COMPILER
Vol. 14, No. 1, May 2025, pp.9-18
ISSN: 2252-2403 (Print), ISSN: 2549-2403 (Online)
Aaccredited Fourth Grade by Kemenristekdikti, Decree No:200/M/KPT/2020
DOI: 10.28989/compiler.v14i1.2819

An innovation study on luggage wheel design for seamless travel

M.Azra Kurudirek[1], K.Afra Kurudirek[2] , Abdullah Kurudirek[3,*]
[1]Ronaki International School, Erbil, Iraq
[2]Department of Computer Science, Kennesaw State University, Atlanta, USA
[3]Department of Mathematics Education, Tishk International University, Erbil, Iraq

Article Info

Article history:

Received January 20, 2025
Accepted June 2, 2025
Published June 13, 2025

Keywords:

Breakage
Damaged baggage
Ergonomic design
Innovation
Renewed luggage design

ABSTRACT

In this paper, a new suitcase study that will enable people to travel comfortably in every aspect is emphasized, and prototype examples are handled. This study reveals the latest innovations in suitcase design aimed at improving travel efficiency and eliminating wheel malfunctions that may occur in the suitcases carried by passengers (especially breakages during loading and unloading in the cargo section). Considering current design trends and the smoothness of travel, as well as the joy of passengers being able to securely retrieve their suitcases from the conveyor belts at their destinations, this research identifies the key features that contribute to enhanced mobility and comfort. This study employs a mixed-methods approach combining both qualitative user feedback and quantitative data to evaluate performance. A total of 60 participants (30 male, 30 female) were included in real-world testing scenarios, while durability tests were conducted under controlled laboratory conditions. Both quantitative and qualitative results indicate that the newly developed suitcase design outperformed standard wheels, especially within the 20–32 kg weight range, in terms of comfort, usability, durability, and overall user satisfaction. Previous research findings indicate that modern design features such as ergonomic handles and lightweight materials significantly enhance travel comfort and efficiency. In this research, the latest wheel designs are expected to contribute to these findings. Throughout this research, we will look at two separate prototype examples to illustrate these cutting-edge concepts simply and understandably. Therefore, this article provides insights for designers, manufacturers, and travelers interested in maintaining the robust functionality of suitcases.

Corresponding Author:

Abdullah Kurudirek,
Department of Mathematics Education,
Tishk International University,
100 mt. Street, F. Baz (Square), Mosul Road, 44001, Erbil, KRI-IRAQ.
Email: *abdullah.kurudirek@tiu.edu.iq

1. INTRODUCTION

A suitcase is a carrying bag designed to contain things and fulfil people's desire to carry everyday basics while they travel. Handbags and briefcases were the first type of luggage to contain things; they eventually gave way to wooden boxes or other bulky wooden trunks. Up until now, as air travel has grown in popularity, various bags have been constructed to be more lightweight and portable, whether made of hard plastic or fabric. People desire to travel quickly and smoothly from one location to another. Along with this, many individuals may understand the difficulties that arise while carrying many belongings simultaneously.

Modern materials and more advanced technologies influence luggage design, giving travellers a more convenient and pleasant means of transportation. All baggage companies must consider this crucial factor when switching from imitation to autonomous innovation in production. A significant subset of the baggage market is the suitcase sector. Conventional bags will be reinvented and developed in tandem with the growth of the

Internet of Things. A significant potential for the growth of the luggage sector will be the intelligent transformation of the suitcase [1].

As it is known, every year, millions of people travel to different parts of the world, both domestic and international, for various reasons. During these travels, they use suitcases, bags, etc., to take some of their essential needs, depending on the purpose and situation.

Wheeled baggage is a material handling storage method commonly used by travelers to store and transfer their products and personal things from one location to another. In recent years, there has been a growth in global travel, which will enhance the need for wheeled baggage [2]. This has resulted in a rise in baggage use and sales. According to the inaugural UNWTO World Tourism Barometer, worldwide tourism finished in 2023 at 88% of pre-pandemic levels, with an expected 1.3 billion international arrivals. The release of residual pent-up demand, greater air connectivity, and a stronger recovery of Asian markets and destinations are predicted to support a complete recovery by the end of 2024 [3].

According to a research consultancy firm, Statista, in 2024, the revenue in the global Luggage and bags market is estimated to be US$187.60bn. It is projected to experience an annual growth rate of 3.93% (CAGR 2024-2028). Additionally, by 2024, 68% of the Luggage and bags market sales will be attributed to non-luxury. Despite the global economic downturn, the demand for luxury luggage and bags in countries like France and Italy remains strong due to their reputation for high-quality craftsmanship and fashion-forward designs [4].

The initial studies and preparations were made to participate in the INPO project competition organized by Stirling Schools across Iraq [5], and the presentation was made. As a result of this competition, where student projects at the middle and high school levels were evaluated and awarded, this work was moved to receive patent rights. As it is known, even smart suitcases currently serve humanity and are an excellent and original work. However, every suitcase that enters the plane's cargo area, especially the suitcases that have four wheels and are preferred because they are easy to carry, has no chance of avoiding this problem. It seems inevitable that workers loading luggage will experience this problem at any time, willingly or unintentionally.

Figure 1. Conveyor belt

In today's travel sector, baggage design is critical to guaranteeing a flawless travel experience. According to [6], ergonomics is the study of how people and the instruments they employ to accomplish tasks interact. In 2020, Lee conducted a study on smart-fashion products, highlighting many efforts to combine technology and fashion to provide customers with digital benefits.

Suitcase designs have evolved in response to the dynamic needs of travelers, with recent advancements focusing on improving mobility, durability, and convenience. However, despite these developments, there remains a notable gap in practical solutions that comprehensively address the real-world challenges faced by travelers, such as broken wheels, limited maneuverability in crowded areas, and airline handling issues. Moreover, there is limited empirical analysis of how novel suitcase designs contribute to both traveler satisfaction and airline efficiency.

To address this gap, the present study investigates two innovative suitcase designs developed to solve common mobility-related problems. It aims to evaluate their effectiveness in enhancing travel experiences and assess their broader implications for airline operations.

The research problem is framed through the following questions:

- What is the contribution of the new suitcase design to the motivation of travelers?
- What are the advantages that airlines will gain with this design?

1.1. Research Objectives

- To analyze the ergonomic and functional features of the new suitcase design.
- To assess the practical contributions of these designs to traveller satisfaction and convenience.
- To evaluate the potential operational advantages for airlines.
- To review relevant literature to situate the new designs within the broader context of luggage technology evolution.

.

1.2. Importance of the Research

The significance of this research lies in attempting to add a new dimension to technologically functional suitcase designs, providing comfort to travelers with creative design, and supporting the sector by offering financial advantages to everyone.

2. AN OVERVIEW OF MODERN LUGGAGE AND USABILITY RESEARCH

The paper [2] overviews the history and many forms of contemporary wheeled luggage, beginning with Bernard Sadow's design of the first commercially successful wheeled suitcase in 1970. It classifies a variety of wheeled luggage designs, including two-wheeled roller suitcases, duffel bags, backpacks, all-terrain bags, spinner-wheeled suitcases, push-trolley baggage, and smart luggage. Each category is examined for its design elements, advantages, and disadvantages. The paper emphasizes ergonomic and practical developments in baggage design, such as introducing spinner wheels for ease of mobility and the rise of smart luggage with technological functions. The research stresses the significance of stability, handling, and user comfort in baggage design, addressing concerns such as rolling instability and physical strain while transferring luggage. The creation and examination of innovative designs, such as the push trolley and smart baggage, indicate continual attempts to improve the user experience in the luggage sector. The researchers [7-10] give a thorough summary of research on the usefulness of wheeled luggage, focusing on elements that influence performance such as load bearing, maneuverability, durability, ergonomics, and user pleasure. The search for relevant literature was wide, encompassing a variety of keywords and databases, with the inclusion criteria centered on wheeled baggage and manual handling.

Key findings of the investigations include:

1. Two-wheeled luggage Instability: Fast pulling can create undamped rocking oscillations, perhaps leading to overturn.
2. Luggage-Use Injuries: Lifting is the leading cause of shoulder injuries, particularly among women.
3. Ergonomics of Handle Design: Research indicates that longer handles and larger wheels reduce downward force and energy expenditure, whereas heavier loads increase pulling forces and energy expenditure.
4. Spine Loading: Pulling two-wheeled baggage reduces anterior and posterior shear stresses on the spine compared to other carrying techniques.
5. Handle Design Effect: Single, curved, and longer poles increase clearance between baggage and user, impacting posture and walking speed.

Overall, the paper emphasizes the need for ergonomic design in wheeled baggage to improve usability and lower the risk of musculoskeletal illnesses.

3. LITERATURE REVIEW

In recent years, research on smart suitcase design has focused mostly on experience design, interactive interface design, intelligent hardware design, intelligent software design, etc. In conclusion, many local and international suitcase investigations focus on experience design and interactive interface design while paying less attention to the design of smart travel products based on user experiences. This topic aims to research the design of smart travel products that improve the user experience. This study focuses on how bags may be returned to passengers undamaged, with no broken wheels, after being placed in airline baggage by passengers.

Previous studies on suitcase design have focused on various factors, including durability, capacity, and security features. For example, studies have demonstrated the relevance of solid wheel systems for mobility and the role of lightweight materials in decreasing travel strain. Recent assessments have also included ergonomic factors such as handle design and simplicity of use. This literature review synthesizes these findings and shows that new original designs and current innovations should be considered to improve the travel experience.

Consumer preferences and market demand are critical to a product's success. Thus, product design must fulfil consumer expectations. Comparative studies reveal more gaps. The study [11] used Kansei engineering to develop a baby bag based on emotional and functional user preferences. In addition to demonstrating various desired features such as neatness, distinctiveness, comfort, safety, and durability, the

study emphasized that while durability is valuable, it is not the only concern. Another proposed push-style luggage cart, intended to replace dragged suitcases, highlights improved ergonomics and reduced risk of injury..

The researchers [2] are interested in reducing the effort and injury hazards related to material handling aids, namely wheeled baggage. The research addresses ergonomic faults in current wheeled luggage designs, notably those that are dragged, and proposes push-trolley baggage as a superior option. The study underlines the importance of additional research and design optimization to increase the usability of wheeled baggage on rugged and rural terrains in developing nations.

Musculoskeletal disorders might be caused by ergonomic issues connected with pushing and pulling transport carts. The study [12] focuses on designing and testing a novel ergonomic handle for industrial transport carts. It investigates how various handle designs and wheel optimizations influence workers' body positioning and biomechanical strain during cartwheeling. The findings show that the new handle design, which is especially useful for workers with lower body mass, encourages more ergonomic body orientations and minimizes biomechanical strain.

The paper [13] investigates the role of ergonomics in the design of smart bags, highlighting their significance in improving both practical and aesthetic elements. The study examines previous literature to better understand how ergonomics influence product design, particularly for smart bags, and seeks to connect these designs with current wearable technology trends. The study examines smart bag ergonomics using inductive and descriptive-analytic methodologies, demonstrating that ergonomic considerations greatly increase product efficiency and user happiness. The study identifies critical ergonomic factors such as the bag's position, theft prevention, device charging capabilities, and sensor usage. It finishes with a proposal to prioritize ergonomic aspects in fashion design and a demand for more study into their influence on fashion accessories. Smart suitcase prototypes that integrate mobile internet technology aim for entertainment and convenience, but they often overlook functional reliability and physical robustness, which are critical for airline compatibility.

The purpose of this study [14] is to examine and improve the design of four-wheeled luggage to increase stability and comfort while lowering the risk of musculoskeletal problems. The research identifies a trend toward utilizing four-wheeled bags for ease of management and greater balance. However, it notes that luggage with middle-opening, split storage platforms frequently experiences rolling instability and discomfort. This instability might result in physical strain over time. The study also involved creating and evaluating the tensile strength of several materials before determining that silicone is the optimum material for boosting product performance.

The article [1] describes the improvement of smart luggage that uses modern mobile internet technology to handle practical challenges such as safety, portability, and entertainment. The study aims to improve the usefulness, design, construction, and materials of typical luggage. The smart suitcase offers a more pleasant and customized travel experience, following the trend of smart products in the Internet of Things age, and strives to benefit both individuals and society by enhancing travel efficiency.

In summary, although significant progress and achievements have been made in smart and ergonomic suitcases, there are still existing gaps, particularly the integration of user-centered ergonomic features and structural durability in response to the challenges of airline baggage handling. This study addresses that gap by examining two newly developed suitcase designs aimed at minimizing damage (e.g., broken wheels) and enhancing overall travel efficiency. It builds upon current ergonomic and smart design principles but focuses more concretely on functional durability and real-world usability— a critical need largely overlooked in the existing literature.

4. METHODS AND MATERIALS

This study compares the durability and user satisfaction of newly developed suitcase wheels with traditional ones through a combination of laboratory tests and real-world user trials.

4.1. Participant Recruitment and Inclusion Criteria

A total of 60 participants (30 male and 30 female), aged between 18 and 65 and representing a range of professions (students, professionals, and frequent travelers), were included using purposive sampling to ensure diversity. The inclusion criteria were as follows:

1. Participants must travel at least twice a year.
2. They must have no prior affiliation with luggage or design companies.
3. They must be willing to use both types of suitcases over the course of one week in real travel scenarios.

4.2. Experimental Procedure

Each participant who volunteered was provided with two types of luggage:

1. A standard wheeled suitcase (capacity: 20–32 kg), and
2. A newly designed suitcase with new wheel mechanisms, but identical in size and load capacity.

Participants were instructed to use each suitcase for one week during their daily commutes or travel routines. A one-week break was given between the two periods to prevent carryover effects. After each usage period, participants completed a standard post-use survey evaluating the following aspects:

1. Comfort
2. Usability
3. Durability
4. Ease of Use
5. Overall Satisfaction

4.3. Laboratory Durability Test

In addition to the user-based evaluation, a laboratory durability test was conducted on both types of suitcases.

4.4 Data Analysis

Analyses were conducted using both quantitative data obtained from the post-use surveys and qualitative data collected during the study.

4.5. Innovative Designs in Suitcases

According to [15], innovation is the practical application of ideas that lead to the introduction of new products or services or an improvement in the provision of existing goods or services. According to [16], innovation frequently occurs when creators create more efficient goods, procedures, services, technology, artwork, or business models that they make accessible to the public, governments, and businesses.

In this section, we strongly emphasize the exploration of innovative suitcase designs that are meticulously crafted to offer travelers unparalleled comfort and convenience in every aspect of their journey. Our goal is to introduce groundbreaking solutions that will redefine the travel experience. Throughout this study, we delve into prototype examples, illustrating these cutting-edge designs simply and understandably. By doing so, we aim to shed light on the exciting possibilities that lie ahead, enhancing the travel experience for individuals worldwide. For this purpose, we tried to focus on the suitcases that have been designed before and are still actively used in many different models, especially those with four wheels. These are among the reasons most passengers prefer them, as they are straightforward. Even in terms of durability, it is possible to see examples of very different materials. Even if there are extreme differences in pricing, people prefer more durable ones to give them peace of mind and avoid any problems. To better understand these points, the proverb "I am not rich enough to buy cheap goods" is perhaps the most common in our daily lives; airports can be visited or observed. We believe that implementing several targeted technical and design changes will considerably improve the durability of this bag type. These upgrades will be confirmed and proven in the upcoming testing rounds.

4.6. Balloon Model Prototype

This innovation was inspired by the balloon, a source of endless fun and children's favorite. Therefore, we call it the Balloon Model. We can raise and lower our wheels like a balloon whenever necessary (Figure 2).

Figure 2. Ballon Model Suitcase

Simply put, the system is created with a button added next to the wheels. Inside the suitcase, slots are made to house the wheels comfortably. When our passenger’s hand over their luggage to the conveyor belt,

they use these buttons to retract the wheels into the suitcase, ensuring that no parts are left exposed before securely handing it over. However, it would still be nice if the baggage claim officials at the airports warned the passengers in case the wheels are left exposed, as a precaution to prevent any problems arising from forgetfulness.

4.7. Plane Model Prototype

This innovation was inspired by airplanes' takeoff and landing scenes (Figure 3). Therefore, we call it the Airplane Model. We thought, why not apply the same technique of retracting the wheels after takeoff to suitcases? This is explained in more detail in the attached Figure 4. The only thing left is to apply this to suitcases and increase the number of smiles on people's faces. Just like with our Balloon Model, slots have been created inside the suitcase to comfortably house the wheels. When passengers hand over their luggage to the conveyor belt, they use a simple mechanical system to retract the wheels into the suitcase, ensuring that no parts are left exposed before securely handing it over.

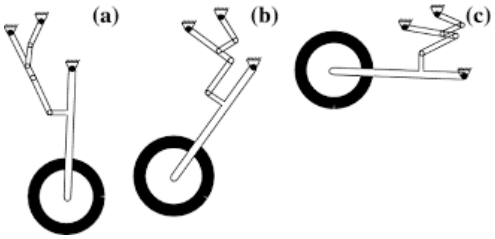

Figure 3. Example nose landing gear mechanisms [17]

Figure 4. Plane Model Suitcase

5. RESULTS AND ANALYSIS

5.1. Laboratory Test Results

No significant difference in durability was observed between the standard and newly designed suitcases in the laboratory setting, primarily because both utilized the same materials and structural frameworks. Similarly, no statistically significant difference was found in overload-carrying capacity, as both models had an average load range of 20–32 kg. These findings indicate that material quality alone does not account for differences in user experience, highlighting the importance of ergonomic and design features.

5.2. Real-World Usage Scenarios

Participants reported higher satisfaction with the newly designed wheeled suitcases than standard ones. Survey results revealed as follows:

The newly designed suitcases received an average comfort rating of 4.7, whereas standard suitcases received a rating of 3.5. The usability of newly designed suitcases was rated 4.5 on average, compared to 3.2

for standard suitcases. Participants rated their overall satisfaction with newly designed suitcases at 4.8, while standard suitcases were rated at 3.3.

Table 1. Survey Results

Evaluation Criterion	Standard Suitcases (Avg.)	Newly Designed Suitcase (Avg.)	p-value
Comfort	3.5	4.7	<0.01
Usability	3.2	4.5	<0.01
Overall Satisfaction	3.3	4.8	<0.01

These findings are consistent with previous research that emphasizes the importance of ergonomic improvements in luggage design for user-centered and hassle-free travel [1,2,6,11,12,13]. Unlike some smart luggage prototypes that focus on digital features while neglecting physical reliability, our design prioritizes both user comfort and structural performance.

5.3. Qualitative Analysis Results

Feedback from participants indicated that the newly designed wheels offer significant improvements in durability, ease of use, and overall satisfaction. Most participants noted that the new wheels are more durable, the suitcases are more comfortable, and they were generally very pleased with the latest design.

Table 2. Q. Analysis Results

Theme	Frequency (n)	Example feedback
Durability	30	The new wheels are considerably more durable.
Ease of use	25	The wheels are more protected and no worry about moving the suitcase.
Overall Satisfaction	28	The new design is amazing.

The increased endurance of newly developed wheels against breakage means they can tolerate harsher travel conditions. This result is beneficial for users who travel frequently or transport large items. Survey results demonstrate that freshly designed wheels increase user pleasure, with greater comfort, use, and overall satisfaction scores. This illustrates that the new design dramatically enhances the user experience.

This research assesses the durability and user satisfaction of newly developed suitcase wheels. The data show that the newly designed wheels have a substantial advantage over regular wheels. With this renewed suitcase design, people will have a more comfortable and safe flight. Most importantly, this product, like other products, will be imitated, not of the same quality, similar in appearance but lower in price, and there is no doubt about this. Therefore, we think the marketing and business parts of the job should be well thought out, and a middle ground should be found where everyone will be happy.

Additionally, as can be seen, a system or mechanism needs to be added to the suitcases. Good planning should ensure that this does not increase the bag's weight. At the same time, the quality of the material to be used is also essential. Otherwise, while trying to prevent wheel breakage, reasons such as increasing the empty weight of the suitcases or the lack of solid mechanisms to be installed will cause other problems. I wish everyone did their job well and correctly so that such additional costs would not arise, and waste would not occur. Still, humans constantly try to create new things by living, seeing, developing, and having different experiences. Here is a life that can be lived by helping each other and memories that can be created with sturdy suitcases in this life.

Have you ever considered what you know about passenger rights? For example, what are the airline's obligations if they damage your luggage? Airlines are obligated to repair or reimburse a passenger for damaged baggage and/or its contents if the damage happens while the bag is in the airline's control during transportation. When the damage to the luggage cannot be repaired, the airline will negotiate a compensation figure based on the bag's worth and depreciation. Although airlines are not obligated to cover normal wear and tear, they cannot avoid the obligation of damage to checked baggage wheels, handles, straps, and other components. The Montreal Convention, an international convention governing airlines' responsibility in the event of harm or damage to passengers, baggage, or cargo, states that airlines are liable for damages up to a specified level. As of my most recent knowledge update in August 2024, the maximum for checked luggage was 1,328 Special Drawing Rights (SDRs) per traveler. The SDR's value fluctuates and is determined by a basket of foreign currencies [18].

Airlines adopting these new designs will lead to increased market activity. Announcing that they will only accept passengers' luggage with these newly designed suitcases in the cargo hold and, if necessary, offering discounts on ticket prices to encourage this will be profitable for everyone in the short and long term.

6. LIMITATIONS OF THE STUDY

The strength of this study lies in its mixed-methods approach, combining real user feedback with laboratory testing. However, it has some limitations. First, the sample size is small, and a bigger participant

group might improve the findings' generalizability. Second, the trial lasted one week. Longer-term usage testing might reveal more information about the newly designed wheels' long-term performance.

7. FUTURE RESEARCH RECOMMENDATIONS

To expand upon the findings of this study and support broader adoption, future research may focus on the following: Performance should be evaluated under various environmental and transportation conditions (e.g., rail, road, sea), such as different weather and surface types, to determine the durability and universal applicability of the newly designed wheels. Longitudinal studies assessing performance under diverse travel conditions (e.g., airports with more demanding usage, and varying climates) would offer deeper insights. In addition, comparative studies using the new wheel design across different suitcase materials should be conducted in conjunction with long-term usage tests on a larger and more diverse group of participants, encompassing various age groups, professions, and travel habits, to assess the wheels' durability and performance over time. Economic impact modelling, measuring cost savings from reduced damage claims and increased luggage lifespan, would be another important area not to be overlooked. Lastly, the integration of smart technologies (e.g., sensors on the wheels to track usage or detect damage), along with the inclusion of modular or adjustable wheel systems, could represent the next step in innovation while maintaining ergonomic efficiency and physical reliability.

8. CONCLUSION

This study makes a novel contribution to the field of luggage design and travel ergonomics by introducing and evaluating newly developed suitcase wheels that significantly outperform standard ones in terms of durability, comfort, and overall user satisfaction. Unlike previous prototypes that focused primarily on digital enhancements, this design bridges a critical gap by integrating user-centred ergonomics with structural reliability—an essential combination that is rarely addressed in the existing literature.

By targeting one of the most common points of failure, wheel breakage, this research demonstrates that practical, low-cost engineering improvements can have a measurable impact on user experience and travel reliability. The newly designed wheels, tested in both laboratory and real-world conditions, offer a robust solution for suitcases with a load capacity of 20–32 kg, confirming their broader applicability within the luggage industry. Future studies will validate these findings and encourage more widespread implementation of the new wheel design. The key innovations and potential impacts of this study include:

1. A pioneering application of ergonomic design principles focused specifically on suitcase wheels—an often-overlooked component.
2. The first user-based field study to evaluate long-term, real-world usage patterns by integrating both qualitative and quantitative data.
3. Potential industry-wide effects such as reductions in customer complaints, airline compensation claims, and environmental waste caused by frequently discarded damaged luggage.
4. Enhanced travel experiences aligned with evolving passenger expectations in the era of smart and sustainable travel, supported by increased comfort and confidence in product reliability.

In harmony with the motto "Think big, start small, but start now," this study shows how a simple and focused intervention can pave the way for meaningful progress in design, economics, and user experience. As travel technologies evolve and AI increasingly integrates into our lives, solid, user-driven innovations like this deliver tangible improvements, leading to safer, smoother, and more satisfying journeys for all.

Introducing newly designed wheels to the market would also represent a significant advance for luggage manufacturers. This innovation is expected to increase customer satisfaction and extend the lifespan of bags. That said, it must be acknowledged that every product has a finite lifespan. Ultimately, every great journey begins and ends with a reliable suitcase.

REFERENCES

[1] Y. Li, "The Design Research of Intelligent Suitcase," *Journal of Digital Information Management*, vol. 15, no. 6, pp. 320-330, Dec. 2017.

[2] D. Chitena, A. U. Ude, V. Chinnasamy, and T. Zeundjua, "A review on the usability of wheeled luggage," *Cogent Engineering*, vol. 9, no. 1, Nov. 2022, doi: 10.1080/23311916.2022.2143038.

[3] UNWTO, "Home | UNWTO," *Unwto.org*, 2023. [Online]. Available: https://www.unwto.org/. [Accessed: Jun. 26, 2025].

[4] "Luggage & Bags - Worldwide | Statista Market Forecast," *Statista*. [Online]. Available: https://www.statista.com/outlook/cmo/accessories/luggage-bags/worldwide. [Accessed: Jun. 26, 2025].

[5] "Iraq National Project Olympiad (INPO) - International Competitions & Scientific Olympiads - School Information," *Stirlingschools.co.uk*, 2024. [Online]. Available: https://stirlingschools.co.uk/en/school-information/international-competitions-scientific-olympiads/iraq-national-project-olympiad-inpo. [Accessed: Jun. 26, 2025].

[6] M. A. Shaban, S. Mahmoud, and W. Galil, "Ergonomic and interactive properties in the design of metal display systems," *Journal of Architecture, Arts, and Humanistic Sciences*, vol. 4, no. 16, pp. 297-308, Jul. 2019, doi: 10.21608/mjaf.2019.13125.1176.

[7] M. Goldstein, "The Triumph of The Roller Bag," *Forbes*, Apr. 16, 2019. [Online]. Available: https://www.forbes.com/sites/michaelgoldstein/2019/04/15/the-triumph-of-the-roller-bag/. [Accessed: Jun. 26, 2025].

[8] T. Hokkanen, "US1413852A - Valise," *Google Patents*, Mar. 29, 1921. [Online]. Available: https://patents.google.com/patent/US1413852A/en. [Accessed: Jan. 20, 2025].

[9] "The first suitcases with wheels," *Retrowow.co.uk*, Feb. 20, 2020. [Online]. Available: https://www.retrowow.co.uk/retro_collectibles/luggage/suitcases_with_wheels.php. [Accessed: Jun. 26, 2025].

[10] Z. Zeng, M. Marinov, and B. Rüger, "Solving Some of the Issues of Luggage Storing on Passenger Trains," *Lecture notes in mobility*, pp. 143-160, Dec. 2021, doi: 10.1007/978-3-030-82095-4_7.

[11] D. Janari and A. Rakhmawati, "Developing Baby Bag Design by Using Kansei Engineering Method," *IOP Conference Series: Materials Science and Engineering*, vol. 105, p. 012031, Jan. 2016, doi: 10.1088/1757-899x/105/1/012031.

[12] B. W et al., "Development and Testing of an Ergonomic Handle and Wheel Design for Industrial Transport Carts," *Global Environment, Health and Safety*, vol. 1, no. 2, Oct. 2017. [Online]. Available: https://www.imedpub.com/articles/development-and-testing-of-an-ergonomic-handle-and-wheel-design-for-industrial-transport-carts.php?aid=21091. [Accessed: Jan. 20, 2025].

[13] A. Nermeen, A. Rahman, Mohamed, R. Ahmed, and S. Al-Shamrani, "Ergonomic design of smart bags: An analytical study," *Journal of Architecture, Arts and Humanities*, vol. 6, no. 26, pp. 637-651, Mar. 2021, doi: 10.21608/mjaf.2020.23953.1527.

[14] A. Musofa, A. A. Nugroho, T. Yuniardi, R. T. Kurniawan, and T. R. Sahroni, "Design analysis of suitcase stabilizer and zipper protector," *IOP Conference Series: Earth and Environmental Science*, vol. 729, no. 1, p. 012022, Apr. 2021, doi: 10.1088/1755-1315/729/1/012022.

[15] J. A. Schumpeter, *The Theory of Economic Development*, 2009.

[16] T. Lijster, "The Future of the New Artistic Innovation in Times of Social Acceleration." [Online]. Available: https://www.westdenhaag.nl/information/exhibitions/18_10_The_Future_of_the_New/more1/TheFutureOfTheNew.pdf. [Accessed: Jun. 26, 2025].

[17] J. A. C. Knowles, B. Krauskopf, and E. B. Coetzee, "Unlocking a nose landing gear in different flight conditions: folds, cusps and a swallowtail," *Nonlinear Dynamics*, vol. 106, no. 4, pp. 2943-2961, Oct. 2021, doi: 10.1007/s11071-021-06928-9.

[18] International Monetary Fund, "SDR Valuation," *Imf.org*, 2009. [Online]. Available: https://www.imf.org/external/np/fin/data/rms_sdrv.aspx. [Accessed: Jun. 26, 2025].