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The Southwest Journal of Arts and Sciences (SJAS) is an interdisciplinary peer-reviewed academic journal housed within University of the Southwest in Hobbs, New Mexico. Its purpose is to foster and promote quality research in the liberal arts and sciences by aspiring and seasoned scholars alike. An entirely electronic journal, SJAS is published through Alexander Street affiliated with ProQuest. Under the direction of its editorial board, all articles accepted into SJAS have passed through a double-blind peer reviewed process by scholars holding terminal degrees in that specific field. While each respective author's thoughts and statements remain his or her own and do not necessarily reflect the thoughts, opinions, or positions of the editorial board of SJAS or University of the Southwest, the peer-reviewed process ensures that such work has been assessed for quality.

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## Journal Unveils Second Issue in the Spirit of Serving Others

*The Southwest Journal of Arts & Sciences (SJAS)* is the culmination of work among faculty at the College of Arts & Sciences at a private Christian university in the southeast corner of New Mexico. University of the Southwest (USW) of Hobbs, NM, became my home in 2012 after I had worked here part time for 10 years. The school really is a home to many of the professors, staff, administrators, and animals. I say animals because of the vast assortment of wildlife on campus. Prairie dogs, squirrels, and birds own the campus, though an occasional dog being walked by a student or coach would not be unusual. Some Hobbs residents visit the university for the sole reason of enjoying the wildlife.

Founded in 1962 with a mission to educate young people in servant leadership, USW has three colleges: Arts & Sciences, Business, and Education. Like many small colleges, USW has a significant portion of student-athletes who attend in person. The institution also features a rapidly growing online only population. As schools around the country struggled to adapt to the all-distance learning scenario during the pandemic, USW was already in a position to thrive. Like a small boat, the university was able to maneuver quickly as the conditions worsened.

Over a three-year period to Jan. 12, 2023, the university's on-campus population fell 32.5% while its online population increased by 46.8%. Eighty percent of USW students study entirely online, 55% of students are nontraditional, and two-thirds of its faculty work remotely.

"I'm incredibly proud of how the university has made the shift," said Dr. Ryan Tipton, USW President. "We had the foresight to see the trends 10 years ago and adjust accordingly. We have more students than we've ever had. You just don't see them on campus as much anymore."

Moreover, the university has decentralized the decision-making process and reduced layers of bureaucracy by, for example, transitioning to a slim leadership structure and consistency across its three colleges.

The interdisciplinary, peer-reviewed SJAS welcomes studies or book reviews from educators or scholars. The fall 2022 issue is our second. The issue contains studies from USW Doctoral Candidate Bizuayehu Lema, Tuskegee University Drs. Chadia Aji and Laretta Garrett, USW Drs. Denise Turley and Yusheng Wu, and some university graduates or current students. The journal's purpose is to foster and promote quality research in the liberal arts and sciences by aspiring and seasoned scholars alike. An entirely electronic journal, SJAS is published through Alexander Street and ProQuest.

All articles accepted into SJAS have passed through a double-blind peer reviewed process by scholars holding terminal degrees. Although each author's thoughts and statements remain his or her own and do not necessarily reflect the opinions, or positions of the SJAS editorial board, the peer-reviewed process ensures that such work has been assessed for quality, format, and accuracy.

As an interdisciplinary journal, SJAS publishes research in the hard sciences (biology, chemistry, physics, etc.), social sciences (psychology, counseling, sociology, anthropology, history, etc.), and the humanities (religion, philosophy,

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literature, etc.). Prospective authors should focus on original research and theory development (both quantitative and qualitative inquiry). Interested authors should submit their inquiry to the managing editors, Dr. Erica Armstrong (social sciences and humanities) at [earmstrong@usw.edu](mailto:earmstrong@usw.edu) or Dr. Yusheng Wu (hard sciences) at [ywu@usw.edu](mailto:ywu@usw.edu), prior to writing to determine the literature's suitability.

Melissa Williams is the Design Editor.

To submit an article to SJAS or for more information, go to the following link: [journal.usw.edu](http://journal.usw.edu) You may email me at [rtrout@usw.edu](mailto:rtrout@usw.edu) or Co-Editor Yusheng Wu at [ywu@usw.edu](mailto:ywu@usw.edu) with any questions about the remarkable students attending USW, or the unforgettable wildlife and sunsets of New Mexico.

Dr. Richard Trout, Co-Editor

Southwest Journal of Arts & Sciences

TABLE OF CONTENTS

Financial Analysis and Gap Analysis on the Current and Future of Amazon.com and the Process of Communication for Planning Integrity, Bizuayehu Lema .....6

A Retention Study on the STEM Student Population at University of the Southwest, Yusheng Wu, Chadia Aji, Laretta Garrett.....11

Career Barriers Still Exist for Black Women in the Workforce: a Qualitative Study, Denise Turley .....19

Temperature Impact on Wild Type and Mutant Strains in *Drosophila melanogaster*, Emma Rocco, Johnna Wier, Yusheng Wu .....25

Developing Balanced Scorecard and Key Performance Indicators of Amazon.com, Bizuayehu Lema .....30

A Study on Inheritance Patterns on Eye Shape and Wing Presence in *Drosophila Melanogaster*, Makenna Medina, Hussein Abujejah, Yusheng Wu.....33

# Financial Analysis and Gap Analysis on the Current and Future of Amazon.com and the Process of Communication for Planning Integrity

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## Abstract

Analyzing and understanding the current and future of a corporate industry paves the way for undertaking gap analysis and designing a sophisticated communication process for the integrity of a strategic and operational plan. Contrary to traditional international financial theories, contemporary financial philosophies contend corporations' primary objective is to optimize shareholder value. Unless multinational corporations like Amazon.com continuously refine and track the ups and downs in operational, strategic, and risk, the unprecedented events will put predictability of the future and the business' sustainability in danger. Based on a framework of financial theories by Peter Atrill and Jeff Madura and a recent annual report of Amazon.com, the researcher reviewed and analyzed the present status of Amazon.com. The reviewer also drew an analysis of the future of Amazon.com in conjunction with the strategy of communicating the plan. The paper is relevant to financial analysts, managers, and corporate shareholders, research practitioners to see strategic areas in corporate industries in the international market competition era.

## The Current Financial Analysis of Amazon.com., Inc.

Financial statements are vital in informing any business industry's financial situation. Different people use financial statements for various purposes. These accounting statements are the balance sheet, income statement, and cash flow statement (Arnold et al., 2018). In this section of the theoretical and empirical analysis, the reviewer analyzes the financial situation of Amazon.com. Thereby, a reader will have a chance to overview the balance sheet (statement of financial position), income statement, and cash flow statements. This review also covers identifying the internal and external sources of finance of Amazon.com.

Theoretical and empirical works of literature categorize the purpose into three significant areas. First, financial statements help to understand the general well-being (Krishnan, 2021). Well-being encompasses ownership, profitability, and cash flow in different forms. Second, financial statements help undertake financial analysis (Erdamar et al., 2013). The investigation may take three significant components: inferential, to analyze trends and compare the company's performance with the respective competitors. Financial statements' third advantage is making an informed decision (Shahwan, 2008). Unless financial and non-financial managers are informed about the organization's current financial situation, any judgment may lead to misleading consequences.

Amazon is the leading e-commerce multinational company in the world. As Sandeep and Pohutezhini (2019) stated, apart from

working in an online business, Amazon provides Artificial Intelligence and Cloud Computing service. Simultaneously, Amazon has physical stores such as Fresh Grocery and Amazon Go. Before undertaking the analysis, let us understand the concept related to types of financial statements. A balance sheet, also called the "statement of financial position," answers the question of what a business owns and owes (Atrill; 2019,33-80). Besides, it further informs the reader of the short-run and long-run financial balance (Mihajlovic et al., 2015).

Amazon's Consolidated Balance Sheet of March 31<sup>st</sup>, 2022, encompasses three significant sections (Amazon,2022a). These include assets, liabilities, and stakeholders' equity. The numbers tell a change in accounts at the specified time. The report indicates that the current asset decreased from \$420,549 million (December 21<sup>st</sup>, 2021) to \$ 410,767 million. Out of the total asset, the current asset balance decreased from \$161,580 million to \$133,876 million in the first quarter of 2022.

According to Atrill (2019), there are two sources finance-internal and external. Internal sources of finance may include "retained earnings, ...receivables, reduction of inventories and payment delayed to trade payables" (Atrill,2019, 295). Besides, the external sources consist of "ordinary shares, preference shares, borrowings, leases, hire purchase agreements and securitization" (Atrill, 2019, 296). The internal and external sources of finance could be short-term or long-term. As Atrill further explains, short-term finances

have less than one year lifetime, while long-term finances may take one or above years. For the Amazon case, according to the Amazon (2022a) report, the account payable for goods and services the company bought owes \$68,547 million, less by \$10,117 million from the previous quarter. Simultaneously, the long-term debt of Amazon decreased from \$48,744 million to \$47,556 million. There are 500 preferred stockholders and 500 common stockholders. Besides, the retained earnings from dividends decreased from \$ 85,915 million to \$82,071 million by \$3,844 million.

The cash flow statement is the second financial statement. It reveals payments made in cash, cash equivalents, and restricted cash (Amazon, 2022a). The payments made according to the cash flow statement of Amazon (2022a) aimed to pay for operating activities, investing activities, financing activities, and other supplemental activities. Compared to the first quarter of 2021, the cash flow decreased by 171% (Amazon, 2022d). Such a decrease in cash flow informs readers to realize how corporates are going to a non-cash system of transactions.

The last financial statement is the income statement. The income statement informs the profit or loss of the company (Faccia et al., 2021). Under the section “Consolidated Statements of Operations,” Amazon (2022a, 10) reports product and service sales, operating expenses and income, income tax, earnings per share, etc. Amazon’s (2022a,1) report indicates an increase in net sales by seven percent in the first quarter of 2022. Besides, compared to the first quarter of 2021, the operating income decreased by \$ 5.2 billion (\$8.9 billion-\$3.7 billion). Consequently, the company lost \$3.8 billion in net amount. The CEO of Amazon, Andy Jassy, associates the challenges of Amazon’s performance to risks of the war in Ukraine, COVID-19, unstable market, and fluctuation of the foreign exchange rate.

Financial analysis is vital to check the trends in the past and understand the present to forecast the future. In this sense, the above analysis of the three core financial statements on Amazon.com would help financial managers check the company’s assets, liability, and capital (Karanovic et al., 2010). Furthermore, the analysis notified us of the shift in market patterns and the profitability of Amazon. In a competitive industry of the corporate world, financial managers working at Amazon need to be flexible to changing environments to control and mitigate challenges related to risk and uncertainties (Lester, 1998). Due to execution challenges, Amazon’s key financial performance indicators were reduced, not only strategic concerns (Kenny, 2020). Amazon’s operational, strategic, and risk-related short-term and long-term plans need improvement

to execute its customer-centric activities.

### **Financial Planning for the Future of Amazon.com., Inc**

This section of the paper focuses on analyzing the future state of Amazon.com. The study follows the theory of financial planning and management. Remarkably, the analysis focuses on the organization’s vision and long-term goals. Hence, this review uncovers the aim and objective of the business and the long-term goals.

According to Atrill (2019), a corporation’s primary objective is to maximize shareholder wealth. Financial managers prefer wealth maximization instead of profit due to drawbacks in measurement and definition. Profit maximization measurement does not consider risks and externalities (Arill, 2019). Consequently, corporations’ main goal is wealth maximization in the contemporary world.

In the 2020 letter to shareholders, the executive chairman of Amazon, Bezos (2021), mentioned that Amazon generated about 1.6 trillion dollars in shareholder wealth. On May 27th according to Forbes (2022), Bezos’s net worth was 140.8 billion dollars, showing a 4.1-billion-dollar change comprising a 2.97 percent increase within a day. Besides, other shareowners of Amazon, such as pension funds, universities, and 401(k)s, own 21 billion dollars as shareholder wealth (Bezos, 2021). Amazon expands its outstanding shares from 519 to 523 in the first quarter of 2022 (Amazon, 2022d). Such an increase in outstanding shares and decreasing share price will likely result in positive returns (Chakraborty, 2012).

To attain the primary objective of an organization, setting the strategic aim is vital (Jaques, 2005). Herewith, Amazon (2022c) has three main goals. These include realizing Amazon as the most customer-centric, best employer, and safest place to work in the corporate industry.

The customer-centric mission of Amazon aims to maximize customer satisfaction and consider customers at the center during the innovations and expansion plans of the corporation (Baboolal-Frank, 2021). Reviewing the customer side in demand analysis will pave to sell more supplies in the product market. As Manral and Harrigan (2021) stated, customer-centric objectives and implementation will likely help get market power and dominance. Thereby, the organization receives a favorable advantage to sustain itself in the market for the long run (Pardo-Jaramillo et al., 2020). This long-run sustainability motive cannot come true without innovation. Studies indicate that corporations’ performance increase due to innovation (Yin & Sheng, 2019). Hence Amazon plans to optimize the features of its innovative product AWS (Amazon Web Services), Kindle Direct Publishing, Kindle, Fire Tablets, Fire TV, Amazon Echo, Alexa, Amazon Studios, etc.

Amazon strives to keep its reputation by providing the best benefit to employees. Moreover, the company works to create the best work environment for operational to scientist-level experts (Bezos, 2021). Such practices make the company at the top-level meeting corporate social responsibility to keep its brand (Verčić & Ćorić, 2018). Simultaneously, as Bezos (2021) stated since about forty percent of injuries concern musculoskeletal disorders (MSDs), the company tries to improve work-related injuries by adopting new technology and initiatives. The other focus area on employees is expanding diversity, equity, and inclusion. Studies indicate that good employers respect diversity, prioritize equality amongst employees, and encourage initiatives and active participation of employees in community-based projects (Bowkett et al., 2017). Moreover, Amazon will expand investing in employees and the work environment to sustain itself as the leading top employer (Amazon, 2022a).

### **Gap Analysis, Plan, and Strategy to Bridge the Performance Gaps in Amazon**

In this section of the paper, the writer analyzes the performance gaps between the present and future of Amazon corporation. The writer will recommend alternative ways to bridge the identified gaps based on Amazon's official reports. Besides, the analysis comprises theories of financial management using gap analysis.

Managers are responsible for financial planning, appraisal of investment projects, financial decisions, capital market operations, and finance control (Atrill, 2019). Accordingly, managers in the corporate world operate in financial management, strategic management, and risk management. Gap analysis is an idea in strategic planning and management (Patel & Younger, 1978). Analyzing gaps helps evaluate present performance based on the proposed plan (Domenico et al., 2020). Hence, gap analysis is vital in performance management to identify discrepancies and challenges in operational and strategic activities during the planning and execution phase (Ningthoujam, 2017; Mohsen et al., 2020).

Mainly, as online goods sales depend on the global market, the COVID-19 pandemic adversely affected sales in recent years by creating demand shocks (Tao & Diao, 2021). A recent Amazon report showed international net sales reduced by six percent (Amazon, 2022d). The existing gap in global sales is about one thousand eight hundred ninety million dollars. Consequently, the operating income lowered above one hundred percent in international sales. The sales and operating income comparison compare the first quarters of 2021 and 2022.

Two further factors contributed to the reduction in sales (Amazon, 2022a). First, as inflation increased, the purchasing power of

customers decreased. Second, the international speed of delivery compared to domestic delivery was minimal. The combined effect of inflation and the delivery rate of parcels during COVID lowered the targeted sales. The strategy-execution gap will narrow as managers adopt a new approach, particularly to fasten the delivery speed and bridge the gap in sales (Mankins, 2017). For the long-run advantage, managers must design strategic procedures to optimize performance (Witta & Leonard, 2017).

Looking at the first quarter report of Amazon (2022a), the corporation faced a net loss of approximately four billion dollars. In theory, as loss increases, the rate of returns to shareholders will decrease. However, as Amazon leaders focus on taking advantage of the long-run shareholder value and wealth, such a decrease in profitability does not severely affect the company's performance (Bezos, 1997). Innovative CEOs like Bezos are forward thinkers and risk lovers. Hence, taking risks for the long-term advantage of the company and the action of CEOs to check and balance the ups and downs will assure the strength of leadership (Hansen et al., 2017; Lovallo et al., 2020). Investment decisions by solid administration and belief in results can reverse short-run pitfalls.

The COVID-19 pandemic had blessings and challenges. During the lockdown, millions of consumers purchased Personal Protective Equipment (PPE) and various goods online (Jassy, 2022). While such an increase in demand resulted in higher sales, the opening to normal also resulted in a supply shock. Thereby, there was a short-term shortage in logistics supply, which resulted in an increase in cost in the trial to fill the gap and satisfy customers' demand (Jassy, 2022).

The expansion strategy of fulfillment centers (doubling the number of centers) nationwide lessened the stress related to the speed of delivery. There was also a challenge in finding a workforce due to the influence of COVID-19 on the labor market. Lastly, the recent challenge of war between Ukraine and Russia starting in February 2022 triggered inflation by increasing the cost of fuel (Jassy, 2022). Nevertheless, as a company stayed in a competitive corporate world for more than twenty-five years, the customer-centric and innovative strategy, tenet, and principle of Amazon can potentially mitigate the challenges.

Bezos's (1997) strategy of building infrastructure and hiring the best and most talented labor force will help achieve Amazon's short-term and long-term goals. In turn, Amazon can reach the targeted sales by increasing the number of customers and establishing long-lasting relationships and customer retention. Besides, the organizational culture and principles are milestones to bridge the perfor-



mance gaps and the expected future (Amazon, 2022b). The sixteen Amazon leadership principles focus on improving the company's performance by focusing on customers, investing in innovation, and creating productive employees.

### Process of Communication for the Integrity of Amazon's Plan

In organizational leadership, effective communication is vital to have the same understanding and commitment to achieving firms' vision by attaining significant performance responsibly (Hamm, 2006). Same works for the case of financial planning. To avoid conflict, firms should have a clear organizational structure. As Amazon has a sophisticated system of organizational structure assisted by technology and agile leadership, the tendency to have miscommunication is lessened. The corporation has daily targets in sales and other operational activities. As Fiske (2011) mentioned, communication is essential in executing the financial and operational plan. For instance, in strategic areas of revenue optimization and change management, poor communication among teams and managerial bodies is likely to lead to failure in performance.

Conflicts may arise due to cultural and agency problems. For instance, as Atrill (2019) stated, corporations like Amazon need to consider the cultural differences of different nations while expanding outreach. To protect the organizational plan's integrity, companies must design compatible leadership styles, principles, and management practices corresponding to a particular location. As Madura (2020) mentioned, agency problems exist when managers decide based on personal interest instead of the shareholders' objective. Such problems prevail while corporations have foreign subsidiaries. Hence, firms must build systematic communication packages of business intelligence and management to avoid such incidents.

Data accuracy and responsibility are two major areas to work on during the planning and reporting activities. Nowadays, technology eases the tracking of each action corresponding to plans (Bouker et al., 2020). Simultaneously, companies need to build responsible employees for each act of activities (Paine, 1999). As integrity is related to the ethics and values of an organization, continuous awareness may boost to consider social and business deals (Chesnut, 2020). Hence, as further suggested by Chesnut (2020), moral reform such as leading by example, designing a code of conduct, communicating problems, establishing reporting system, and training matters to build stakeholders' and employees' integrity.

### Conclusion

Financial managers and expert-level practitioners play a significant role in analyzing corporate industries' overall ups and downs to meet the strategic goal of wealth maximization instead of a mere

profit. Multinational companies like Amazon.com became dominant in electronic commerce due to the adoption and massive investment in sophisticated, innovative-operational, strategic, and risk management systems. In the competitive and unprecedented digital era of the financial market, excellence and agility can pave the way to out-state and make extraordinary excellence in production and service exceeding sustainability challenges. When reviewing the recent financial statement of Amazon, the current asset showed a decrease in millions of dollars. Besides, due to the non-cash system of transactions, the cash flow statement reveals a more remarkable change in the rate of cash flow. Based on the recent income statement report, the company lost \$3.8 billion, which could be related to the supply chain challenge due to the war in Ukraine, the COVID-19 impact, instability of the market, and foreign exchange rate. Further studies might be required on how Amazon sustained excellence in its reputation. Besides, future researchers can review Amazon's business model practice of innovative culture, agile leadership, business intelligence, and management system using inferential analysis.

### References

- Amazon. (2022a, April). *Amazon.com announces first-quarter results*. <https://bit.ly/3sPQbJ7>
- Amazon. (2022b). *Amazon's global career site*. Amazon.Jobs. <https://www.amazon.jobs/en/principles>
- Amazon. (2022c, May). *Notice of 2022 Annual Meeting of Shareholders & Proxy Statement*. <https://rb.gy/mqwes2>
- Amazon. (2022d). *2022 Financial Results Conference Call Slides*. <https://bit.ly/3wBWDGe>
- Arnold, A. G., Ellis, R. B., & Krishnan, V. S. (2018). Toward effective use of the statement of cash flows. *Journal of Business and Behavioral Sciences*, 30(2), 46-62.
- Atrill, P. (2019). *Financial Management for Decision Makers* (ePub ed.) [E-book]. Pearson.
- Baboolal-Frank, R. (2021). Analysis of amazon: customer-centric approach. *Academy of Strategic Management Journal*, 20, 1-16.
- Bezos, J. (1997, March 21st). *Original 1997 Letter to Amazon Shareholders*. About Amazon. <https://rb.gy/aplho8>
- Bezos, J. (2021, April 15th). 2020 Letter to Shareholders. *About Amazon*. <https://www.aboutamazon.com/news/company-news/2020-letter-to-shareholders>
- Bouker, M., Wielaard, N., & Geelen, F. (2020). *The CFO in Pole Position: Leading next-generation decision-making in a data-driven organization* [E-book]. Management Impact Publishing.
- Bowkett, C., Hauptmeier, M., & Heery, E. (2017). Exploring the role of employer forums – the case of business in the community wales. *Employee Relations*, 39(7), 986-1000. <https://doi.org/10.1108/ER-11-2016-0229>

- Chakraborty, M. (2012). The equity market around the ex-split date: Evidence from India. *Vikalpa*, 37(1), 57-68. <https://doi.org/10.1177/0256090920120105>
- Chesnut, R. (2020, July 30th). How to Build a Company That (Actually) Values Integrity. *Harvard Business Review*. <https://hbr.org/2020/07/how-to-build-a-company-that-actually-values-integrity>
- Domenico, A., De, S. V., Scala, S., & Fasolino, A. R. (2020). A model-driven engineering approach for supporting questionnaire-based gap analysis processes through application lifecycle management systems. *Software Quality Journal*, 28(2), 535-565. <https://doi.org/10.1007/s11219-019-09479-w>
- Erdamar, C., Adiloglu, B., & Gürsoy, T. (2013). Financial indicators of steady success in manufacturing companies: Research on big manufacturing companies in turkey. *Advances in Management and Applied Economics*, 3(4), 217-234.
- Faccia, A., Manni, F., & Capitanio, F. (2021). Mandatory ESG reporting and XBRL taxonomies combination: ESG ratings and income statement, a sustainable value-added disclosure. *Sustainability*, 13(16), 8876. <https://doi.org/10.3390/su13168876>
- Fiske, R. M. (2011, July 26th). The Business of Communicating Values. *Harvard Business Review*. <https://hbr.org/2011/07/the-business-of-communicating>
- Forbes. (2022). *The world's real-time billionaires: Today's Winners and Losers*. <https://rb.gy/crkr1g>
- Hamm, J. (2006, May 1st). The Five Messages Leaders Must Manage. *Harvard Business Review*. <https://hbr.org/2006/05/the-five-messages-leaders-must-manage>
- Hansen, M., Ibarra, H., & Peyer, U. (2017, January 26th). The Best-Performing CEOs in the World. *Harvard Business Review*. <https://hbr.org/2010/01/the-best-performing-ceos-in-the-world>
- Jaques, T. (2005). Systematic, objective setting for effective issue management. *Journal of Public Affairs*, 5(1), 33-42. <https://doi.org/10.1002/pa.3>
- Jassy, A. (2022, April 14th). *2021 Letter to Shareholders*. About Amazon. <https://www.aboutamazon.com/news/company-news/2021-letter-to-shareholders>
- Karanovic, G., Bogdan, S., & Baresa, S. (2010). Financial analysis fundamentals for assessing the value of the company. *UTMS Journal of Economics*, 1(1), 73-84.
- Kenny, G. (2020). *Don't Mistake Execution for Strategy*. Harvard Business Review. <https://bit.ly/3PyLEES>
- Krishnan, L. R. K. (2021). Financial literacy: driving business results through the development of employees. *Journal of the International Academy for Case Studies*, 27(2), 1-2.
- Lester, R., Piore, M., & Malek, K. (1998). *Interpretive Management: What General Managers Can Learn from Design*. Harvard Business Review.
- Lovallo, D., Koller, T., Uhlaner, R., & Kahneman, D. (2020, February 19). Your Company Is Too Risk-Averse. *Harvard Business Review*. <https://hbr.org/2020/03/your-company-is-too-risk-averse>
- Madura, J. (2020). *International Financial Management* (14th ed.). Cengage Learning.
- Mankins, M. (2017, November 20th). 5 Ways the Best Companies Close the Strategy-Execution Gap. *Harvard Business Review*. <https://hbr.org/2017/11/5-ways-the-best-companies-close-the-strategy-execution-gap>
- Manral, L., & Harrigan, K. R. (2018). Corporate advantage in customer-centric diversification. *Journal of Strategic Marketing*, 26(6), 498-519. <https://doi.org/10.1080/0965254X.2017.1299789>
- Mihajlovic, d., Stankovic, s., & Nikolic, m. (2015). Analysis financial balance as base management company. *Ekonomika*, 61(1), 141-149.
- Mohsen, A., Farhadinia, M. S., Cushman, S. A., Mahmoud-Reza, H., Nezami, B. B., Housman, J., & Macdonald, D. W. (2020). Species and space: A combined gap analysis to guide management planning of conservation areas. *Landscape Ecology*, 35(7), 1505-1517. <https://doi.org/10.1007/s10980-020-01033-5>
- Ningthoujam, S. (2017). Training and development: Theories and applications. *South Asian Journal of Management*, 24(4), 173-177.
- Paine, L. S. (1999, April 1st). Managing for Organizational Integrity. *Harvard Business Review*. <https://hbr.org/1994/03/managing-for-organizational-integrity>
- Pardo-Jaramillo, S., Muñoz-Villamizar, A., Osuna, I., & Roncancio, R. (2020). Mapping research on customer centricity and sustainable organizations. *Sustainability*, 12(19), 7908. <https://doi.org/10.3390/su12197908>
- Patel, P., & Younger, M. (1978). A frame of Reference for Strategy Development. *Long Range Planning*, 11(2), 6.
- Sandeep, V., & Pohutezhini, B. (2019). The E-commerce revolution of amazon.com: A quarterly peer-reviewed multi-disciplinary international journal. *Splint International Journal of Professionals*, 6(4), 33-39.
- Shahwan, Y. (2008). Qualitative characteristics of financial reporting: A historical perspective. *Journal of Applied Accounting Research*, 9(3), 192-202. <https://doi.org/10.1108/09675420810919748>
- Tao, C., & Diao, G. (2021). The dynamic impacts of the COVID-19 pandemic on log prices in China: An analysis based on the TVP-VAR model. *Forests*, 12(4), 449. <https://doi.org/10.3390/f12040449>
- Verčić, A. T., & Ćorić, D. S. (2018). The relationship between reputation, employer branding, and corporate social responsibility. *Public Relations Review*, 44(4), 444.
- Wiita, N., & Leonard, O. (2017, November 23). How the Most Successful Teams Bridge the Strategy-Execution Gap. *Harvard Business Review*. <https://hbr.org/2017/11/how-the-most-successful-teams-bridge-the-strategy-execution-gap>
- Yin, M., & Sheng, L. (2019). Corporate governance, innovation input and corporate performance: Empirical research based on endogeneity and industry categories. *Nankai Business Review International*, 10(1), 120-137. <https://doi.org/10.1108/NBRI-10-2018-0057>

# A Retention Study on the STEM Student Population at University of the Southwest

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## Abstract

The Hispanic population, 14.9%, consists of the total workforce, but less than half (6.5%) is in science, technology, engineering, and mathematics (STEM) fields (Landivar, 2013). To enlarge the Hispanic STEM workforce, consistently high retention at Hispanic Serving Institutions (HSIs) becomes essential and imperative. University of the Southwest (USW) was one of four HSIs to participate in a National Science Foundation (NSF) funded retention study led by Tuskegee University. As part of the study, focus groups with undergraduate students, graduates, faculty, administrators, staff and a survey were conducted at USW. Data was collected and analyzed using qualitative and statistical methods such as multiple regression. The results, which are shared in this paper, describe the addition of new programs and the creation of new co-curriculum activities at USW. In addition, a new scholarship and student health coverage are offered, increasing enrollment and retention at USW. The research study was funded by NSF HRD Grant # 1623237.

**Keywords:** retention, STEM, Hispanic serving institution

## Introduction

Most technological innovation and patents are linked to the disciplines of science, technology, engineering, and mathematics (STEM). In the last 50 years, more than half of America's sustained economic growth has been fueled by its engineers, scientists, and advanced-degree technologists because of their education, scientific knowledge, and technological innovation (Shultz, Metz, Lowes, McGrath, & McKay, 2008). However, many challenges lie ahead, such as the shortage of American workers to meet the demand for a STEM workforce. One way to satisfy these demands is to educate and train a workforce that fills the need for innovation and development in STEM fields. The White (non-Hispanic) population composes 66.9% of the total U.S. workforce and 70.8% in STEM fields, while the Asian population constitutes 5.5% and 14.5%, respectively (Landivar, 2013). Non-Asian minority populations, including Hispanics, are underrepresented in STEM professions. The Hispanic population accounts for only 14.9% of the workforce and 6.5% in STEM fields (Landivar, 2013). The National Science Board (2014) found that 40% of Hispanic or Latino freshmen intended to major in science or engineering from 2010 to 2012. However, the retention rate dropped during the study by Mitchell (2011). Mitchell (2011) pointed out that factors contributing to underrepresented minority student success in STEM were the following: (a) an academically rigorous curriculum, (b) cumulative GPA, (c) percent

of classes completed, and (d) percent of classes passed. Researchers have described three categories: motivation, extrinsic, intrinsic, and amotivation (Vallerland et al., 1992; Petersen et al., 2009; Brouse et al., 2010). Emotion was related to two feelings: perceived stress (Petersen et al., 2009) and self-efficacy (Wadsworth et al., 2007). Social factors included social involvement and support (Cutrona & Russell, 1987). Structural factors consisted of the curriculum scholarship, financial, and professional programs; tutorial and support centers and programs; infrastructure and resources; and other institutional programs and resources intended to support students (Zajacova et al., 2005).

The foundational study on STEM student retention in HSIs was led by Tuskegee University and funded by the National Science Foundation. University of the Southwest (USW) was chosen as one of the four HSI participants. The study's goals were to identify factors that influence the retention of students in STEM disciplines, establish an aligning action plan in each HSI in light of important factors, and execute the plan to improve retention at the institution.

## Methods

### A. USW data collection

A researcher from Tuskegee University visited University of the Southwest, and coordinated by a representative on campus. Focus group interviews were arranged to collect the data. Later, the USW

representative was invited to attend a workshop in which Dr. Garrett and other participants disseminated the results from the foundational study and individual study, respectively.

There were two phases to obtain the data. In phase one, focus group interviews and a survey were conducted with small samples of current undergraduate students, graduates, faculty, administration, and staff. Later in phase two, Dr. Garrett implemented similar surveys with larger samples online. For the students and graduates, the emphasis was on educational experiences, success, and obstacles to their studies. For the faculty, administrators, and staff, the emphasis was to determine whether the institution provides a good working environment and helps faculty to influence student motivation and success.

### B. Focus group interviews and survey

The interviewees were divided into three focus groups: student; graduate; and faculty. The groups had between five and 10 participants who answered a set of questions presented by the researcher during the interview for each group. The recordings were saved and returned to the host institution (Tuskegee University) for further analyses. The participants also took the survey separately. Focus group data was openly coded by researchers, and codes were entered into MaxQDA qualitative analysis software. The unit of analysis was one semantic paragraph, and the methodology was constant comparative analysis (Creswell, 2007; Garrett, Huang, & Carter, 2017; Glaser & Strauss, 1967). The software aided the re-

searchers with grouping and merging codes with similar themes and developing a framework of key ideas important to institution STEM stakeholders.

### C. Online student/graduate survey

Online survey results were obtained from 22 USW undergraduate students and five USW graduates. The survey examined psychosocial and structural factors impacting retention in STEM. The scale of the factors was assigned as 4 = strongly agree, 3 = somewhat agree, 2 = somewhat disagree, 1 = strongly disagree, and 0 = not applicable. To show which emotional factors produced greater stress, any positively worded items were reverse coded. Higher survey scores indicated increased emotional stress or a more negative opinion. Means were calculated for each survey item for the 27 students and graduates who responded, with the response of 0 = not applicable omitted from the calculation to give a mean only for those to whom the item applied. Participants who did not reply or replied with “no opinion” will be in the findings.

### D. Aligning action plan

Based on the analyses of each factor that influenced the retention of STEM students, USW set up a college strategic plan containing five goals followed by different objectives (Table 1). An aligning action plan was established and put into practice to improve the factors highlighted by the participant students through the interviews and surveys.

**Table 1** College of Arts and Sciences strategic plan

<b>Goal 1 Increase student academic performance</b>	<b>Goal 2 Increase enrollment</b>	<b>Goal 3 Expand academic programming</b>	<b>Goal 4 Establish a Program of Research</b>	<b>Goal 5 Improve technology</b>
<ul style="list-style-type: none"> <li>• <b>Objective 1.1 Increase rigor</b> <ul style="list-style-type: none"> <li>• Rubrics for all course assignments</li> <li>• Degree paths for athletes</li> <li>• Midterm student evaluations</li> <li>• Systematic assignment review and rotation or replacement</li> <li>• Increase Internships</li> </ul> </li> <li>• <b>Objective 1.2 Honors Track</b> <ul style="list-style-type: none"> <li>• Identify eligible programs and honors core</li> <li>• Degree plans with area of specialization</li> <li>• Opportunities for student leadership</li> <li>• Research requirement</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Objective 2.1 Recruitment</b> <ul style="list-style-type: none"> <li>• Establish/enhance relationships with HHS, LHS, NMJC and local hospitals</li> <li>• Identify alternative sources of scholarship for non athletes</li> <li>• Regular recruitment trips in the community</li> <li>• Program materials and swag</li> <li>• Commercial</li> <li>• Increase opportunities for non-athletes to be involved on campus</li> </ul> </li> <li>• <b>Objective 2.2 Community on campus</b> <ul style="list-style-type: none"> <li>• Monthly or bi-semester cross-disciplinary social events</li> <li>• SAS student/faculty lounge</li> <li>• Separate women and men's small groups</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Objective 3.1 Master's programs</b> <ul style="list-style-type: none"> <li>• RN to BSN</li> <li>• School Psychology</li> <li>• Forensic Science with CJ &amp; FP tracks</li> <li>• Athletic Training</li> <li>• Christian Studies</li> <li>• TA positions</li> </ul> </li> <li>• <b>Objective 3.2 Undergrad Programs</b> <ul style="list-style-type: none"> <li>• Computer Science</li> <li>• Chemistry - Minor + a couple courses</li> <li>• Math - Expand Minor to Major</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Objective 4.1 Identify funding sources</b> <ul style="list-style-type: none"> <li>• Mini-grants</li> <li>• Non-profit to funnel grants</li> <li>• Professional development for grant writing</li> </ul> </li> <li>• <b>Objective 4.2 Research lab</b> <ul style="list-style-type: none"> <li>• Practical component to all research courses</li> <li>• Lab manager(s) and RA positions</li> </ul> </li> <li>• <b>Objective 4.3 Conference presentation and journal publication</b> <ul style="list-style-type: none"> <li>• Student presentation and writing workshops</li> <li>• Travel scholarships</li> <li>• Yearly student research colloquium</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Objective 5.1 Building upgrades</b> <ul style="list-style-type: none"> <li>• Create more outlets in classroom</li> <li>• Smartboards</li> </ul> </li> <li>• <b>Objective 5.2 Instructional technology</b> <ul style="list-style-type: none"> <li>• Increase use of different technology in classroom</li> <li>• Faculty sharing in monthly meetings</li> </ul> </li> <li>• <b>Objective 5.3 Technology resource center</b> <ul style="list-style-type: none"> <li>• Establish technology committee</li> <li>• Bi-semester workshops</li> <li>• Student-worker positions</li> </ul> </li> </ul>

## Results

### A. Focus Groups

The survey of the focus groups was to hear the voices of students from USW to gain a better understanding of the major factors impacting minority retention in STEM disciplines. The students' comments from focus group interviews emphasized beneficial aspects of their USW education, some of which were mentioned by undergraduate student Hunter<sup>1</sup>:

*In high school, I could've got pushed a little harder because I breezed through high school, and I don't remember even picking up a book in high school [laughter]. But when I came here, it got a lot harder. But I've been able to keep a 4.0, but that's because I've had good professors. And the benefit of having smaller classes is that I can pretty much ask whatever question however many times I need to. And they have the time to, instead of having a class that—I have some friends that have 300 people in their class, and they don't have the resources that I do because even if I have a question outside of class, these professors have office hours that they're available to sit down, and help you, and talk to you. That's why I think the education here, for me, has been pretty solid, because I've had resources of professors who are willing to help, and that's helped me achieve my educational goals.*

Among the benefits mentioned were bus Wifi available for athletic students during sports trips; family housing offered for adult students, so their families were around during the study; and one-on-one meetings with coaches and financial-aid assistants for first-generation students to ease the pressure from financial concerns and family responsibilities. Emotional support, care from faculty, and freshmen tutoring by junior and senior students were also mentioned as vital. Some challenges were also mentioned, as noted in these student comments:

*While playing tennis, the hotels or the school buses provided for us with Wi-Fi. And sometimes we're able to use it, but most of the time, no, because it's pretty horrible. And so you do come back, especially if you have online classes. And it's just really hard to get back into it, but your professors work with you.*

(Jay, undergraduate student)

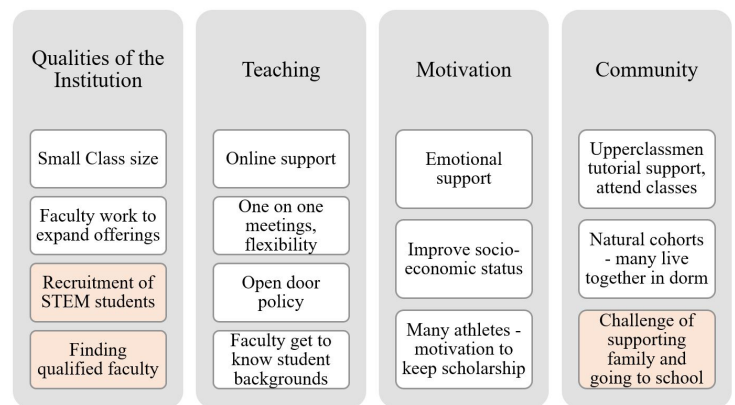
*A big distraction for me has been my mom was diagnosed with cancer. So just kind of dealing with that, and having your support system crumble back home, it's kind of hard to stay focused out here.*

(Debbie, undergraduate student)

Often, the Wi-Fi on the buses was not stable, and it was hard for students to catch up with their classes' progress when they came back from the trips. In addition, some students had classes rescheduled and family pressures on their education.

The comments of the faculty and staff from focus group interviews underscored the positive aspects such as the development of pedagogical training and cross-cultural communication; faculty participation at student events; faculty help in finding the required internships for seniors; and faculty help and support to seniors in preparing applications to graduate schools or positions in business and industry.

Below is a summary of positive and negative features that resulted from the focus groups (Figure 1). The white background indicates positive items, and the red indicates negative items needing to be addressed. The institution provides an excellent learning environment for the students in qualities of the institution, teaching, motivation and community support. However, recruiting STEM students, finding qualified faculty, and the challenge of supporting family while attending school can be improved.



**Figure 1** Framework of key ideas emerging from focus group data

The results in the figure were shared with the University and it was highly recommended to set up an action plan addressing the three areas to improve.

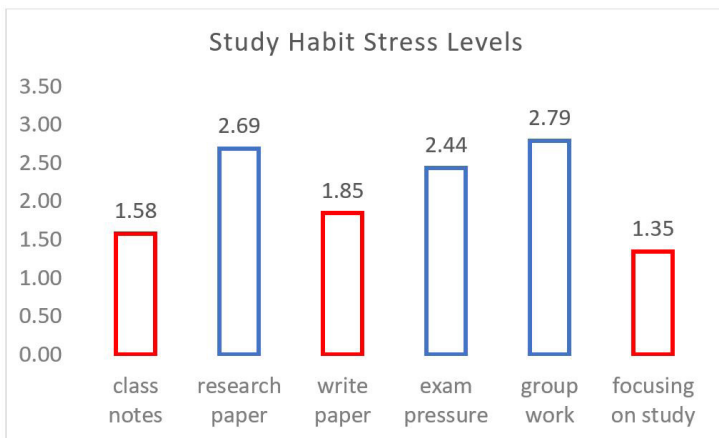
### B. Surveys

The results of the data analyses from the large group survey are divided into four categories: study habits (Fig. 2), self-reliance (Fig. 3), financial concerns (Fig. 4), and coping with stress (Fig. 5). The result discussed below for each category is given in the corresponding figure based on the 4-point scale in which 4 = strongly agree, 3 =

<sup>1</sup> Names have been changed.

somewhat agree, 2 = somewhat disagree, and 1 = strongly disagree.

In Figure 2, the average of the responses to the positive items was about less than 2 while the average of the negative items was about 2.4. This result indicates that completing research, exam pressures, and group work methods need to be addressed to improve student study habits when they study at the institution. In future research studies, the possible explanations can be investigated. For example, a term paper would produce greater stress if they are first-generation students. Trouble working in groups could be due to minorities not finding connection with group members of other ethnic groups.



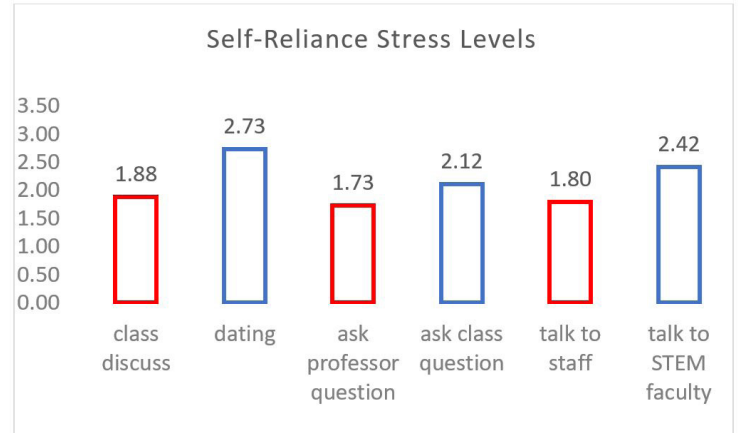
**Figure 2:** The test values for study habit (the legend given below, reverse coded items in red).

Numbers in parentheses indicated the number of responses (responded with 1-4/did not respond/no opinion).

1. Taking good class notes comes easily to me. (26/1/0)
2. Researching a term paper makes me anxious. (26/1/0)
3. Writing course papers comes easily to me. (26/1/0)
4. The pressure to do well on my exams makes it hard for me. (25/2/0)
5. Group assignments are harder to do than individual assignments. (24/1/2)
6. I can focus on my studying when I set aside the time to do so. (26/1/0)

The items in Figure 3 are related to student self-reliance. Students did not have confidence in communicating with faculty in their STEM field and their peers (items 2 and 6). However, they were more comfortable in class discussions, asking a professor questions, and talking to service staff on campus (items 3 and 5). Possible reasons, such as the language barrier, personal disposition,

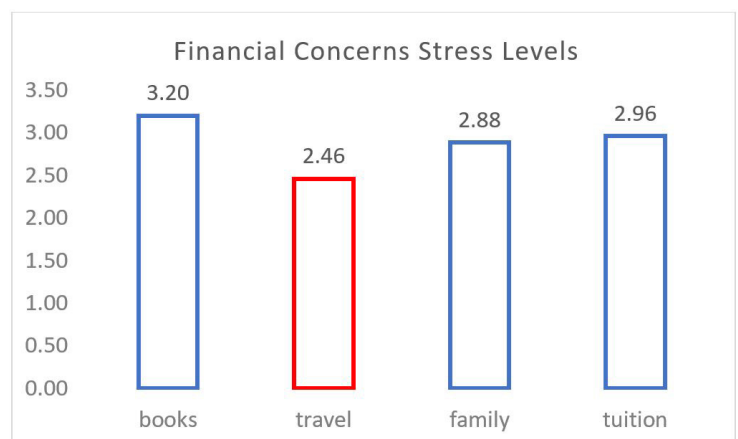
study habit, etc., could be explored in additional studies.



**Figure 3:** The test values for self-reliance (the legend given below, reverse coded items in red)

1. Participating in class discussions comes naturally to me. (26/1/0)
2. Asking someone to go out with me is very hard. (26/1/0)
3. Asking a professor a question comes easily to me. (26/1/0)
4. I find it hard to ask questions in class. (26/1/0)
5. Talking to the secretaries and housekeeping personnel is absolutely tough for me. (25/1/1)
6. Talking to the faculty in my STEM field is stressful. (24/1/2)

Financial concerns (Fig. 4) produced the highest stress levels concerning higher education. Students are worried about book expenses, tuition, and living expenses. The item of least worry was financial support to travel back and forth between home and campus (item 2).



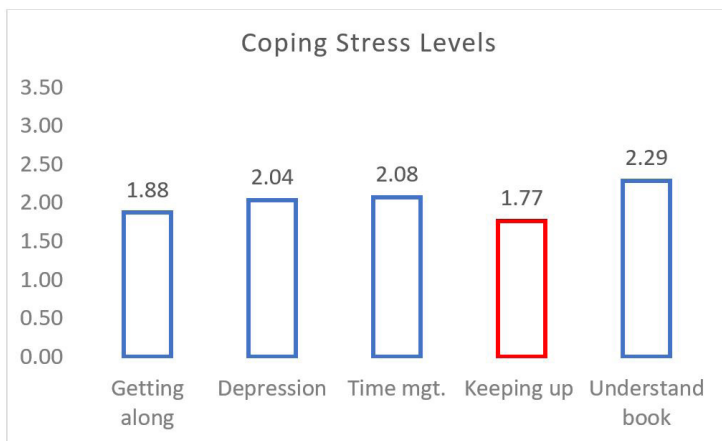
**Figure 4:** The test values for financial concerns (the legend given below, reverse coded items in red)

1. I am worried about paying for books and other expenses at

college. (25/1/1)

2. Paying for travel to school and back home is not a problem. (26/1/0)
3. My family's financial situation adds to my worries about how to pay for school. (26/1/0)
4. I am concerned about how I am going to pay for my tuition. (25/1/1)

Regarding everyday stress (Fig. 5), the results were more moderate; understanding the textbook was tied to the greatest stress. Keeping up with schoolwork produced the least amount of stress.



**Figure 5:** The test values for coping with stress (the legend given below, reverse-coded items in red)

1. Trying to get along with others I live with produces a lot of stress. (24/1/2)
2. I get depressed sometimes because there is no way I can accomplish what I plan to do. (26/1/0)
3. Effectively managing my time has been difficult to do. (26/1/0)
4. Keeping up to date with my schoolwork is no problem. (26/1/0)
5. Understanding my textbook is quite stressful. (24/1/2)

Results for stress related to studying habits show that students have challenges with group work, research, and exams. Changing their study habits may include such measures as always reviewing their notes before starting an assignment; avoiding distractions while studying; starting with the most difficult subject, and learning to use study groups effectively. Examining stress levels related to self-reliance shows that students may need help improving their ability to participate in class discussions and communicate with faculty in their STEM field and with their peers. Students' financial concerns were identified as the costs for the books, tuition, and

living expenses; however, they were better able to travel back and forth. Coping levels show that students experience less stress keeping up but more stress understanding the textbook.

## Discussion and conclusion

### A. The action plan and its outcomes

An action plan containing five objectives was implemented. They are 1) to increase enrollment by recruiting STEM students and keeping them until graduation; 2) to identify alternative sources of scholarship for academic students (not athletes); 3) to expand academic programs by finding qualified faculty; 4) to establish research programs to inspire students who lack interest in undergraduate research. The University of the Southwest has a variety of study groups and professional groups, including Sigma Tau Delta (international English honor society), Pi Gamma Mu Epsilon (international honor society in social sciences), and Healthcare Occupations Group which is a career exploration and preparation student organization for USW students interested in jobs in the healthcare field. Further, USW encourages students to join any of the study or professional groups to adjust to the academic environment, to improve communication with faculty and fellow students, to build good study habits, and to prepare for careers. To help students with financial concerns, the administration plans to establish new scholarships and optimize the office of financial aid by increasing staff.

The outcomes of performing action plans are encouraging and consistent.

#### 1) Recruitment and new programs

To increase enrollment, the recruiters publicize the institution at local high schools, a junior colleges, hospitals, and labs. Consequently, between 2017 and 2019, the total number of STEM students increased by 71.3% from 23 to 80 and sustained between 50 and 60 students. This range has been consistent since then. New emphases, including pre-nursing, pre-physical therapy, and environmental science, were added. Hiring a qualified faculty member is critical to ensure the quality of learning.

The university has begun several measures to attract students to STEM fields. First, new Master of Science emphases such as forensic biology and genetics have been launched to offer opportunities for students to continue graduate STEM study at USW. The eligible undergraduate alums who pursue the master's degree online will receive free tuition in the academic year 2020-2021. Second, USW has associated with the U.S. Integrated Media (USIM) agency, the fastest-growing independent media agency in the country. USIM has designed a website for online learning programs. After receiving

the leads from USIM, USW enrollment counselors will contact the university applicants promptly to facilitate their registration. Third, all the students who decide to attend the institution won't pay for textbooks, which are embedded in every Blackboard course.

## 2) Co-curricular activities

To establish a research project, STEM faculty used the relationships with local labs and nearby large universities. The faculty performed STEM research project by cooperating with the Wastewater Treatment Plant in Hobbs. Another was carried out in a USW lab with the University of New Mexico. The institution provides scholarships for the students who were designated as officers of the STEM research group and invited an additional four undergraduate students to join. Since 2018, the research group launched two research projects in environmental science and genetics, conducted experiments, and jointly published the results (Morey et al., 2019; Stock et al., 2020). Moreover, internal funding has been allocated to the undergraduate research program with administrative support. The faculty members have finished the following.

- Organized and conducted a field trip to University of New Mexico
- Visited health professional schools at UNM
- Discussed the opportunity to collaborate
- Started undergraduate research projects in environmental science and genetics
- Delivered poster presentations about the results of the Annual New Mexico Research Symposium in Albuquerque
- Published two papers in the *New Mexico Journal of Science* and the *Southwest Journal of Arts and Sciences*, respectively.
- Arranged field trips to the Wastewater Treatment Plant in Hobbs, a local science exhibition, and an animal hospital.

## 3) New scholarship grants (USW, 2020)

In addition to the existing grants, i.e., the Presidential Grant, Provost Grant, and Scholar-Athlete Grant, the USW administration has initiated several additional grants. The first is a local matching grant. Any Lea county prospect receiving a local scholarship may be awarded a matching sum of up to \$6,000. A prospect must be a Lea county resident and incoming freshman or transfer student. This grant applies only to locally awarded scholarships. The second is a universal college grant (4-year program). Qualified students who are admitted to USW with a 3.0-3.49 GPA will receive a \$4,000 scholarship per semester (for a maximum of four semesters). Students with a 3.5-4.0 GPA will receive a \$5,000 scholarship per semes-

ter (for a maximum of four semesters). The third is the fast-track grant (2-year program), designed as a partnership between area high schools, New Mexico Junior College (NMJC), and USW. It is intended to recognize the value of dual-credit courses taken by high school students after they complete additional credits and receive a degree from NMJC. The same students also have an opportunity to complete their undergraduate degrees at USW in as little as one year (two or three semesters). Under the fast-track program, students are eligible to complete up to 60-80 hours of undergraduate credit through dual credit and direct credit awarded by NMJC. Students may then be admitted as full time at USW to complete the remaining 40-60 hours of upper-division credits.

## 4) Student health coverage

USW offers innovative solutions to help keep students healthy. It has partnered with Teladoc Health to provide a HealthiestYou membership to all students at no cost to them. A student at USW can use the virtual healthcare benefit as follows: Access to a doctor 24 hours a day, 365 days a year; unlimited and free service (no copay); physicians can diagnose, treat, and prescribe for acute illnesses, i.e., flu, allergies, upper respiratory infections, earache, sinusitis, and strep throat.

## B. The retention percent

The enrollment percentage dropped slightly at USW in the academic year 2017 to 2018 (Table 2). The athletic department director had left suddenly, and administration delayed a candidate search for the position. The coaches had low urgency to recruit students. The situation was resolved swiftly by carrying out the action plan. Student retention went up considerably in the academic year 2018 to 2019.

Term	Total Students	Biology students		Percent of enrollment in biology (%)	Retention percent (%)
		Registered	Retained		
Fall 17	403	81		21.1	
Spring 18	361	54	23	15.0	28.4
Fall 18	442	55	22	12.4	40.7
Spring 19	399	54	50	13.5	90.9

Note: Enrollment percent = the number of registered biology students / the number of total students × 100%; Retention percent = the number of retained biology students / the number of registered biology students × 100%

**Table 2** The retention data at University of the Southwest 2017-2019



In conclusion, the findings of focus group interviews supported distinctive learning environments at USW from various perspectives (student, faculty, and staff). As seen in Figure 1, focus group results highlighted the need to improve the recruitment of STEM students, find qualified faculty, and help students balance supporting family and going to school. The survey outcomes demonstrated that the students were comfortable with their note-taking skills and keeping up with their coursework. However, students found preparing for exams, writing research papers, doing group work, talking to STEM faculty, and understanding their textbook more stressful. Financial issues produced the greatest level of stress. During this study and beyond, the institution has carried out various measures, such as adding new programs, increasing enrollment, creating co-curricular activities, and offering new scholarships and student health coverage. The effect on retention is evident and sustainable.

Suggestions for future research include creating a predictive model and incorporating graduation rates. A predictive model can explore each factor separately in a quantitative way. The graduation rate can be incorporated into the model. The correlation between factors impacting retention and graduation may be investigated.

University of the Southwest has benefitted from executing the action plan. The expansion of recruitment, the addition of new programs, co-curricular activities, scholarships, and student health coverage have buoyed the institution to the next level of student satisfaction, retention, and recruitment. New retention data will be examined to assess whether institutional actions are setting a rising course.

## References

- Astin, A. (1999). Student Involvement: A development theory for higher education. *Journal of College Student Development*, 40(5): 519-529.
- Bean, J. (1981). *The synthesis of a theoretical model of student attrition*. Paper presented at the annual meeting of the American Educational Research Association, Los Angeles. Retrieved from <https://files.eric.ed.gov/fulltext/ED202444.pdf>.
- Brouse, C., Basch, C., LeBlanc, M., McKnight, K., & Lei, T. (2010). College students' academic motivation: Differences by gender, class, and source of payment. *College Quarterly*, 13(1), 1-10.
- Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*. Sage Publications
- Cutrona, C., & Russell, D. (1987). The provisions of social relationships and adaptation to stress. In Jones, H., & Pearlman, D., (Eds.). *Vol. 1. Advances in personal relationships*, pp. 37-67. Jai Press Inc.
- Garrett, L., Huang, L., & Carter, V. (2017). Findings in STEM retention at historically Black colleges and universities. *Negro Educational Review*, 68(1-4), 81-108,157.
- Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Aldine.
- Higher Education Research Institute (HERI). (2014). Undergraduate teaching faculty: The 2013-2014 HERI faculty survey. Retrieved from <https://www.heri.ucla.edu/monographs/HERI-FAC2014-monograph-expanded.pdf>.
- Huber, S., & Huber, O. (2012). The Centrality of religiosity scale (CRS). *Religions*, 3, 710-724.
- Iqbal A., & Kokash, H. (2011). Faculty perception of stress and coping strategies in a Saudi private university: An exploratory study. *International Education Studies*, 4(3), 137-149.
- Landivar, L. (2013). *Disparities in STEM employment by sex, race, and Hispanic origin*. American Community Survey Reports, 1-25. U.S. Census Bureau.
- Mitchell, S. (2011). *Factors that contribute to persistence and retention of underrepresented minority undergraduate students in science, technology, engineering, and mathematics (STEM)*. (Dissertations 657). Retrieved from <https://aquila.usm.edu/dissertations/657>.
- Morey, M., Stringfellow, H., Wilson C., & Wu, Y. (2019). The analysis of the water quality for different samples in Hobbs. *New Mexico Journal of Science*, 53(1), 4-10.
- National Science Board. (2014). *Science and engineering indicators 2014* (NSB 14-01). National Center for Science and Engineering Statistics (NCSES). National Science Foundation.
- Petersen, I.-H., Louw, J., & Dumont, K. (2009). Adjustment to university and academic performance among disadvantaged students in South Africa. *Educational Psychology*, 29(1), 99-115.
- Robbins, S., Lauver, K., Le, H., Davis, D., & Langley, R. (2004). Do psychosocial and study skill factors predict college outcomes? A meta-analysis. *Psychological Bulletin*, 130(2), 261-288.
- Schultz, D., Metz, S., Lowes, S., McGrath, B., & McKay, M. (2008). *Engineering our future New Jersey: Guidance counselors mission critical*. In Stevens Institute of Technology, The proceedings of the American Society for Engineering Education Mid-Atlantic (pp. 1-10). Stevens Institute of Technology.
- Spector, P. (1985). Measurement of human service staff satisfaction: Development of the job satisfaction survey. *American Journal of Community Psychology*, 13(6), 693-713.
- Spreitzer G. (1995). An empirical test of a comprehensive model of intrapersonal empowerment in the workplace. *American Journal of Community Psychology*, 23(5), 601-629.
- Stock, U., Stringfellow H., & Wu Y. (2021). The study on genetic patterns of eye color and wing presence in *Drosophila melanogaster*. *Southwest*

*Journal of Arts and Sciences*, 1(1), 38-41.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research*, 45, 89-125.

Trice, A. (1985). An academic locus of control scale for college students. *Perceptual and Motor Skills*, 61, 3\_suppl, 1043-1046.

University of the Southwest. (2020). Scholarships. Retrieved from <https://www.usw.edu/Admissions/Financial-Aid/Scholarships>

Vallerland, R., Pelletier, L., Blais, M., Brière, N., Senécal, C., & Vallières, E. (1992). The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement*, 52, 1,003-1,017.

Wadsworth, L., Husman, J., Duggan, M., & Pennington, M. (2007). Online mathematics achievement: Effects of learning strategies and self-efficacy. *Journal of Developmental Education*, 30(3), 6-14.

Zachary L. (2012). *The Mentor's guide: Facilitating effective learning relationships* (2nd ed.). John Wiley & Sons.

Zajacova, A., Lynch, S., & Espenade, T. (2005). Self-efficacy, stress, and academic success in college. *Research in Higher Education*, 46(6), 677-706.

# Career Barriers Still exist for Black Women in the Workforce: a Qualitative Study

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## Abstract

This qualitative study describes the barriers encountered by Black women in the leadership journey. Seo et al. (2017) highlight the problem of vertical gender segregation in top management at many organizations. Even though studies attest there are more similarities than differences in leadership ability between men and women, resistance remains in promoting women to executive leadership positions. Women continue to be thought of as less capable of fulfilling the duties of a leader despite mounting evidence of their ability to perform just as well (Seo et al., 2017). Less than 1 percent of Black women in the workforce have broken through the glass ceiling to rise to the C-Suite (Catalyst, 2022; Corneille et al., 2019). The lack of leadership diversity was camouflaged in earlier years, but changes in the national demographics underscore the underrepresentation of minorities (Poole et al., 2021). Frequent barriers to career advancement for Black women include discrimination, microaggression, and internalized feelings of inadequacy. The findings of the study add to the literature on Black women leaders and provide recommendations to improve career outcomes for aspiring Black women.

Keywords: Black women leaders, barriers, adversity, resilience, discrimination, microaggression

## Background

Research confirms that Black women remain underrepresented in both middle and senior management positions (Bloch et al., 2021). Male dominance in the workforce allows the persistence of masculine culture and an oppressive mindset against women. Deeply rooted organizational cultures devalue the potential of women as executive leaders (Seo et al., 2017). Historical research confirms social status among groups is unequal, particularly across gender and race (Seo et al., 2017). Black Women continue to be thought of as less capable of fulfilling the duties of a leader despite mounting evidence of their ability to perform just as well (Seo et al., 2017). Unless senior management is deliberate with increasing diverse candidates in leadership, existing attitudes and cultural biases will remain the same. This study explored the career barriers facing Black women leaders. The following questions guided this study:

1. Please tell me about any roadblocks/barriers you experienced in your career journey
2. How did you overcome any barriers – what strategies did you use?
3. What barriers remain in your way?
4. What advice do you have for Black women aspiring to leadership positions?
5. What advice do you have for leaders to create a culture to attract, promote and retain Black women?

The current research illuminates the barriers faced by Black women leaders and the tactics used to overcome those barriers. The findings of this study provide guidance for all women attempting to shatter the glass ceiling while illuminating the experiences of a specific marginalized group.

## Literature Review

A review of the literature indicates a labyrinth of career-limiting barriers for Black women. Authors confirm the significant barriers women face in the workplace (Beckwith et al., 2016; Seo et al., 2017; Xiang et al., 2017). Women encounter more difficulties ascending the corporate ladder than men; indeed, minority women struggle much more than White women (Xiang et al., 2017). According to Beckwith et al. (2016), Black women experience career blockers in many disguises. External barriers such as discrimination and bias kept Black women in lower-level jobs as did their inability to develop influential networks. As a result, Black women reported feeling unsupported, demotivated, and depressed and did not understand strategies to overcome bias, oppression, and discrimination (Beckwith et al., 2016). A combination of career-limiting obstacles is often considered a glass ceiling (Radhakrishnan, 2019).

## Glass Ceiling

The term glass ceiling gained popularity in the late 1980s (Radhakrishnan, 2019; Taylor, 2018). The glass ceiling refers to invisible barriers or blockages creating hurdles for women and other minorities to rise to top leadership positions (Radhakrishnan, 2019; Taylor,

2018). Xiang et al. (2017) described the glass ceiling as a phenomenon where women are underrepresented in the upper levels of an organization. Glass ceilings, glass cliffs, and concrete ceilings all refer to the almost impossible task of women ascending to leadership and sustaining success once there.

Glass ceilings exist for many reasons, but in the simplest form are a method of discrimination and oppression. Further, systemic barriers deeply embedded in organizations account for many hurdles women face. Hurdles present as blocking women's access to networking, mentoring, training, and support (Radhakrishnan, 2019; Taylor, 2018). Despite more Black women earning college degrees, career progression often seems out of reach (Beckett, 2020).

### **Discrimination**

Discrimination is illegal in the United States of America, and yet discriminatory behaviors are prominent in society (Berwise & Mena, 2020; McElhattan et al., 2017). Structural oppression continues to form a barricade to promotion for many women (Seo et al., 2017).

Discrimination permeates the deep realms of society, impacting where people live, attend a school, or go for recreation. Identity-based mistreatment threatens a person's sense of self as acts of workplace discrimination compound. According to Dhanani et al. (2018), job stress is an outcome of perceived workplace discrimination. Interpersonal discrimination takes the form of micro-aggressions but is no less harmful than formal discrimination on overall well-being (Dhanani et al., 2018). Discrimination can reinforce social inequalities and is likely to create resentment and resistance against the sources of the perceived injustice (Floyd & Stodolska, 2019). In 2020, American society experienced a surge in racial conflict and demands for ethnic diversity and equity (Lang & Spitzer, 2020).

### **Intersectionality**

Intersectionality has a significant impact on the lived experiences of Black women (Cole, 2020; Crenshaw, 2017; Kelly et al., 2021). Intersectionality as a theory was developed from the work of Black feminist scholars and argues the combination of identities such as race, gender, and sexuality combine as powerful forces of oppression and discrimination (Kelly et al., 2021).

Crenshaw (2017) believed treating race and gender as separate categories were fundamentally flawed when examining the experiences of Black women. Focusing on race or sex as a single-axis framework ignores those who are burdened by the combination of racism and sexism. The sum of the impacts of racism and sexism is far greater than each component. Without the lens of intersec-

tionality, one cannot sufficiently address the subordination of Black women (Bauer et al., 2021; Crenshaw, 2017). America's workplace has a history of white hegemony, where Black women are exposed and vulnerable to subordination (Angel & Peters, 2020; Haynes et al., 2020).

Intersectionality has matured to become a truism (Cole, 2020). Systemic inequality and discrimination interlock to form a system of oppression and subordination (Cole, 2020). Identity research claims ethnicity labels influence societal experiences in youth as social position awareness is developed (Ross et al., 2021; Velez & Spencer, 2018). Therefore, being a Black woman suggests identity and place in America's social structure. Oppression and marginalization are experienced at intersections (Haynes et al., 2020; Velez & Spencer, 2018). Women remain significantly underrepresented in leadership positions in the United States despite mounting evidence of their ability to lead effectively (Radhakrishnan, 2019; Xiang et al., 2017). The experience of Black women in leadership positions tells a story of continued struggles to overcome barriers, prove their worth, act authentically, and assimilate to the perceived norms (Dickens & Chavez, 2018; Sales et al., 2020; Seo et al., 2017).

### **Microaggressions**

According to Gause (2021), Black women who have ascended to leadership positions report microaggressions as a common theme. The author reports Black women being belittled in the workplace and assumed to be someone's assistant versus an executive. Moreover, Black women reported having their work product validity questioned or ridiculed, while others reported womanizing comments and slights toward them. Attempts to thwart the leadership journey of Black women are commonplace (Gause, 2021). Kumar et al. (2018) argue that almost every industry offers less support, unconscious bias, and microaggressions toward women of color (Kumar et al., 2018). The author adds working in a world designed to hold women of color back means career advancement is a marathon where most fail. The pain from microaggressions is palpable.

Gender discrimination happens for many women, but women of color experience a combination of gender and racial bias (Kim & O'Brien, 2018). Kim and O'Brien's 2018 study, assessing women's career barriers across racial/ethnic groups, reported that all women of color reported higher career barriers than White women. Perception of bias is a profoundly personal experience grounded in individual beliefs and perceptions. Women relate barriers to personal experience, and as such, each barrier may be perceived differently by different women (Kim & O'Brien, 2018).

### Method

This qualitative study explored the career experiences of Black women leaders in Virginia. Embracing a phenomenological design, the researcher interviewed twelve participants using video conference technology. The study participants were purposely selected who identified as Black women, working in a manager level or higher position, and living or working in Virginia. Participants were over the age of 21. Data were collected through semi-structured interviews with the participants responding to open-ended questions. The researcher confirmed data redundancy upon hearing repetitive comments and validating a lack of new themes by analyzing the participant responses (Lowe et al., 2018).

### Procedures

The researcher has a moral and ethical obligation to protect the rights of each study participant. Therefore, to ensure consideration is given to protecting the privacy of participants from beginning to end. The researcher received research approval from The University's Institutional Review Board (IRB). Participation in this study was voluntary. The participant's identity remained confidential by substituting first and last name with a key, known as pseudo-anonymizing (Syed et al., 2021). Invitations were emailed to Black women leaders to invite them to participate in the study. Upon confirming participant eligibility and receiving a signed participant consent form, the researcher conducted teleconferenced interviews. Participants did not receive any compensation for participation.

### Data Analysis

Phenomenology attempts to transform expressions of lived experience into a description of its essence that maintains the authenticity of the experience (Kleinknecht et al., 2018). Qualitative data contains descriptive revelations about people's experiences and perspectives. As a researcher in a qualitative study, data was interpreted to understand how participants apply meaning to everyday occurrences. Kleinknecht et al. (2018) consider qualitative research more art than science without any strict prescription of process. The researcher collected primary, qualitative data in the form of participant responses to open-ended interview questions conducted via video calls using technology. To enhance reliability and validity, meetings were recorded using Zoom's recording feature. Descriptive notes were taken during the interview as a backup for technology failures. Interview questions were designed to build on data in a sequential manner. Themes were identified as they appeared using a clustering or grouping method (J.W. Creswell & J.D Creswell, 2017). The interview transcripts were reviewed to identify codes and themes in combination with Nvivo software.

### Findings

The findings of this study validate that Black women experience barriers in the journey to leadership. Thematic analysis of the interview responses identified three salient themes to help answer the research question: (1) negative self-talk; (2) microaggressions; (3) having to work harder than others. The research revealed the participant's responses agreed with the literature reviewed within the study and is well suited for additional research to understand more about the Black women leader's experience.

Each respondent recalled barriers in the journey to leadership. Negative self-talk and feelings of being unworthy or not good enough were mentioned as barriers more frequently than any others. Eighty-three percent of respondents mentioned keywords relating to self-doubt as a major barrier to their success. Participant 2 shared, "I did not think leadership position was available to someone like me. I thought someone else could do it better." Participant 6 stated, "I do not feel confident every day; it is a daily struggle." Participant 8 added, "my barriers were mainly internal." Fields and Cunningham-Williams (2021) discussed imposter syndrome as a feeling of self-doubt. Imposter syndrome describes highly competent individuals who fail to internalize their worthiness and struggle with self-doubt. Many study participants ascribed their worthiness of success to luck, faith, or assistance from others.

Micro-aggressions were also mentioned as barriers. Participant 9 stated she is still dealing with micro-aggressions but has become more tactful when dealing with them. Participant 2 highlighted that micro-aggressions continue to happen, but she now has the confidence to address them directly. Participant 2 viewed acts of microaggression as an opportunity to educate those who offend. Participant 1 recalled being passed over 3-times for promotion despite having the required formal education and certifications as major barriers to her ascension. Participants 1, 2, 3, 6, 7, and 12 discussed intersectionality as a barrier, ascertaining black women are often overlooked or unheard. Participant 1's experience aligns with Gause's (2021) claim that Black women are passed over for less qualified, White candidates.

The participants described experiences with microaggressions, discrimination, and self-doubt. Participants agreed there is pressure, sometimes self-inflicted, to work harder and outperform others to prove themselves. All of the study participants experienced barriers of one form or another. However, the barriers did not present as immovable, impenetrable objects. Instead, they were hurdles to overcome, duck under, or skirt around.

### Recommendations

Recommendations from this research may assist business leaders, policymakers, professors in education, prospective researchers with similar interests, and aspiring leaders from marginalized groups.

#### Recommendation 1: Increase Black Women in Senior Roles

Diversity should exist at all levels of the organization. Leaders should be deliberate in developing a strategy to hire and promote Black women in executive roles. The study participants repeated the need to see leaders who were representative of them. Promoting Black women to executive levels can dismantle the deeply rooted culture of devaluing women (Seo et al., 2017). Companies demonstrating support for gender diversity in top management positions provide role models for aspiring women and enable a diverse profile for recruiting high-potential female talent (Kendall et al., 2021). In addition, adding racial diversity to the higher rungs of the organization offers an opportunity for additional advocates for marginalized groups. Increasing Black women in senior roles will foster dismantling barriers such as those shared by the study participants.

#### Recommendation 2: Create Support Networks

A vital component of organizational success rests on employees feeling supported and having a sense of belonging. Mentors and sponsors can be instrumental in aiding newcomers with assimilating into a group and forming a professional identity and network. The findings from this study support the establishment of opportunities for peer networking, mentoring, and sponsorship. Organizations should integrate support systems as part of the onboarding process for new hires. A mentoring program should be developed and managed as part of employee development efforts. High-performing Black women should be coached and paired with a sponsor for potential promotion to executive roles. Organizations may encourage and support membership in professional organizations and sponsor conference attendance. Support efforts should be diligently tracked and evaluated for effectiveness on an ongoing basis.

#### Recommendation 3: Create an inclusive culture

A culture of diversity and inclusion is instrumental in aiding women of color in breaking through the glass ceiling (Corneille et al., 2019; Wanyama, 2018). Creating and sustaining an inclusive culture requires embracing differences, valuing diversity, and honoring authenticity (Rengers et al., 2019). Inclusion recognizes and appreciates diverse thinking and supports collaboration and culture. The workplace should provide a sense of belonging and safety for all employees regardless of race, sexual orientation, religious preference, age, or gender. Adding cultural sensitivity and cultural awareness training may support teams in embracing each other's

differences. Without genuine commitment, budget, and accountability, diversity and inclusion programs risk losing the trust and respect of marginalized groups.

### Conclusion

The existence of career barriers for Black women is not a disputed topic. Scholars recognize the extensive list of career blockers in place for Black women to ascend the corporate hierarchy (Beckwith et al., 2016; Kamesha et al., 2020; Travis & Thorpe-Moscon, 2018). The voices from this study confirm the work of prior authors who write of the lingering impacts on Black women from slavery, discrimination, and oppression (Beckwith et al., 2016; Kamesha et al., 2020; Travis & Thorpe-Moscon, 2018). Building networks of support is critical for Black women to navigate the workplace (Cooke & Odejimi, 2021). In reality, neither Black executives nor White are stepping up to advocate for Black team members (Nair & Deborah, 2021). The recommendations described in this study may help leaders create strategies and a culture that allows Black women to thrive. Additionally, the findings enable aspiring Black women to understand existing barriers and develop opportunities to overcome them.

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### References

- Angel, M. N., & Peters, A. L. (2020). For 0RW1S34RfeSDcfkexd09rT2us-1RW1S34RfeSDcfkexd09rT2: Towards an intersectional leadership conceptualization by black women for black girls. *Journal of Educational Administration and History*, 52(3), 270-282. <http://dx.doi.org/10.1080/00220620.2020.1785403>
- Bauer, G. R., Churchill, S. M., Mahendran, M., Walwyn, C., Lizotte, D., & Villa-Rueda, A. A. (2021). Intersectionality in quantitative research: A systematic review of its emergence and applications of theory and methods. *SSM - Population Health*, 14, . doi:10.1016/J.SSMPH.2021.100798
- Beckett, M. H. (2020). A Phenomenological Qualitative Study on the Concrete Ceiling for Women of Color in the Workplace (Order No. 28026777). Available from ProQuest One Academic. (2436350100). <https://ezproxy.usw.edu:8176/dissertations-theses/phenomenological-qualitative-study-on-concrete/docview/2436350100/se-2?accountid=39522>
- Beckwith, A. L., Carter, D. R., & Peters, T. (2016). The underrepresentation

- of African American women in executive leadership: What's getting in the way? *Journal of Business Studies Quarterly*, 7(4), 115–134. Retrieved from [https://jbsq.org/wpcontent/uploads/2016/06/June\\_2016\\_9.pdf](https://jbsq.org/wpcontent/uploads/2016/06/June_2016_9.pdf)
- Berwise, C. A., & Mena, J. A. (2020). Perceived discrimination and educational attainment for U.S. black adults: The influence of black racial identity. *Social Psychology of Education : An International Journal*, 23(5), 1385-1406. <http://dx.doi.org/10.1007/s11218-020-09587-7>
- Bloch, K. R., Taylor, T., Church, J., & Buck, A. (2021). An intersectional approach to the glass ceiling: Gender, race and share of middle and senior management in U.S. workplaces. *Sex Roles*, 84(5-6), 312-325. <http://dx.doi.org/10.1007/s11199-020-01168-4>
- Catalyst. (2022). Women in Management. (March 1, 2022). <https://www.catalyst.org/research/women-in-management/>
- Cole, E. R. (2020). Demarginalizing women of color in intersectionality scholarship in psychology: A black feminist critique. *Journal of Social Issues*, 76(4), 1036-1044. <https://doi.org/10.1111/josi.12413>
- Cooke, S. M., & Odejimi, K. B. (2021). Examining Practices of Retaining Black Female Faculty and Staff in Independent Schools. *Journal of Black Studies*, 52(2), 202-219.
- Corneille, M., Lee, A., Allen, S., Cannady, J., & Guess, A. (2019). Barriers to the advancement of women of color faculty in STEM: The need for promoting equity using an intersectional framework. *Equality, Diversity and Inclusion: An International Journal*, 38(3), 328-348. <http://dx.doi.org/10.1108/EDI-09-2017-0199>
- Crenshaw, K. (2017). "On Intersectionality: Essential Writings" . *Faculty Books*. 255. <https://scholarship.law.columbia.edu/books/255>
- Creswell, J. W., & Creswell, J. D. (2017). *Research Design* (5th Edition). SAGE Publications, Inc. (U.S.). <https://online.vitalsource.com/books/9781506386690>
- Dhanani, L. Y., Beus, J. M., & Joseph, D. L. (2018). Workplace discrimination: A meta-analytic extension, critique, and future research agenda. *Personnel Psychology*, 71(2), 147-179. <https://doi.org/10.1111/peps.12254>
- Dickens, D. D., & Chavez, E. L. (2018). Navigating the workplace: The costs and benefits of shifting identities at work among early career U.S. black women. *Sex Roles*, 78(11-12), 760-774. <http://dx.doi.org/10.1007/s11199-017-0844-x>
- Fields, L. N., & Cunningham-Williams, R. M. (2021). Experiences With Imposter Syndrome and Authenticity at Research-Intensive Schools of Social Work: A Case Study on Black Female Faculty. *Advances in Social Work*, 21(2/3), 354-373.
- Floyd, M. F., & Stodolska, M. (2019). Scholarship on race and ethnicity: Assessing contributions to leisure theory and practice. *Journal of Park and Recreation Administration*, 37(1)<http://dx.doi.org/10.18666/JPRA-2019-8339>
- Gause, S. A. (2021). White privilege, Black resilience: Women of color leading the academy. *Leadership*, 17(1), 74–80. <https://doi.org/10.1177/1742715020977370>
- Haynes, C., Joseph, N. M., Patton, L. D., Stewart, S., & Allen, E. L. (2020). Toward an Understanding of Intersectionality Methodology: A 30-Year Literature Synthesis of Black Women's Experiences in Higher Education. *Review of Educational Research*, 90(6), 751-787. doi:10.3102/0034654320946822
- Kamesha, S., Evans Na'Tasha, M., Watts, B. C., Nasra, A., & Tierra, J. (2020). Keeping ourselves sane: A qualitative exploration of black Women's coping strategies for gendered racism. *Sex Roles*, 82(9-10), 513-524. <http://dx.doi.org/10.1007/s11199-019-01077-1>
- Kelly, C., Kasperavicius, D., Duncan, D., Etherington, C., Giangregorio, L., Presseau, J., & Straus, S. (2021). 'Doing' or 'using' intersectionality? Opportunities and challenges in incorporating intersectionality into knowledge translation theory and practice. *International Journal for Equity in Health*, 20(1), 187. doi:10.1186/S12939-021-01509-Z
- Kendall, D. L., Cannon, S., & Gill, J. K. (2021). The role of white support in predicting racial minorities' feelings of inclusion and retention. *Journal of Organizational Psychology*, 21(2), 168-182. <https://www.proquest.com/scholarly-journals/role-white-support-predicting-racial-minorities/docview/2543522836/se-2?accountid=39522>
- Kim, Y. H., & O'Brien, K. M. (2018). Assessing women's career barriers across racial/ethnic groups: The Perception of Barriers Scale. *Journal of Counseling Psychology*, 65(2), 226.
- Kleinknecht, S. W., Van den Scott, L. J. K., & Sanders, C. B. (Eds.). (2018). *The craft of qualitative research: A handbook*. Canadian Scholars.
- Kumar, R., Zusho, A., & Bondie, R. (2018). Weaving cultural relevance and achievement motivation into inclusive classroom cultures. *Educational Psychologist*, 53(2), 78-96. <http://dx.doi.org/10.1080/00461520.2018.1432361q>
- Lang, K., & Spitzer, A. K.-L. (2020). Race Discrimination: An Economic Perspective. *Journal of Economic Perspectives*, 34(2), 68–89. <https://doi.org.links.franklin.edu/10.1257/jep.34.2.68>
- Lowe, A., Norris, A. C., Farris, A. J., & Babbage, D. R. (2018). Quantifying thematic saturation in qualitative data analysis. *Field methods*, 30(3), 191-207.
- McElhattan, D., Beth Nielsen, L., & Weinberg, J. D. (2017). Race and determinations of discrimination: Vigilance, cynicism, skepticism, and attitudes about legal mobilization in employment civil rights. *Law & Society Review*, 51(3), 669-703.
- Nair, N., & Deborah, C. G. (2021). Microaggressions and coping with linkages for mentoring. *International Journal of Environmental Research and Public Health*, 18(11), 5676. <http://dx.doi.org/10.3390/ijerph18115676>
- Poole, A. H., Agosto, D., Greenberg, J., & Xia Lin., & Erjia, Yan. (2021). Where Do We Stand? Diversity, Equity, Inclusion, and Social Justice in North American Library and Information Science Education. *Journal of*

- Education for Library & Information Science, 62(3), 258–286. <https://doi-org.links.franklin.edu/10.3138/jelis.2020-0018>
- Radhakrishnan, R. (2019). Cultural variations in the glass ceiling effect: A review. *Artha Journal of Social Sciences*, 18(1), 23-30. <http://dx.doi.org/10.12724/ajss.48.3>
- Rengers, J. M., Heyse, L., Otten, S., & Wittek, R. P. (2019). “It’s not always possible to live your life openly or honestly in the same way”—workplace inclusion of lesbian and gay humanitarian aid workers in doctors without borders. *Frontiers in psychology*, 10, 320.
- Ross, M. S., Huff, J. L., & Godwin, A. (2021). Resilient engineering identity development critical to prolonged engagement of Black women in engineering. *Journal of Engineering Education*, 110(1), 92–113. <https://doi-org.links.franklin.edu/10.1002/jee.20374>
- Sales, S., Monica, G. B., & Cannonier, C. (2020). African American women leadership across contexts: Examining the internal traits and external factors on women leaders’ perceptions of empowerment. *Journal of Management History*, 26(3), 353-376. <http://dx.doi.org/10.1108/JMH-04-2019-0027>
- Seo, G., Huang, W., & Han, S. C. (2017). Conceptual views of underrepresentation of women in senior leadership positions from a perspective of gendered social status in the workplace: Implication for HRD research and practice. *Human Resource Development Review*, 16(1), 35-59. <http://dx.doi.org/10.1177/1534484317690063>
- Syed, S., Syed, M., Syeda, H. B., Garza, M., Bennett, W., Bona, J., Begum, S., Baghal, A., Zozus, M., & Prior, F. (2021). API Driven On-Demand Participant ID Pseudonymization in Heterogeneous Multi-Study Research. *Healthcare Informatics Research*, 27(1), 39-47. <https://doi.org/10.4258/hir.2021.27.1.39>
- Taylor, S. (2018). Black ceiling exists for African-American women seeking nonprofit leadership roles.
- Travis, D. J., & Thorpe-Moscon, J. (2018). Day-to-day experiences of emotional tax among women of color in the workplace. *Catalyst.org*. Retrieved from <http://www.catalyst.org/system/files/emotionaltax.pdf>
- Velez, G., & Spencer, M. B. (2018). Phenomenology and intersectionality: Using PVEST as a frame for adolescent identity formation amid intersecting ecological systems of inequality. *New directions for child and adolescent development*, 2018(161), 75-90.
- Wanyama, M. W. (2018). Influence of Cultural Diversity on Competitive Advantage at Sga Security (K) Limited
- Xiang, X., Ingram, J., & Cangemi, J. (2017). Barriers contributing to underrepresentation of women in high-level decision-making roles across selected countries. *Organization Development Journal*, 35(3), 91-106. <https://www.proquest.com/scholarly-journals/barriers-contributing-underrepresentation-women/docview/2002996653/se-2?accountid=39522>



# Temperature Impact on Wild Type and Mutant Strains in *Drosophila melanogaster*

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## Abstract

The fruit fly, *Drosophila melanogaster*, was chosen due to its small size, short life cycle, and significant genetic variability. It is relatively inexpensive to propagate. It can survive, grow, and reproduce best when living conditions such as humidity, photoperiod, pH, etc., are favorable. Little is known about the effects of temperature on insufficient development due to gene mutation. This study aimed to explore the interaction between temperature and strain on individual weight and length. Data analysis included ANOVA statistical methods. The results showed that temperature affected the growth period of the strains. The higher the temperature, the shorter the required growth period was for each strain. The results of t-tests showed that the individual weight and length for both females and males of the wild-type strain, between 20°C and 25°C were significantly different at 1% or 5% levels, respectively. After the F tests showed significant differences between the strains, multiple comparisons of means were performed. The results indicated that some means were significantly different, and others were not. It seems that temperature had mixed impacts on weight and length in females and males of the wild-type strain and two mutant strains. The interactions between temperature and strain were preliminarily detected using plots for females and males of the strains. A future study is proposed.

## Introduction

The fruit fly, *Drosophila melanogaster*, is commonly used as a model organism due to its short life cycle, significant genetic variation, relatively inexpensive propagation, small body size, etc. Fruit flies survive, grow, and reproduce only when living within a physiologically tolerable range of environmental conditions for humidity, photoperiod, pH, etc. There were quite a few studies conducted in the past. Researchers (Belyi et al. 2020) observed a strong negative correlation between age and stress tolerance. The most significant change in the age-dependent decline in survival occurred under oxidative and osmotic stress. Kim (Kim et al. 2020) demonstrated how environmental temperature and macronutrient balance combine to affect key life-history traits related to fitness and to mediate trade-offs among these traits. Hamby (Hamby et al. 2016) reviewed the work on juvenile development, adult reproduction, and seasonal variation in life-history parameters, including the abiotic or biotic factors that influence these processes in *Drosophila suzukii*. Schönborn (Schönborn et al. 2019) investigated the resource allocation process during the larval development of *Drosophila melanogaster* using iterative wet lab and modeling experiments. The predictions correctly identified the essential amino acids as growth-limiting factors and metabolic flux differences in agreement with the experimental data. Disrupting gene function by causing missense or nonsense mutations can lead to a deficiency in the growth of the fruit flies (Johnston, 2002). The Mendelian traits such as wing shape, body-color, eye color, and wing presence were chosen to explore whether the segregation ratios followed the traditional genetic laws (Wiles et al., 2013, Wu et al., 2020, Stock et al., 2021).

Temperature is an influential environmental factor for rearing *Drosophila melanogaster*. Little is known about the effects of temperature on insufficient development due to gene mutation. The objectives set to explore the role of temperature and its effects on strain development and for both weight and length include (1) to identify differences in dates for observation of the first egg, larva, pupa, and adult fly at different temperatures for the wild-type strain and two mutant strains; (2) to examine the effects of temperature on weight and length of adult flies for the three strains.

## Materials and Methods

**Fruit fly strain** The mutant bar eye (*Bar/B*) and apterous (*apterous/ap*) strains were purchased from Carolina Biological Supply Company (Carolina 2020).

**Fruit fly handling** Flies were maintained in sponge capped plastic vials containing roughly one inch of culture media and yeast cells. The end of a wand was soaked with FlyNap (an anesthesia agent) and inserted into the vials containing the flies without allowing any to escape. The flies were monitored to determine when the FlyNap should be removed from the vial once fully anesthetized. The process of anesthetizing the flies took around 2 minutes. Caution was taken to avoid overexposing flies to FlyNap, which is lethal in excessive dosage.

**Propagation of Flies** After the flies were fully anesthetized, the vial cap was removed, and the flies were transferred onto a white card. They were then placed under a dissecting microscope to iden-

tify sexual features. Once the sex of each fly was determined, five males and five females were placed into a vial containing culture media. The vial was placed on its side to ensure the flies did not get stuck to the culture medium. After the flies recuperated from the FlyNap, the vials were turned upright. In 4 days, the parental generation of flies were removed from the vial. The larvae developed into mature fruit flies within 10-20 days. Upon the emergence of the next generation, adult fruit flies were ready to be counted and measured under a dissecting microscope.

**The first emergency of pupa and adult fly** The dates for the first pupa and adult fly emergence were recorded for the three strains.

**Adult fly collection** The adult flies were placed on a standard commercial diet in a vial and allowed to mate and oviposit. After eggs were observed, parental flies were discarded. Adult flies were collected from each vial at the defined time.

**Adult fly size measurements** Pupa were collected and size measurements were taken at the indicated time. Subsequently, each emerged adult specimen was measured using a dissection microscope camera image. The length and width of each specimen were measured using Motic Images Plus 3.0 software. Three biologically independent repeat measurements were taken for three flies per vial.

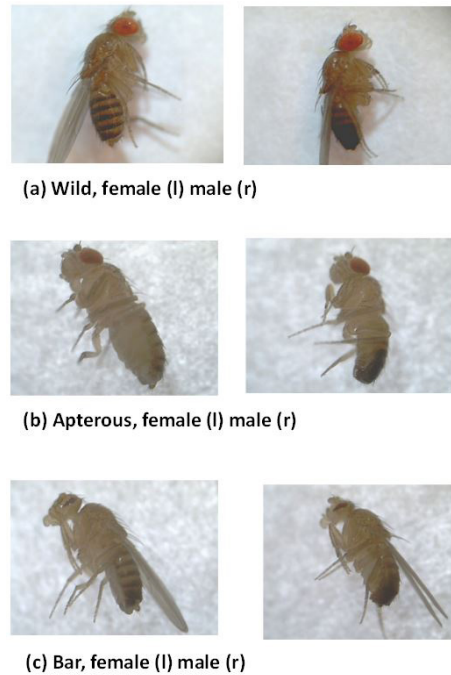
**Wet and dry weight measurements for adult fly** The wet weight was determined by transferring the adult flies into pre-weighed 1.5mL tubes and weighing them on an analytical scale. The flies were dried at 60°C with the tube lids open in an oven. After 24hours, measurements were taken again to determine the weight (dry weight). We performed three biologically independent repeats and measured all flies per vial. Single fly dry weight was calculated by dividing the total weight of the flies by the total number of flies in a vial.

**Temperature treatments** There were three different temperature settings in the experiment. Treatment 1: low temperature (20°C), Treatment 2: medium temperature (25°C), Treatment 3: high temperature (30°C). In each treatment, there were three repeats for all measurements. Due to the adverse environment at the high temperature, the flies did not survive. Therefore, no data was collected for the treatment.

**Statistical analysis** The variance of analysis (ANOVA) was performed using Data Analysis in Excel (Brase et al. 2023). The posthoc Tukey Honestly Significant Difference (HSD) test was conducted by an online test calculator for comparing multiple treatments (Vasavada 2016).

## Results

### 1. The strain phenotypes



**Figure 1** A display of the phenotypes of the strains

From Figure 1, one can observe that the wild strain has round eyes and full wings. The apterous strain appears wingless. The bar strain shows the bar shape of the eye.

### 2. The difference in the growth days for the strains at different temperature

**Table 1** Fly growth days recorded from the mating dates at different temperatures

Temperature	Strain	Egg	Larva	Pupa	Adult
20°C	Wild	1	3	8	22
	Apterous	1	2	8	10
	Bar	1	3	7	10
25°C	Wild	1	3	5	6
	Apterous	1	2	4	8
	Bar	1	2	4	7

In Table 1, there were no differences among the strains at the egg stage. There were only one- or two-days difference observed at the larva and pupa stages. However, the wild strain grew more slowly than the other two mutant strains at the adult stage under the low temperature. In contrast, there was only a slight difference at the same stage for all three strains under medium temperature. Overall, the medium temperature caused a shorter growth period for all the strains than the low temperature.

### 3. The descriptive statistics and one-way ANOVA for two traits in the strains at different temperature

**Table 2** The statistics for weight and length in the strains at two different temperatures

Temperature (°C)	Sex	Strain	Individual weight (mg)			Individual length (µm)		
			Mean	Standard Deviation	CV(%)	Mean	Standard Deviation	CV(%)
20	Female	Wild	264.2	3.8	1.4	2471.3	121.9	4.9
		Apterous	244.4	48.1	19.7	2365.6	124.4	5.3
		Bar	252.0	11.3	4.5	2145.4	126.2	5.9
	Male	Wild	202.7	4.6	2.3	2101.1	48.15	2.3
		Apterous	105.0	48.2	45.9	2159.4	310.9	14.4
		Bar	185.8	21.2	11.4	1838.5	151.7	8.3
25	Female	Wild	179.9	35.1	19.5	2061.8	14.8	0.7
		Apterous	255.6	53.6	21.0	2497.5	31.8	1.3
		Bar	227.8	31.7	13.9	2012.1	22.4	1.1
	Male	Wild	137.5	10.8	7.9	1925.8	75.2	3.9
		Apterous	140.0	52.9	37.8	2077.6	150.8	7.3
		Bar	158.8	35.7	22.5	1552.7	126.2	8.1

Note: CV means coefficient of variance.

In Table 2, the CV values for individual weight of females and males varied greatly at different temperatures. The values were from 1.4% to 19.7% for the wild strain. For the apterous strain, the values ranged from 19.7% to 45.9%. For the bar strain, these values fell between 4.5% and 22.5%. The CV values for the individual length of females and males were also large at different temperatures. For the wild strain, they varied from 0.7% to 4.9%. For the apterous strain, the values were from 1.3% to 14.4%. For the bar strain, these values changed from 1.1% and 8.3%. The small CV values indicated a slight variation of the means for the two traits. The large CV values represented a considerable variation of the means for the two traits.

**Table 3** The results of t test for the traits of the strains between 20°C and 25°C

Sex	Strain	Individual weight		Individual length	
		t	P value	t	P value
Female	Wild	4.13**	0.014	5.78**	0.004
	Apterous	-0.27	0.802	-1.78	0.150
	Bar	1.24	0.281	1.80	0.146
Male	Wild	9.59**	0.001	3.40*	0.027
	Apterous	-0.85	0.445	0.41	0.703
	Bar	1.13	0.323	2.51	0.066

Note: t critical value of two-tail for both traits was 2.78 and df=4. \*: significant at 5%. \*\*: significant at 1%.

The t-tests for the traits of the three strains were conducted between 20°C and 25°C. In Table 3, the results revealed that the

individual weight and length for both females and males of the wild strain were significantly different at 1% or 5% levels. However, for the other two strains, the means of these two traits showed no difference.

**Table 4** The results of F test in ANOVA for two traits at different temperatures

Temperature (°C)	Sex	Individual weight		Individual length	
		F	P value	F	P value
20	Female	0.37	0.708	5.38*	0.046
	Male	8.78*	0.017	2.16	0.197
25	Female	2.58	0.156	370.78**	5.17×10 <sup>-7</sup>
	Male	0.29	0.757	14.81**	0.005

Note: F critical value for both traits was 5.14. \*: significant at 5%. \*\*: significant at 1%.

Based on one-way ANOVA for two traits at different temperatures in Table 4, the results of F tests showed that the individual weight in the male group and the individual length of three strains in the female group at 20°C were significantly different at a 5% level. The individual length of three strains in female and male groups at 25°C was significantly different at a 1% level. The multiple comparisons of means were needed to examine which means were significantly different and which were not.

**Table 5** The results of Tukey HSD test for weight of the strains at 20°C

Sex	Strain pair	Individual weight	
		Q statistic	P value
Male	Wild / apterous	5.54*	0.018
	Wild / bar	0.96	0.771
	Apterous / bar	4.59*	0.040

Note: \*: significant at 5%.

The Tukey HSD test was performed for the males of three strains at 20°C (Table 5). The results showed that the means of individual weight for the wild strain versus the apterous strain and the apterous strain versus the bar strain were significantly different at the 5% level.

For the females of the three strains at 20°C, the results of the Tukey HSD test (Table 6) revealed that only the mean of individual length for the wild strain versus the bar strain was significantly different at the 5% level. At 25°C, the means of individual length for the wild strain versus the apterous strain and the wild strain versus the bar strain were significantly different at a 1% level. For the males of three strains at 25°C, the means of individual length for the wild

strain versus the bar strain and the apterous strain versus the bar strain were significantly different at 5% and 1% levels, respectively.

**Table 6** The results of Tukey HSD test for length of the strains at different temperatures

Temperature(°C)	Sex	Strain pair	Individual length	
			Q statistic	P value
20	Female	Wild / apterous	1.48	0.579
		Wild / bar	4.55*	0.042
		Apterous / bar	3.07	0.155
25	Female	Wild / apterous	31.41**	0.001
		Wild / bar	3.58	0.098
		Apterous / bar	35.00**	0.001
	Male	Wild / apterous	2.16	0.343
		Wild / bar	5.32*	0.021
		Apterous / bar	7.48**	0.004

Note: \*: significant at 5%. \*\*: significant at 1%.

**4. The interaction between two traits at different temperatures**

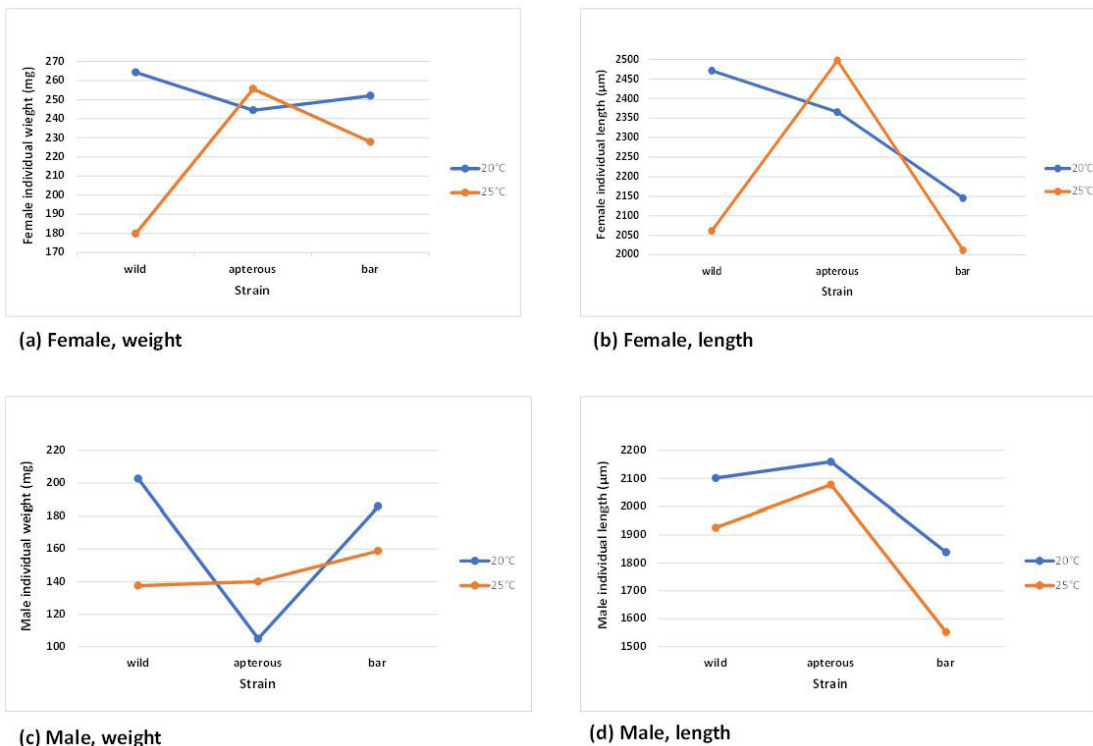
In order to observe the interaction between the strain and temperature, plots were produced and are shown in Figure 2. It was clear that the potential interactions for individual weight and length could exist in females of the apterous strain. The interaction for individual weight could also be detected in males of the apterous strain. The two-way ANOVA can be implemented to examine the interactions for both traits when the statistical software is available to use in the future.

**Discussion**

The temperature affected the growth period of the strains. The higher temperature revealed a shorter growth period for each strain. The standard deviation and coefficient of variation of the means for individual weight and length varied from one another. The results of t tests revealed that the individual weight and length for both females and males of the wild strain between 20°C and 25°C were significantly different at 1% or 5% levels. The F tests in one-way ANOVA demonstrated that the individual weight in the male group and the individual length of three strains in the female group at 20°C were significantly different at the 5% level. The individual length of three strains in female and male groups at 25°C was significantly different at a 1% level. The multiple comparisons of means were followed to provide details about which means were significantly different and which were not. It seems that temperature had a mixed impact on weight and length in females and males of the wild type strain and two mutants. The interactions between temperature and strain were briefly described using the plots in females and males of the strains. Two-way ANOVA can be performed to further explain the interactions at a statistical level.

The research work by Belyi (2016) showed the resistance to other types of stress factors, such as genotoxin, proteotoxic, starvation, and infection with pathological microbes at different ages in *D. melanogaster*. Our future study of investigating the effect of the stress factors on additional mutant genotypes will help to further expand the knowledge in this regard.

**Figure 2** The tendency of interaction for the traits at different temperatures



### Acknowledgments

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### References

- Belyi, A. A., Alekseev, A. A., Fedintsev, A. Y., Balybin, S. N., Proshkina, E. N., Shaposhnikov, M. V., & Moskalev, A. A. (2020). The Resistance of *Drosophila melanogaster* to Oxidative, Genotoxic, Proteotoxic, Osmotic Stress, Infection, and Starvation Depends on Age According to the Stress Factor. *Antioxidants*, *9*(12), 1,239
- Brase, C. H., Brase, C. P., & Dolor, J. S. (2023). *Understandable statistics concepts and methods*. Boston: Cengage Learning Inc., pp. 588-597
- Carolina Biological Supply Company. (2020). *Drosophila* Manual. Retrieved from <https://www.carolina.com/drosophila-fruit-fly-genetics/drosophila-manual-carolina/452620.pr>
- Hamby, K. A., Bellamy, D. E., Chiu, J. C., Lee, J. C., Walton, V. M., & Wiman, N. G. (2016). Biotic and abiotic factors impacting development, behavior, phenology, and reproductive biology of *Drosophila suzukii*. *Journal of Pest Science*. *89*(3), 605-619.
- Johnston, D. S. (2002). The art and design of genetic screens: *Drosophila melanogaster*. *Nature Reviews Genetics*, *3*(3), 176-88.
- Kim, K. E., Jang, T., & Pum, L. K. (2020). Combined effects of temperature and macronutrient balance on life-history traits in *Drosophila melanogaster*: implications for life-history trade-offs and fundamental niche. *Oecologia*, *193*(2), 299-309.
- Schönborn, JW, Jehrke, L, Mettler-Altmann, T, & Beller, M. (2019). Fly-Silico: Flux balance modeling of *Drosophila* larval growth and resource allocation. *Scientific Reports*, *9*, 1-16.
- Stock, U., Stringfellow, H., & Wu, Y. (2021). The study on genetic patterns of eye color and wing presence in *Drosophila melanogaster*. *Southwest Journal of Arts and Sciences*, *1*(1): 38-41.
- Vasavada, N. (2016). One-way ANOVA (ANalysis Of VAriance) with post-hoc Tukey HSD (Honestly Significant Difference) Test Calculator for comparing multiple treatments. Astatsa. [https://astatsa.com/OneWay\\_Anova\\_with\\_TukeyHSD/](https://astatsa.com/OneWay_Anova_with_TukeyHSD/)
- Wiles, S., & Hargadon, K. M. (2013). Inheritance patterns in monohybrid and dihybrid crosses for sepia eye color and apterous (wingless) mutations in *Drosophila melanogaster*. *HSC Journal of Sciences*, *8*, 1-5.
- Wu, Y., Stock, U., Garcia, J., & Chavez, I. (2020). A study on inheritance patterns on wing shape, body color and eye color in *Drosophila melanogaster*. *New Mexico Journal of Science*, *54*(1), 57-66.

# Developing Balanced Scorecard and Key Performance Indicators of Amazon.com

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## Abstract

The success and failure of multinational corporations are determined by how well managers handle strategic, operational, and risks related to the industry. In the managerial process, identifying and targeting strategic and operational vital areas is crucial to compete in the globalized era of the international market. Following Kaplan and Norton's approach to designing the Balanced Scorecard (BSC) system and Parmenter's roadmap to identify KPIs (Key Performance Indicators), the researcher developed Amazon's BSC and KPIs by drawing indicators from annual reports and shareholder letters of Amazon.com. Based on the review, the researcher developed financial, customer, learning and growth, and internal business process perspectives of BSC of Amazon.com. The reviewer suggests considering agile and lean leadership, risk, CSR (Corporate Social Responsibility), and other uncovered dimensions of BSC in future studies and analyses. Moreover, the paper draws winning KPIs for Amazon.com as a framework to track operational activities in the business intelligence system to have data-driven decision-making.

### Developing Balanced Scorecard: A Particular Focus on Amazon.Com

Corporate managers perform in three major managerial areas: strategic, operational, and risk (Atrill, 2019). While strategic management focuses on achieving long-term objectives, operational management concentrates on realizing short-term targets of firms. Risk management relies on identifying and managing strategic, operational, and external risks limiting a company's performance.

The traditional approach to measuring corporate performance mainly focuses on financial accomplishments and ignores non-financial implementations. Forward-thinking Chief Finance Officers (CFOs) need financial and non-financial dimensions for better decision-making (Bouker et al., 2020). To align day to day activities of an organization with long-term strategic objectives, Kaplan and Norton (2007) developed a comprehensive measuring approach named Balanced Scorecard in 1992. The Balanced Scorecard encompasses financial and non-financial dimensions. Adding three more non-financial dimensions, Kaplan and Norton (2007) established the four major perspectives to track implementations and manage activities strategically. The four perspectives are (1) financial, (2) customer, (3) learning and growth, and (4) internal business process.

In the analytical essay, the reviewer develops BSC for Amazon by translating Amazon's vision and strategy into the four perspectives building on previous works. Simons (2019) recommends four significant steps in building BSC- (1) defining the business strategy, (2) drawing a strategy map, (3) identifying and selecting measures

for the map, and (4) assigning accountability to individual managers. In identifying goals and measures corresponding to the four perspectives, the BSC answers the following four strategic questions- (1) How does Amazon look to shareholders? (Financial Perspective) (2) How do customers see Amazon? (Customer Perspective) (3) How can Amazon continue to improve and create value? (Learning and Growth Perspective) and (4) At what must Amazon excel? (Internal Business Perspective). The strategic questions are aligned to objectives to increase revenue (financial), enhance customer loyalty by on-time delivery (customer), increase process quality and reduce process cycle time (internal business process) by improving employees' skills (learning and growth) (Simons, 2019).

To draw specific measures corresponding to the four perspectives of BSC, Bezos's (2021) letter to shareholders and recent Amazon's (2022a) report were used as a milestone. The financial dimension focuses on the number of sales and the percentage in each category of Amazon's products and services delivered domestically and internationally. Amazon's marketplace's profit margin and conversion rate must be considered (Segarra et al., 2016). Moreover, based on the same framework analysis, the average session and number of returning users to purchase will help analyze the customer perspective. Besides, customer engagement with Amazon's new tools, such as the Amazon One payment system, and expansion of warehouses, boost the internal process performance. Lastly, optimizing search algorithms, recommendations, and increased productivity of employees will pave the way to have high performance in learning and growth perspectives. Implementing the BSC system could potentially expand the sustainability of such big firms (Rafiq et al., 2020).

Further study analysis is required to have an extended and comprehensive BSC encompassing CSR (Corporate Social Responsibility), agile and lean leadership, and other dimensions for better strategic management.

**Figure 1** Proposed Balanced Scorecard (BSC) for Amazon.com



### Key Performance Indicators (KPIs) in Amazon.com

According to Parmenter (2012), KPIs (Key Performance Indicators) answer the question of what to do to boost institutional performance, whether operational, finance, etc. The KPIs are like a road map for an organization's present and future performance (Parmenter, 2020). Understanding the meaning of KPIs clears confusion on what to measure. As Mauboussin (2012) stated, managerial bodies such as executives of MNCs (Multinational Corporations) had problems selecting what to measure. Moreover, the misunderstanding arises differentiating the drivers of the performance and the result by itself. Firms commonly use statistics of the rate of growth of revenue and sales as performance indicators. However, drivers of the high revenue or shareholder value performance evolve from the casual effect. Hence, to identify the push factors-the KPIs, practitioners and managers need to execute three significant processes (Mauboussin, 2012). First, define the primary objective of the institution. Second, review the financial and non-financial aspects of the institution. Third, link employees and the processing unit of each department's activities with the respective focus areas for better performance achievement. Hence, mapping key participants help to identify key performance measures (Kenny, 2021).

To design winning KPIs, Parmenter (2020) suggests three main stages. First, as creating KPIs is part of the change and organizational management, team members in each department of the firm need to be aware of the necessary change through training and discussion. Second, managers and experts must identify CSF (Critical Success

Factors) driving the organizational performance. Most commonly, instead of having over-listed CSF, Parmenter (2020) suggests organizations have five to eight CSF. Furthermore, Parmenter (2020) considers an organization without CSF as a participant in a soccer contest without a goalkeeper.

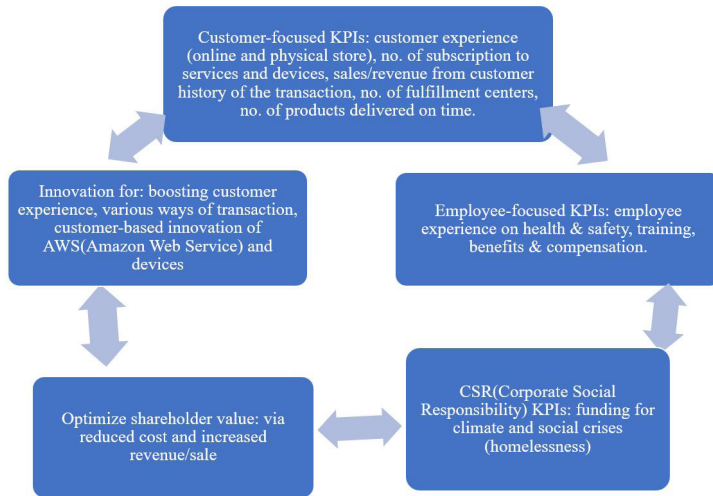
The following analytical review of Amazon's KPIs is developed based on Parmenter's (2020) approach to identifying KPIs and the 2021 annual report of Amazon (2022b). The first and foremost attention of Amazon driving organizational performance is the focus on the customers. Hence, Amazon tries to build loyal customers by boosting customer experience in physical stores and online sales. Mainly, customers give ratings for the online experience. Simultaneously, Amazon tracks customers' previous purchases to suggest goods and services according to customers' prior history of transactions. Ads and suggestions in the online email and home page of customers' accounts drive sales and revenue. Besides, Amazon has subscriptions such as prime membership offers a yearly fee for the fast delivery of products ordered online.

Second, according to Amazon (2022b) reports, Amazon expanded the number of fulfillment centers and delivery networks to realize fast delivery. Hand in hand, the expansion will help to deliver products on time, subject to constraints. Third, particularly for workers in the fulfillment and physical stores of Amazon, the case of health and safety is critical. As the well-being issue is related to human resource performance, as the recent report of Amazon (2022b) indicates, the corporation strives to improve the employee experience by providing training and supplying appropriate health insurance and benefits packages and compensations.

Third, to keep the high-profile brand name in the international market, Amazon participates in CSR (Corporate Social Responsibilities) activities such as climate and other social crises like homelessness. Fourth, Amazon aims to optimize shareholders' value while simultaneously reducing costs and increasing revenue by increasing sales (Atrill, 2019; Amazon, 2022b). The financial measures commonly coincide with financial statements such as balance sheets, cash flow statements, and income statements. The Amazon (2022b) report utilizes comparative differences in the annual financial performance of sales and expenditures to track the organization's profitability. The metrics associated with Amazon's (2022b) innovation coincide with targeting to boost Amazon customers' experience by developing various transactions to ease selling and buying online. Simultaneously, Amazon's customer-based innovations of products such as AWS (Amazon Web Services) and devices like Kindle and Smart Home Echo devices, etc., are particular targets of achieve-

ment. Amazon tracks the performance by the number of subscriptions to the service and devices as the sales boost revenue. Though the costs related to investments in innovation lead to losses, Amazon strategically invests massive money for the long-run advantage.

**Figure 2** Proposed Key Performance Indicators(KPIs) for Amazon.com



### Conclusion

In today's competitive digital era of the international market of multinational companies, corporations such as Amazon.com, having a clear strategic goal, can execute and outperform in strategic, operational, and risk-related issues. Managers need to design and target strategic areas and things that matter most to perform better and realize the longevity of organizations. Based on Kaplan and Norton's technique of developing a Balanced Scorecard (BSC), Amazon's organizational performance can be evaluated using the four dimensions: financial, customer, internal process, and learning and growth perspectives. Designing strategic targets and measures help to manage routine and strategic activities. Moreover, such a practice helps effectively utilize business intelligence data for data-driven decision-making. Herewith, identifying vital strategic metrics is equally essential. Hence, the reviewer developed Key Performance Indicators (KPIs) of Amazon coinciding with Parmenter's approach, mainly focusing on customers, employees, CSR (Corporate Social Responsibility), and innovation. As previous works in BSC fail to consider agile and lean leadership, risk, and CSR (Corporate Social Responsibility), the reviewer suggests future researchers analyze other uncovered dimensions of BSC and KPIs for Amazon.com.

### References

- Amazon. (2022a, April). *AMAZON.COM announces first-quarter results*. <https://ir.aboutamazon.com/quarterly-results/default.aspx>
- Amazon. (2022b, February). *2021 Amazon Annual Report*. <https://rb.gy/omosfn>

- Atrill, P. (2019). *Financial Management for Decision Makers* (ePub ed.) [E-book]. Pearson.
- Bezos, J. (2021, April 15). 2020 Letter to Shareholders. *About Amazon*. <https://www.aboutamazon.com/news/company-news/2020-letter-to-shareholders>
- Bouker, M., Wielaard, N., & Geelen, F. (2020). *The CFO in Pole Position: Leading next-generation decision-making in a data-driven organization* [E-book]. Management Impact Publishing.
- Kaplan, R., & Norton, D. (2007, March 8). *Using the Balanced Scorecard as a Strategic Management System*. Harvard Business Review. <https://hbr.org/2007/07/using-the-balanced-scorecard-as-a-strategic-management-system>
- Kenny, G. (2021, November 29). KPIs Aren't Just About Assessing Past Performance. *Harvard Business Review*. <https://hbr.org/2021/09/kpis-arent-just-about-assessing-past-performance>
- Mauboussin, M. J. (2012, October 1). The True Measures of Success. *Harvard Business Review*. <https://hbr.org/2012/10/the-true-measures-of-success>
- Parmenter, D. (2012). *Key Performance Indicators for Government and Non-Profit Agencies*. Wiley.
- Parmenter, D. (2020). *Key Performance Indicators (KPI)* (Fourth Edition). Wiley.
- Rafiq, M., Zhang, X., Yuan, J., Naz, S., & Maqbool, S. (2020). Impact of a balanced scorecard as a strategic management system tool to improve sustainable development: Measuring the mediation of organizational performance through PLS-smart. *Sustainability*, 12(4), 1365. <https://doi.org/10.3390/su12041365>
- Segarra, L. L., Almalki, H., Elabd, J., Gonzalez, J., Marczewski, M., Alrasheed, M., & Rabelo, L. (2016). A framework for boosting revenue incorporating big data. *Journal of Innovation Management*, 4(1), 39-68.
- Simons, R. (2019, March 22). Strategy Execution Module 9: Building a Balanced Scorecard. *HBR Store*. <https://store.hbr.org/product/strategy-execution-module-9-building-a-balanced-scorecard/117109>



# A Study on Inheritance Patterns on Eye Shape and Wing Presence in *Drosophila melanogaster*

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## Abstract

Due to its small size, short life cycle, abundance of genetic variability, and relative inexpensiveness, *Drosophila melanogaster*, the fruit fly, is used as the model organism. The purpose of the study was to develop an understanding for the inheritance patterns observed in *Drosophila melanogaster*. Mendelian traits studied were eye shape and apterous body (wingless). The wild-type phenotype was round eyes with wings, while the mutant phenotypes are apterous body (*ap*, chromosome 2) and bar-shaped eyes (*B*, chromosome 1 or sex chromosome). The crosses and reciprocal crosses were produced for one-gene and two-gene segregations. The goodness of fit test for the observed data was analyzed using  $\chi^2$  statistical test. For the eye shape gene on the sex chromosome in the monohybrid crosses, the segregation ratio was not observed in the cross (round  $\times$  bar). However, it followed 1:1 ratio in the reciprocal cross (bar  $\times$  round) for either female or male. When the data were combined, the disagreement of the segregation appeared again. In two dihybrid crosses, none of the segregation ratios fit conventional genetic ratios. The reasons that caused the distortion appear to include the penetrance and expressivity of the traits. Future investigation would provide the insightful explanation in this regard.

## Introduction

Fruit fly, *Drosophila melanogaster*, is commonly used as a model organism because it has significant properties such as short life cycle, abundance in genetic variations, relative inexpensiveness, small body size, etc. The Mendelian traits such as wing shape, body color, eye color, and wing presence were chosen to explore whether the segregation ratios followed the traditional genetic laws (Wiles et al. 2013; Wu et al. 2020; Stock et al. 2021). The previous studies showed that most of the traits didn't segregate in accordance with the classic genetic laws. In order to continue the exploration, the eye shape and apterous body (wingless) were selected in the study. The wild phenotype was round eyes with wings, while the mutant phenotypes were apterous body (*ap*, chromosome 2) and bar-shaped eyes (*B*, chromosome 1 or sex chromosome). For one-gene segregation, the crosses were produced between the round eye strain and bar eye strain. For two-gene segregation, the crosses were created between apterous strain and bar strain. The objective of the study was to investigate gene segregation ratios in the traditional genetic patterns for eye shape and wing presence using the commercial strains.

## Materials and Methods

**Fruit fly strain** The strains were purchased from Carolina Biological Supply Company (Carolina ... 2020). The wild (+) phenotype showed round eyes with wings, while the mutant phenotypes were apterous body (*ap*, chromosome 2) and bar-shaped eyes (*B*, chromosome 1 or sex chromosome).

## Fruit fly handling

Flies were maintained in spongecapped plastic vials containing roughly one inch of culture media and yeast cells. In order to cross the flies, FlyNap (an anesthesia agent) was soaked on the end of a wand. The wand was then inserted into the vial containing the  $F_1$  generation of flies, in a manner which allowed none of the flies to escape. The flies were monitored to determine when the FlyNap should be removed from the vial once fully anesthetized. The process of anesthetizing the flies took around 2 minutes. Caution was taken in order to avoid overexposure to FlyNap which was lethal to the flies in excessive dosage.

**Generation of crosses** After the flies were fully anesthetized, the cap of the vial was removed and the flies were transferred on to a white surface. They were then placed under a dissecting microscope to identify sexual features. Once the sex of each fly was identified, 5 males and 5 females were placed into a vial containing culture media. This selection occurred four times and a total of twenty males and twenty females were selected and placed in four separate vials. The flies had to be placed in their respective vials while the vials were lying on the side to ensure the flies did not get stuck to the culture medium in the new vials. After the flies recuperated from the FlyNap, the vials were placed upright. The same procedure was followed in setting up the crosses for the monohybrid flies which were only heterozygous for the sepia eye mutation.

**Scoring fruit flies** After 4 days, the  $F_1$  generation of flies was removed from the vials. Upon the removal of the  $F_1$  generation, larvae developed into mature fruit flies within 10-20 days. Upon the

emergence of the F<sub>2</sub> generation, mature fruit flies were counted and scored under a dissecting microscope according to their inherited traits.

**Mating maps**

For the gene on sex chromosome, male and female flies were scored separately. The genotype, phenotype and segregation ratios can be found below.

One Mendelian trait: eye shape

(P<sub>1</sub> × P<sub>2</sub>) cross

P<sub>1</sub>: X<sup>+</sup>X<sup>+</sup> (round) ♀ × P<sub>2</sub>: X<sup>B</sup>Y (bar) ♂

↓

F<sub>1</sub> X<sup>+</sup>X<sup>B</sup> (round) ♀ × X<sup>+</sup>Y (round) ♂

↓

F<sub>2</sub> generation

Gamete genotype	X <sup>+</sup>	Y
X <sup>+</sup>	X <sup>+</sup> X <sup>+</sup> (round) ♀	X <sup>+</sup> Y (round) ♂
X <sup>B</sup>	X <sup>+</sup> X <sup>B</sup> (round) ♀	X <sup>B</sup> Y (bar) ♂

Expected female phenotypic ratio: all round eye female

Expected male phenotypic ratio: 1 round eye male : 1 bar eye male

Expected overall phenotypic ratio: 3 round eye : 1 bar eye

(P<sub>2</sub> × P<sub>1</sub>) reciprocal cross

P<sub>2</sub>: X<sup>B</sup>X<sup>B</sup> (bar) ♀ × P<sub>1</sub>: X<sup>+</sup>Y (round) ♂

↓

F<sub>1</sub> X<sup>+</sup>X<sup>B</sup> (round) ♀ × X<sup>B</sup>Y (bar) ♂

↓

F<sub>2</sub> generation

Expected female phenotypic ratio: 1 round eye female : 1 bar eye female

Gamete genotype	X <sup>B</sup>	Y
X <sup>+</sup>	X <sup>+</sup> X <sup>B</sup> (round) ♀	X <sup>+</sup> Y (round) ♂
X <sup>B</sup>	X <sup>B</sup> X <sup>B</sup> (bar) ♀	X <sup>B</sup> Y (bar) ♂

Expected male phenotypic ratio: 1 round eye male : 1 bar eye male

Expected overall phenotypic ratio: 1 round eye female : 1 bar eye

female : 1 round eye male : 1 bar eye male

For the Mendelian trait in a dihybrid cross, male and female flies were also scored separately. The genotype, phenotype and segregation ratios can be seen below.

Two Mendelian traits: apterous body and eye shape (*a*: apterous/*ap*)

(P<sub>1</sub> × P<sub>2</sub>) cross

P<sub>1</sub>: aaX<sup>+</sup>X<sup>+</sup> (apterous, round eye) ♀ × P<sub>2</sub>: ++X<sup>B</sup>Y (winged, bar eye) ♂

↓

F<sub>1</sub> +aX<sup>+</sup>X<sup>B</sup> (winged, round eye) ♀ × +aX<sup>+</sup>Y (winged, round eye) ♂

↓

F<sub>2</sub> generation

Gamete genotype	+X <sup>+</sup>	aX <sup>+</sup>	+Y	aY
+X <sup>+</sup>	++X <sup>+</sup> X <sup>+</sup>	++X <sup>+</sup> X <sup>+</sup>	++X <sup>+</sup> Y	+aX <sup>+</sup> Y
+X <sup>B</sup>	++X <sup>+</sup> X <sup>B</sup>	+aX <sup>+</sup> X <sup>B</sup>	++X <sup>B</sup> Y	+aX <sup>B</sup> Y
aX <sup>+</sup>	+aX <sup>+</sup> X <sup>+</sup>	aaX <sup>+</sup> X <sup>+</sup>	+aX <sup>+</sup> Y	aaX <sup>+</sup> Y
aX <sup>B</sup>	+aX <sup>+</sup> X <sup>B</sup>	aaX <sup>+</sup> X <sup>B</sup>	+aX <sup>B</sup> Y	aaX <sup>B</sup> Y

Expected ratio: 3 winged, round (+\_X<sup>+</sup>X<sup>-</sup>) : 1 apterous, round (aa\_X<sup>+</sup>X<sup>-</sup>) in female, 3 winged, round (+\_X<sup>+</sup>Y) : 3 winged, bar (+\_X<sup>B</sup>Y) : 1 apterous, round (aa\_X<sup>+</sup>Y) : 1 apterous, bar (aa\_X<sup>B</sup>Y) in male.

(P<sub>2</sub> × P<sub>1</sub>) reciprocal cross

P<sub>2</sub>: ++X<sup>B</sup>X<sup>B</sup> (winged, bar eye) ♀ × P<sub>1</sub>: aaX<sup>+</sup>Y (apterous, round eye) ♂

↓

F<sub>1</sub> +aX<sup>+</sup>X<sup>B</sup> (winged, round eye) ♀ × +aX<sup>B</sup>Y (winged, bar eye) ♂

↓

F<sub>2</sub> generation

Gamete genotype	+X <sup>B</sup>	aX <sup>B</sup>	+Y	aY
+X <sup>+</sup>	++X <sup>+</sup> X <sup>B</sup>	++X <sup>+</sup> X <sup>B</sup>	++X <sup>+</sup> Y	+aX <sup>+</sup> Y
+X <sup>B</sup>	++X <sup>B</sup> X <sup>B</sup>	+aX <sup>B</sup> X <sup>B</sup>	++X <sup>B</sup> Y	+aX <sup>B</sup> Y
aX <sup>+</sup>	+aX <sup>+</sup> X <sup>B</sup>	aaX <sup>+</sup> X <sup>B</sup>	+aX <sup>+</sup> Y	aaX <sup>+</sup> Y
aX <sup>B</sup>	+aX <sup>B</sup> X <sup>B</sup>	aaX <sup>B</sup> X <sup>B</sup>	+aX <sup>B</sup> Y	aaX <sup>B</sup> Y

Expected ratio: 3 winged, round (+\_X<sup>+</sup>X<sup>-</sup>) : 3 winged, bar (+\_X<sup>B</sup>X<sup>B</sup>) : 1 apterous, round (aa\_X<sup>+</sup>X<sup>B</sup>) : 1 apterous, bar (aa\_X<sup>B</sup>X<sup>B</sup>) in female, 3 winged, round (+\_X<sup>+</sup>Y) : 3 winged, bar (+\_X<sup>B</sup>Y) : 1 apterous, round (aa\_X<sup>+</sup>Y) : 1 apterous, bar (aa\_X<sup>B</sup>Y) in male.

**Statistical analysis** The χ<sup>2</sup> statistical test was chosen to detect the fitness of the segregation ratios (Klug et al. 2010). The software called MegaStat in Excel will be used to analyze the data.

Results

1. Eye shape gene on X chromosome in the monohybrid crosses

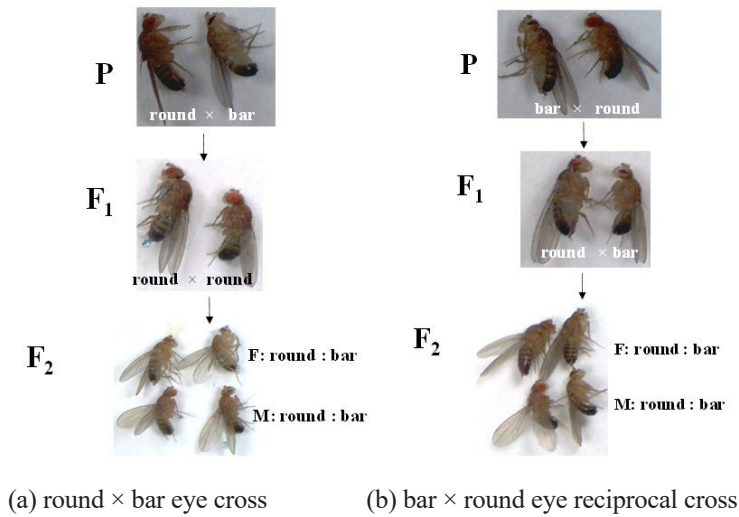


Figure 1 A display of the phenotypes of fruit flies in two monohybrid crosses

From a cross between round eye female and bar eye male in (a) of figure 1, round eye was the uniform phenotype in F<sub>1</sub>. The round eye and bar eye for both female and male were present in F<sub>2</sub>. In (b), when a reciprocal cross (bar eye female and round eye male) was created, the phenotypes in F<sub>1</sub> were shown as round eye for female and bar eye for male. But the phenotypes in F<sub>2</sub> were present as round eye and bar eye for both female and male.

Table 1 The results of  $\chi^2$  tests for the monohybrid cross (Round  $\times$  Bar)

Phenotype	Female (all round eye)			Male (1:1)			Female + Male (3:1)		
	Obs	Exp	$\chi^2$	Obs	Exp	$\chi^2$	Obs	Exp	$\chi^2$
Round eye	252	-	-	208	175.0	6.22	460	559.5	17.69
Bar eye	144	-	-	142	175.0	6.22	286	186.5	53.08
Total	396	-	-	350	350	12.45	746	746	70.78

In Table 1, the  $\chi^2$  tests were performed on the number of flies in the cross between round eye and bar eye strain related to eye shape. For female, the result didn't generate because there were 144 flies with bar eye which disagreed with the expectation according to the mating map. For male and overall (female and male), the  $\chi^2$  value was higher than 3.84 ( $\chi^2$  value at 5% significant level with degrees of freedom of one). The probability was smaller than 5% indicating that the observed segregation ratio didn't fit the expected 1:1 or 3:1 ratio. On the whole, there was no agreement in terms of the segregation ratio for eye shape in the cross.

Table 2 The results of  $\chi^2$  tests for either female or male in the monohybrid reciprocal cross (Bar  $\times$  Round)

Phenotype	Female (1:1)			Male (1:1)		
	Obs	Exp	$\chi^2$	Obs	Exp	$\chi^2$
Round eye	143	140.0	0.06	190	189.0	0.01
Bar eye	137	140.0	0.06	188	189.0	0.01
Total	280	280	0.13	378	378	0.02

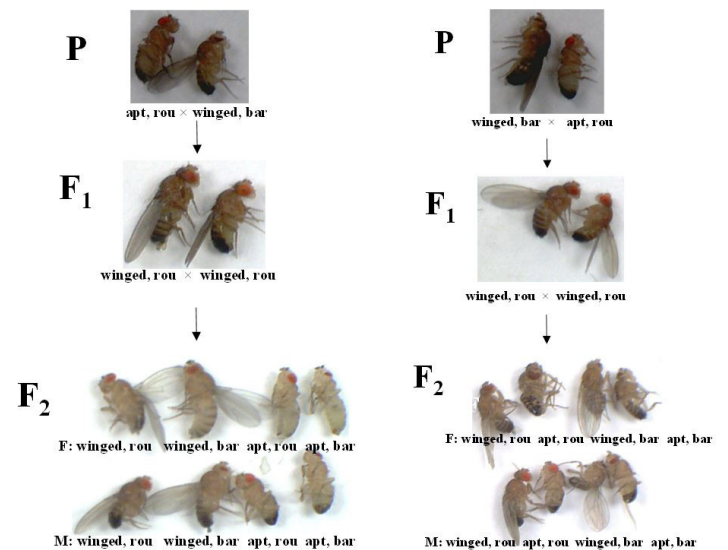
In the reciprocal cross between bar eye and round eye strain (Table 2), the results for female and male revealed that  $\chi^2$  value was lower than  $\chi^2_{0.05,1} = 3.84$ . The probability was greater than 5% demonstrating that the observed segregation ratio followed the expected 1:1 ratio.

Table 3 The results of  $\chi^2$  tests for both female and male in the monohybrid reciprocal cross (Bar  $\times$  Round)

Phenotype	Female + Male (1:1:1:1)		
	Obs	Exp	$\chi^2$
Round eye (female)	143	164.5	2.81
Bar eye (female)	137	164.5	4.60
Round eye (male)	190	164.5	3.95
Bar eye (male)	188	164.5	3.36
Total	658	658	14.72

In the reciprocal cross (Table 3),  $\chi^2$  value was higher than  $\chi^2_{0.05,3} = 7.82$ . The probability was smaller than 5% illustrating that the observed segregation ratio didn't fit the expected 1:1:1:1 ratio.

2. Eye shape and wing presence in dihybrid crosses



(a) apterous, round  $\times$  winged, bar cross (b) winged, bar  $\times$  apterous, round reciprocal cross

Figure 2 A display of the phenotypes of fruit flies in two dihybrid crosses

In a dihybrid cross between the strains of apterous body with round eye, and winged body with bar eye in (a) of Figure 2, the phenotypes for female and male in  $F_2$  were present as winged, round eye; winged, bar eye; apterous, round eye; and apterous, bar eye. In the dihybrid reciprocal cross between the strain of winged, bar eye and the strain of apterous, round eye shown as (b), the phenotypes for female and male in  $F_2$  were the same as seen in (a).

The  $\chi^2$  tests were conducted for two dihybrid crosses on the number of female and male flies in relation eye shape and wing presence.

**Table 4** The results of  $\chi^2$  tests for the dihybrid cross (apterous, round eye  $\times$  winged, bar eye)

Phenotype	Female (3 wing, round : 1 apterous, round)			Male (3:3:1:1)		
	Obs	Exp	$\chi^2$	Obs	Exp	$\chi^2$
Winged, round	71	-	-	82	43.1	35.04
Winged, bar	16	-	-	20	43.1	12.40
Apterous, round	7	-	-	11	14.4	0.79
Apterous, bar	1	-	-	2	14.4	10.65
Total	95	-	-	115	115	58.89

In the dihybrid cross (Table 4) to observe two-gene segregation, for female, the  $\chi^2$  test result didn't produce because there were 17 flies with winged, bar eye and apterous, bar eye which disagreed with the expectation according to the mating map. For male, the  $\chi^2$  test results indicated that probabilities were smaller than 5% because all  $\chi^2$  values were greater than  $\chi^2_{0.05,3} = 7.82$ . It meant that the segregation of the genes controlling eye shape and wing presence didn't obey second Mendelian genetic law.

**Table 5** The results of  $\chi^2$  tests for the dihybrid reciprocal cross (winged, bar eye  $\times$  apterous, round eye)

Phenotype	Female (3:3:1:1)			Male (3:3:1:1)		
	Obs	Exp	$\chi^2$	Obs	Exp	$\chi^2$
Winged, round	70	69.4	0.01	127	92.6	12.76
Winged, bar	107	69.4	20.41	107	92.6	2.23
Apterous, round	4	23.1	15.82	5	30.9	21.68
Apterous, bar	4	23.1	15.82	8	30.9	16.95
Total	185	185	52.05	247	247	53.62

As shown in Table 5, the dihybrid reciprocal cross was created also for the observation of two-gene segregation. For both female and male, all  $\chi^2$  test results indicated that probabilities were smaller than 5% because all  $\chi^2$  values were greater than  $\chi^2_{0.05,3} = 7.82$ . It

meant that the segregations of the genes controlling eye shape and wing presence didn't conform to second Mendelian genetic law. The similar test results were found from the dihybrid cross above.

## Discussion

For the eye shape gene on X-linked chromosome in the monohybrid crosses, the segregation was not observed in the cross (round  $\times$  bar). However, it followed 1:1 ratio in the reciprocal cross (bar  $\times$  round) for either female or male. When the data were combined, the disagreement of the segregation appeared again. In two dihybrid crosses, none of the segregation ratios fit conventional genetic ratios.

There are several speculations for the discord detected in the study.

The penetrance and expressivity of different traits could affect the phenotypic expression. Retinoblastoma (Rb), the most common pediatric intraocular neoplasm, results from inactivation of both alleles of the RB1 tumor suppressor gene. Eloy (Eloy et al. 2016) showed that some Rb families displayed low penetrance and variable expressivity. Bardet-Biedl syndrome (BBS) is a rare oligogenic disorder characterized by the hallmarks of developmental and learning difficulties. Eichers (Eichers et al. 2006) revealed that the extensive characterization of the penetrance and variable expressivity in the Bbs4 mouse model was observed.

In many organisms, genetic factors, called Meiotic Drive Elements (MDs), have found ways to break Mendel's laws of heredity (Grognet et al. 2014). MDs skew the expected 1:1 ratio in their favor and are thus overrepresented in the progeny after meiosis. They have been observed in metazoans, plants and fungi (Pennisi 2003). They may play a critical role in population behavior, leading to sex ratio distortion and thus decreasing population size. Additionally, fitness can also be altered by MD factors if they are genetically linked to alleles that confer deleterious traits (Saupe 2012).

Investigation of "Segregation Distorter" in *Drosophila* (Sandler et al. 1951; Larracuenta and Presgraves 2012), has showed that MDs are composed of at least two linked genes, the distorter that acts as a toxin by disrupting the formation of gametes, and the responder that acts as an antitoxin that protects from the deleterious distorter effects. Researchers (Anderson et al. 2009) characterized patterns of polymorphism and divergence in the protein-coding regions of 33 genes across of *Drosophila melanogaster*. Along the *D. melanogaster* lineage several loci exhibited patterns consistent with the maintenance of protein variation.

The major gene effects and segregation at a major locus are

usually masked by a large number of environmental effects, genetic × environmental interactions, as well as polygenic effects (Zeng 2000).

In the future it is interesting to conduct a study on investigating the factors that cause the deviation of classical genetic ratios in these fruit fly strains. For example, to find how the penetrance and expressivity influence the phenotype ratios among the mutants will be meaningful.

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### References

- Anderson, J. A., Gilliland, W. D., & Langley, C. H. 2009. Molecular population genetics and evolution of *Drosophila* meiosis genes. *Genetics*, *181*(1), 177-185.
- Carolina Biological Supply Company. (2020). *Drosophila Manual*. Retrieved from <https://www.carolina.com/drosophila-fruit-fly-genetics/drosophila-manual-carolina/452620.pr>
- Erica, R. E., Abd-El-Barr, M. M., Paylor, R., Lewis, R. A., Bi, W., Lin, X., Meehan, T. P., Stockton, D. W., Wu, S. M., Lindsay, E., Justice, M. J., Beales, P. L., Katsanis, N., & Lupski, J. R. 2006. Phenotypic characterization of Bbs4 null mice reveals age-dependent penetrance and variable expressivity. *Human Genetics*, *120*, 211–226.
- Eloy, P., Dehainault, C., Sefta, M., Aerts, I., Doz, F., & Cassoux, N. (2016). A Parent-of-Origin Effect Impacts the Phenotype in Low Penetrance Retinoblastoma Families Segregating the c.1981C>T/p.Arg661Trp Mutation of RB1. *PLoS Genetics*, *12*(2), e1005888. doi:10.1371/journal.pgen.1005888.
- Grognon, P., Lalucque, H., Malagnac, F., & Silar, P. (2014). Genes that bias mendelian segregation. *PLoS Genetics*, *10*(5), 10. e1004387. 10.1371/journal.pgen.1004387
- Klug, W. S, Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2010). *Essentials of genetics* (7th ed.). Pearson Education Inc., pp. 49-51
- Larracuente, A. M., & Presgraves, D. C. (2012). The selfish segregation distorter gene complex of *drosophila melanogaster*. *Genetics*, *192*, 33-53.
- Pennisi, E. (2003). Meiotic drive: Bickering genes shape evolution. *Science*, *301*, 1837-1839.
- Sandler, L., Hiraizumi, Y., & Sandler, I. (1959). Meiotic drive in natural populations of *drosophila melanogaster*: the cytogenetic basis of segregation/distortion. *Genetics*, *44*, 233-250.
- Saupe, S. J. (2012). A fungal gene reinforces Mendel's laws by counteracting genetic cheating. *Proc Natl Acad Sci USA*, *09*, 11900-11901.
- Stock, U., Stringfellow, H., & Wu, Y. (2021). The study on genetic patterns of eye color and wing presence in *Drosophila melanogaster*. *Southwest Journal of Arts and Sciences*, *1*(1): 38-41.
- Wiles, S., & Hargadon, K. M. (2013). Inheritance patterns in monohybrid and dihybrid crosses for sepia eye color and apterous (wingless) mutations in *drosophila melanogaster*. *HSC Journal of sciences*, *8*, 1-5.
- Wu, Y., Stock, U., Garcia, J., & Chavez, I. (2020). A study on inheritance patterns on wing shape, body color and eye color in *Drosophila melanogaster*. *New Mexico Journal of Science* *54*(1), 57-66.
- Zeng, W. (2011). Statistical methods for detecting major genes of quantitative traits using phenotypic data of a diallel mating (unpublished dissertation). North Carolina State University, Raleigh, NC.



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