Clustering Results Summary

1. **Optimal Number of Clusters:**
   Based on the Davies-Bouldin Index (DB Index) and Silhouette Score, the optimal number of clusters was determined to be **3**.
2. **Evaluation Metrics:**
   - **Davies-Bouldin Index:** 0.769
     (Lower values indicate better separation between clusters.)
   - **Silhouette Score:** 0.415
     (Scores closer to 1 indicate well-separated and cohesive clusters.)
   - **Inertia (Sum of Squared Distances):** 151.59
     (Measures compactness; lower is better.)
3. **Cluster Assignments:** Each customer was assigned to one of the three clusters based on their spending, transaction frequency, and quantity purchased.
4. **Cluster Visualization:** The PCA-based scatterplot shows distinct clusters, indicating meaningful segmentation of customers based on their behavior.

Cluster Characteristics

Cluster 0: High-Value Customers

- **Profile:** Customers in this cluster are characterized by high total spending and a high number of transactions. They are likely frequent buyers and contribute significantly to revenue.
- **Business Strategy:**
  - Offer loyalty rewards, VIP perks, and early access to sales to retain these customers.
  - Use personalized marketing to upsell premium products.

Cluster 1: Low-Value Customers

- **Profile:** This cluster includes customers with low total spending and fewer transactions. They may represent new or less engaged customers.
- **Business Strategy:**
  - Run engagement campaigns, such as offering first-time discounts or introducing them to popular products.
  - Provide incentives for repeat purchases (e.g., free shipping on the next order).

Cluster 2: Moderate-Value Customers

- **Profile:** Customers in this group have moderate spending and transaction frequency. They represent a mix of regular buyers who occasionally make larger purchases.
- **Business Strategy:**
  - Focus on cross-selling and targeted advertising to increase average order value (AOV).
  - Nurture these customers toward becoming high-value customers.

Key Insights

1. **Distinct Segmentation:**
   The clustering analysis effectively identified three distinct customer groups with varying spending behaviors, allowing targeted marketing and resource allocation.

2. **Cluster Contribution:**
   Cluster 0 (High-Value Customers) likely generates the largest share of revenue despite being a smaller segment, while Cluster 1 (Low-Value Customers) may represent the bulk of customers but contributes less to revenue.
3. **Actionable Strategies:**
   - Retain high-value customers through loyalty programs and personalized service.
   - Re-engage low-value customers with promotions or educational content about products.
   - Upsell and cross-sell to moderate-value customers to increase their spending.
4. **Cluster Cohesion and Separation:** While the Davies-Bouldin Index is satisfactory (0.769), the Silhouette Score (0.415) suggests some overlap between clusters. Further refinement of features (e.g., including regional or categorical spending patterns) may improve clustering performance.

Recommendations
1. **Data Refinement:** Include additional customer attributes (e.g., signup date, product preferences) to refine segmentation and improve cluster separation.
2. **Targeted Campaigns:**
   - **High-Value Customers:** Focus on retention strategies and exclusivity.
   - **Low-Value Customers:** Reactivate with incentives like discounts or bundles.
   - **Moderate-Value Customers:** Increase spending through upselling and cross-selling.
3. **Periodic Analysis:** Perform clustering periodically to track changes in customer behavior and adjust strategies accordingly.