In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.cluster import KMeans
from sklearn.metrics import davies_bouldin_score
from sklearn.decomposition import PCA
```

In [2]:
```
# Load the datasets
customers_df = pd.read_csv('Customers.csv')
products_df = pd.read_csv('Products.csv')
transactions_df = pd.read_csv('Transactions.csv')
```

In [3]:
```
# Convert date columns to datetime format
customers_df['SignupDate'] = pd.to_datetime(customers_df['SignupDate'])
transactions_df['TransactionDate'] = pd.to_datetime(transactions_df['Transa
```

In [4]:
```
# Merge datasets
merged_df = transactions_df.merge(customers_df, on='CustomerID', how='inne
merged_df = merged_df.merge(products_df, on='ProductID', how='inner')
merged_df
```

Out[4]:

	TransactionID	CustomerID	ProductID	TransactionDate	Quantity	TotalValue	Price_x
0	T00001	C0199	P067	2024-08-25 12:38:23	1	300.68	300.68
1	T00112	C0146	P067	2024-05-27 22:23:54	1	300.68	300.68
2	T00166	C0127	P067	2024-04-25 07:38:55	1	300.68	300.68
3	T00272	C0087	P067	2024-03-26 22:55:37	2	601.36	300.68
4	T00363	C0070	P067	2024-03-21 15:10:10	3	902.04	300.68
...	...	...	...	...	...	...	...
995	T00630	C0031	P093	2024-10-08 23:58:14	2	609.88	304.94
996	T00672	C0165	P044	2024-07-28 00:09:49	4	75.28	18.82
997	T00711	C0165	P044	2024-06-11 15:51:14	4	75.28	18.82
998	T00878	C0165	P044	2024-09-24 21:15:21	3	56.46	18.82
999	T00157	C0169	P044	2024-11-09 09:07:36	2	37.64	18.82

1000 rows × 13 columns

In [5]:
```
# ==================
# Feature Engineering
# ==================

# Calculate total spending per customer
customer_spending = merged_df.groupby('CustomerID')['TotalValue'].sum().re
customer_spending.columns = ['CustomerID', 'TotalSpending']
```

In [6]:
```
# Calculate transaction count per customer
customer_transactions = merged_df.groupby('CustomerID')['TransactionID'].co
customer_transactions.columns = ['CustomerID', 'TransactionCount']
print(customer_transactions)
```

```
    CustomerID  TransactionCount
0        C0001                 5
1        C0002                 4
2        C0003                 4
3        C0004                 8
4        C0005                 3
..         ...               ...
194      C0196                 4
195      C0197                 3
196      C0198                 2
197      C0199                 4
198      C0200                 5

[199 rows x 2 columns]
```

In [7]:
```
# Calculate product category preferences per customer
category_preferences = merged_df.pivot_table(index='CustomerID', columns='(
print(category_preferences)
```

```
Category CustomerID  Books  Clothing  Electronics  Home Decor
0             C0001      1         0            3           1
1             C0002      0         2            0           2
2             C0003      0         1            1           2
3             C0004      3         0            2           3
4             C0005      0         0            2           1
..              ...    ...       ...          ...         ...
194           C0196      1         1            0           2
195           C0197      0         0            2           1
196           C0198      0         1            1           0
197           C0199      0         0            2           2
198           C0200      1         2            1           1

[199 rows x 5 columns]
```

In [8]:
```
# Merge all features into a single dataset
customer_features = customers_df.merge(customer_spending, on='CustomerID',
customer_features = customer_features.merge(customer_transactions, on='Cus
customer_features = customer_features.merge(category_preferences, on='Custo
customer_features
```

Out[8]:

	CustomerID	CustomerName	Region	SignupDate	TotalSpending	TransactionCount	Bo
0	C0001	Lawrence Carroll	South America	2022-07-10	3354.52	5.0	
1	C0002	Elizabeth Lutz	Asia	2022-02-13	1862.74	4.0	
2	C0003	Michael Rivera	South America	2024-03-07	2725.38	4.0	
3	C0004	Kathleen Rodriguez	South America	2022-10-09	5354.88	8.0	
4	C0005	Laura Weber	Asia	2022-08-15	2034.24	3.0	
...	...	...	...	...	...	...	
195	C0196	Laura Watts	Europe	2022-06-07	4982.88	4.0	
196	C0197	Christina Harvey	Europe	2023-03-21	1928.65	3.0	
197	C0198	Rebecca Ray	Europe	2022-02-27	931.83	2.0	
198	C0199	Andrea Jenkins	Europe	2022-12-03	1979.28	4.0	
199	C0200	Kelly Cross	Asia	2023-06-11	4758.60	5.0	

200 rows × 10 columns

In [9]:
```
# Fill missing values with 0
customer_features.fillna(0, inplace=True)
```

In [12]:
```
# Normalize numerical features for clustering
numerical_features = ['TotalSpending', 'TransactionCount'] + list(category_
customer_features_normalized = customer_features[numerical_features]
customer_features_normalized = (customer_features_normalized - customer_fea
```

In [19]:
```
# Clustering
# -------------------
# Use KMeans for clustering
from sklearn.cluster import KMeans
from sklearn.metrics import davies_bouldin_score
import matplotlib.pyplot as plt
import seaborn as sns

cluster_metrics = {}
for k in range(2, 11):
    kmeans = KMeans(n_clusters=k, random_state=42)
    customer_features[f'Cluster_{k}'] = kmeans.fit_predict(customer_featur
    db_index = davies_bouldin_score(customer_features[numerical_features],
    cluster_metrics[k] = db_index
```

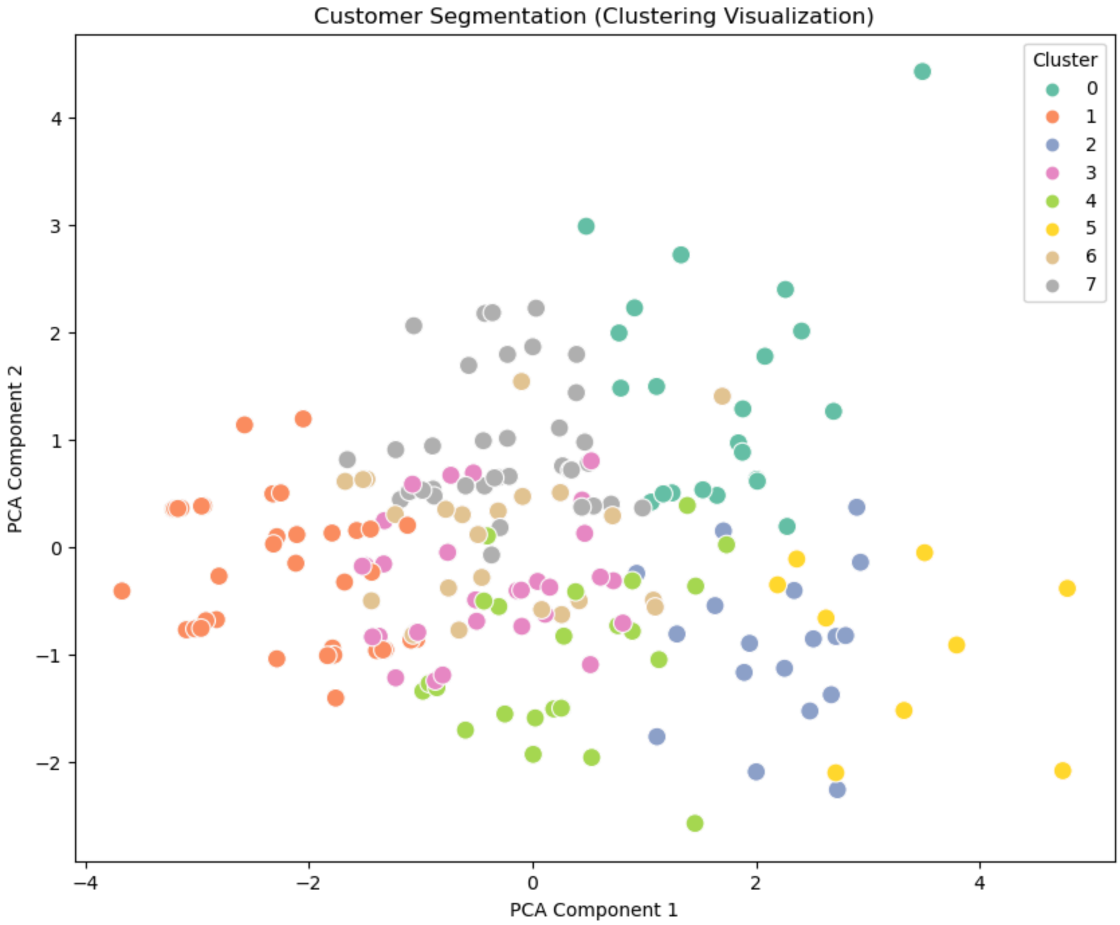
In [20]:
```
# Select optimal number of clusters
optimal_k = min(cluster_metrics, key=cluster_metrics.get)
print(f"Optimal Number of Clusters: {optimal_k}")
print(f"Davies-Bouldin Index for Optimal Clusters: {cluster_metrics[optima
```

```
Optimal Number of Clusters: 8
Davies-Bouldin Index for Optimal Clusters: 1.2385086058556265
```

In [21]:
```
# Final clustering with optimal_k
kmeans = KMeans(n_clusters=optimal_k, random_state=42)
customer_features['Cluster'] = kmeans.fit_predict(customer_features[numeri
```

In [22]:
```
# Visualize clusters using PCA (dimensionality reduction)
from sklearn.decomposition import PCA
pca = PCA(n_components=2)
customer_features['PCA1'] = pca.fit_transform(customer_features[numerical_
customer_features['PCA2'] = pca.fit_transform(customer_features[numerical_
```

In [23]:
```
plt.figure(figsize=(10, 8))
sns.scatterplot(data=customer_features, x='PCA1', y='PCA2', hue='Cluster',
plt.title('Customer Segmentation (Clustering Visualization)')
plt.xlabel('PCA Component 1')
plt.ylabel('PCA Component 2')
plt.legend(title='Cluster')
plt.show()
```



In [24]:
```
# Save clustering results
customer_features[['CustomerID', 'Cluster']].to_csv('Customer_Segmentation
```

In [25]:
```
# Report clustering metrics
print("\nClustering Metrics:")
for k, db_index in cluster_metrics.items():
    print(f"Number of Clusters: {k}, DB Index: {db_index:.4f}")
```

```
Clustering Metrics:
Number of Clusters: 2, DB Index: 1.4506
Number of Clusters: 3, DB Index: 1.6213
Number of Clusters: 4, DB Index: 1.5238
Number of Clusters: 5, DB Index: 1.3496
Number of Clusters: 6, DB Index: 1.3838
Number of Clusters: 7, DB Index: 1.2603
Number of Clusters: 8, DB Index: 1.2385
Number of Clusters: 9, DB Index: 1.2575
Number of Clusters: 10, DB Index: 1.2484
```

In [ ]: