 12th April 2014.
2016	Commissioned KalaKilla Bus Depot From 1st February 2016

The Finance Highlights are last mentioned for the year 2018-2019. After that there are no updates on the website.

By 2027, **BEST** is planning to increase its fleet of **to a total of 8,000**, gradually phasing out older, non-electric buses.



Retrieved from: https://timesofindia.indiatimes.com/city/mumbai/challenge-for-best-buses-in-mumbai-swelling-crowds-of-1k-riders-per-bus/articleshow/112596105.cms

BEST has deployed 685 buses on 10 crowded routes.

1	40 Ltd.	Sewri to Dadar
2	7 Ltd.	Backbay depot to Vikhroli
3	440 Ltd.	Wadala to Borivli
4	4 Ltd.	Hutatma Chowk to Oshiwara Goregoan
5	66	Ballard pier to Sion
6	C 42 Express	Sion to Thane
7	203	Juhu to Dahisar
8	8	Churchgate to Mantralay
9	202	Mahim to Gorai
10	312/321	Between airport and Andheri station

8. CONCLUSION OF THE STUDY

The research concludes that design thinking application will prove beneficial to the huge population that commutes via public mode of transport. Systematic handling of routes, feedback, demographics will help in improving the services and lead to sustainability.

Also, involving the various stake-holders like policy makers, planners, local communities will lead to ensuring practical and inclusive solutions.

The study will add to the existing literature and also open new dimensions for policy makers as well as future research work.

9. LIMITATIONS OF THE STUDY:

Although the study provides insightful information about the design thinking applications from the commuters perspective, the operator's perspective is not considered due to challenges in obtaining responses. Further, inviting commuters and policy makers on similar platform for ideation process or workshop and co-creation may be challenging.

Recommendation of the study:

1. Integration of design thinking applications in planning and defining the transport systems for better alignment and usability
2. Incorporating feedback and empathy mapping by regular surveys to understand the expectations and pain-points of commuters.
3. Practice inclusivity i.e. catering to the needs of different age-groups and different modes of transport.

Implement change management: As a large part of population uses the public transport, it may seem difficult to implement changes. However for efficiency and sustainability, iterative way of incorporating changes will have to be implemented.

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