

Assignment 03

Julio Vargas

September 21, 2025

```
from pyspark.sql import SparkSession
from pyspark.sql import functions as F
from pyspark.sql.functions import col, split, explode, regexp_replace, transform, when
from pyspark.sql.functions import col, monotonically_increasing_id
from pyspark.sql.types import StructType # to/from JSON

import json
import re
import numpy as np
import pandas as pd

import plotly.express as px
import plotly.io as pio
import plotly.graph_objects as go

np.random.seed(30) # set a fixed seed for reproducibility
pio.renderers.default = "vscode+notebook" #
# Initialize Spark Session
spark = SparkSession.builder.appName("JobPostingsAnalysis").getOrCreate()
# Load schema from JSON file
with open("data/schema_lightcast.json") as f:
    schema = StructType.fromJson(json.load(f))

# Load Data
df = (spark.read
      .option("header", "true")
      .option("inferSchema", "false")
      .schema(schema) # saved schema
      .option("multiLine", "true")
      .option("escape", "\\")
```

```

        .csv("data/lightcast_job_postings.csv")
    )

df.createOrReplaceTempView("job_postings")
# Show Schema and Sample Data
#df.printSchema()
df.show(5)
df.count()

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time (> 32 h...|          2|          2|          false| NULL|          0|
2051.01|Business Intellig...|15-2051.01|Business Intellig...|[\n  "45.0601",\n...|[\n  "Econ
0000|Computer and Math...|  15-2000|Mathematical Scie...|  15-2050|Data Scientists|  15-
2051|Data Scientists|          23|Information Techn...|          231010|Business Intellig..
0000|Computer and Math...|15-2000|Mathematical Scie...|15-2050|Data Scientists|15-
2051|Data Scientists|          [\n  7\n]|  [\n  "Artificial ...|          44|          Retail Tra
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2051.01|Business Intellig...|15-2051.01|Business Intellig...|          []|
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2051|Data Scientists|          NULL|          NULL|          56|Administrative an

```

85318b12b3331fa49...	9/6/2024	2024-09-06 20:32:...	1 6/2/2024	7/7/2024
time (> 32 h...	5	NULL	false	NULL
Fort Worth...	48	Texas	48113	Dallas, TX
Fort Worth...	19100	Dallas-Fort Worth...	52	Finance and Insur...
2051.01	Business Intellig...	15-2051.01	Business Intellig...	[]
0000	Computer and Math...	15-2000	Mathematical Scie...	15-2050
2051	Data Scientists	23	Information Techn...	231113
0000	Computer and Math...	15-2000	Mathematical Scie...	15-2050
2051	Data Scientists	NULL	NULL	52
1b5c3941e54a1889e...	9/6/2024	2024-09-06 20:32:...	1 6/2/2024	7/20/2024
time (> 32 h...	3	NULL	false	NULL
Mesa-Chan...	4	Arizona	4013	Maricopa, AZ
Mesa-Chan...	38060	Phoenix-Mesa-Chan...	52	Finance and Insur...
2051.01	Business Intellig...	15-2051.01	Business Intellig...	[]
0000	Computer and Math...	15-2000	Mathematical Scie...	15-2050
2051	Data Scientists	23	Information Techn...	231113
0000	Computer and Math...	15-2000	Mathematical Scie...	15-2050
2051	Data Scientists	[\n 6\n]	[\n "Data Privac...	52
cb5ca25f02bdf25c1...	6/19/2024	2024-06-19 07:00:00	0 6/2/2024	6/17/2024
time / full-...	NULL	NULL	false	92500
2051.01	Business Intellig...	15-2051.01	Business Intellig...	[]
0000	Computer and Math...	15-2000	Mathematical Scie...	15-2050
2051	Data Scientists	23	Information Techn...	231010
0000	Computer and Math...	15-2000	Mathematical Scie...	15-2050
2051	Data Scientists	NULL	NULL	99

```

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```

[Stage 39:>                                     (0 + 1) / 1]

72498

```

1 1.1 Casting salary and experience columns

1.1 1.1 Computing medians

```

from pyspark.sql.functions import col, regexp_replace, trim
# 1.1 Casting salary and experience columns

df = df.withColumn("SALARY", col("SALARY").cast("float")) \
        .withColumn("SALARY_FROM", col("SALARY_FROM").cast("float")) \
        .withColumn("SALARY_TO", col("SALARY_TO").cast("float")) \
        .withColumn("MIN_YEARS_EXPERIENCE", col("MIN_YEARS_EXPERIENCE").cast("float")) \
        .withColumn("MAX_YEARS_EXPERIENCE", col("MAX_YEARS_EXPERIENCE").cast("float"))
#df.select("SALARY", "SALARY_FROM", "SALARY_TO", "MIN_YEARS_EXPERIENCE", "MAX_YEARS_EXPERIENCE")
df.select("SALARY", "SALARY_FROM", "SALARY_TO", "MIN_YEARS_EXPERIENCE", "MAX_YEARS_EXPERIENCE")

```

```

+-----+-----+-----+-----+-----+
| SALARY|SALARY_FROM|SALARY_TO|MIN_YEARS_EXPERIENCE|MAX_YEARS_EXPERIENCE|
+-----+-----+-----+-----+-----+
|  NULL|      NULL|      NULL|                2.0|                2.0|
|  NULL|      NULL|      NULL|                3.0|                3.0|
|  NULL|      NULL|      NULL|                5.0|                NULL|

```

NULL	NULL	NULL	3.0	NULL
92500.0	35000.0	150000.0	NULL	NULL
+-----+-----+-----+-----+-----+				

only showing top 5 rows

1.2 1.2 Computing medians

```
# 1.2 Computing medians
def compute_median(sdf, col_name):
    q = sdf.approxQuantile(col_name, [0.5], 0.01) #50 percentile 1% error
    return q[0] if q else None

median_from = compute_median(df, "SALARY_FROM")
median_to = compute_median(df, "SALARY_TO")
median_salary = compute_median(df, "SALARY")
```

[Stage 43:>

(0 + 1) / 1]

```
# 1.2 Output
#the median_from, median_to , median_salary respectively are:

print("- Median SALARY_FROM: $" + str(median_from))
print("- Median SALARY_TO: $" + str(median_to))
print("- Median SALARY: $" + str(median_salary))
```

```
- Median SALARY_FROM: $87295.0
- Median SALARY_TO: $130042.0
- Median SALARY: $115024.0
```

1.3 1.3 Imputing missing salaries

```
# 1.3 Imputing missing salaries
df = df.fillna({
    "SALARY_FROM": median_from,
    "SALARY_TO": median_to,
    "SALARY": median_salary
})
```

```
# 1.3 Add new column Average_Salary
df = df.withColumn("Average_Salary", (col("SALARY_FROM") + col("SALARY_TO")) / 2)

export_cols = ["Average_Salary", "SALARY", "EDUCATION_LEVELS_NAME", "REMOTE_TYPE_NAME",
               "MAX_YEARS_EXPERIENCE", "LOT_V6_SPECIALIZED_OCCUPATION_NAME"]

# 1.3 Output
df.select(*export_cols).show(5, truncate=False)
```

```
+-----+-----+-----+-----+
+-----+-----+-----+-----+
|Average_Salary|SALARY |EDUCATION_LEVELS_NAME      |REMOTE_TYPE_NAME|MAX_YEARS_EXPERIENCE
+-----+-----+-----+-----+
+-----+-----+-----+-----+
|108668.5      |115024.0|[\n  "Bachelor's degree"\n] | [None]          |2.0
|108668.5      |115024.0|[\n  "No Education Listed"\n]| Remote          |3.0
|108668.5      |115024.0|[\n  "Bachelor's degree"\n] | [None]          |NULL
|108668.5      |115024.0|[\n  "No Education Listed"\n]| [None]          |NULL
|92500.0       |92500.0 |[\n  "No Education Listed"\n]| [None]          |NULL
+-----+-----+-----+-----+
+-----+-----+-----+-----+
```

only showing top 5 rows

1.4 1.4 Cleaning Education column

```
#1.4 Cleaning Education column
#remove the \n and \r
df1 = df.withColumn("EDUCATION_LEVELS_NAME",
                    trim(
                        regexp_replace(regexp_replace(col("EDUCATION_LEVELS_NAME"), r"\n|\r", ""), #remove \n
                                         r"[\s+\\\"", "[\\"]" ) #remove spaces.
                    )
)

# 1.4 Output
df1.select(*export_cols).show(5, truncate=False)
```

```
+-----+-----+-----+-----+
+-----+-----+-----+-----+
|Average_Salary|SALARY |EDUCATION_LEVELS_NAME      |REMOTE_TYPE_NAME|MAX_YEARS_EXPERIENCE|LOT_V6
```

```

+-----+-----+-----+-----+-----+
+-----+
|108668.5      |115024.0|["Bachelor's degree"]  |[None]          |2.0             |Genera
|108668.5      |115024.0|["No Education Listed"]|Remote          |3.0             |Orac
|108668.5      |115024.0|["Bachelor's degree"]  |[None]          |NULL            |Data
|108668.5      |115024.0|["No Education Listed"]|[None]          |NULL            |Data
|92500.0       |92500.0 |["No Education Listed"]|[None]          |NULL            |Orac
+-----+-----+-----+-----+-----+
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```

only showing top 5 rows

1.5 1.5 Exporting Cleaned Data

```

#1.5 Exporting Cleaned Data
# Export to CSV
df_selected=df1.select(*export_cols)
pdf = df_selected.toPandas()
pdf.to_csv("data/lightcast_cleaned.csv", index=False)

print("Data cleaning complete. Rows retained:", len(pdf))

```

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(0 + 1) / 1]

Data cleaning complete. Rows retained: 72498

1.6 2 Salary Distribution by Industry and Employment Type

1.7 2.0 TEMPLATE

```

import plotly.graph_objects as go
import plotly.io as pio

pio.templates["nike"] = go.layout.Template(
    # LAYOUT
    layout = {
        # Fonts and colors
        'title': {
            'font': {'family': 'HelveticaNeue-CondensedBold, Helvetica, Sans-serif',

```



```

        'size': 30,
        'color': '#13007c'}
    },
    'font': {'family': 'Helvetica Neue, Helvetica, Sans-serif',
             'size': 16,
             'color': '#3b3b3b'}},

    'colorway': ['#fffb00', '#e010fc'],
    # Adding others
    'hovermode': 'x unified',
    'plot_bgcolor': '#E5ECF6',
    'paper_bgcolor': "#FFFFFF",

},
# DATA
data = {
    # Default style applied to all bar charts
    'bar': [go.Bar(
        texttemplate = '%{value:$.2s}',
        textposition = 'outside',
        textfont = {'family': 'Helvetica Neue, Helvetica, Sans-serif',
                    'size': 20,
                    'color': '#ff6874'} # FFFFFFFF
    )]
}
)

```

1.8 2.1 Salary Distribution by Industry and Employment Type

```

#your code for first query
import pandas as pd
import polars as pl
from IPython.display import display, HTML

#2.2 Filter the dataset - Remove records where salary is missing or zero.
df_valid_salaries = df.filter(df["SALARY"] > 0).select("NAICS2_NAME", "EMPLOYMENT_TYPE_NAME",

#2.2 output - convert to pandas
pdf = df_valid_salaries.toPandas()
print("Data cleaning complete. Rows retained:", len(pdf))

```

#2.3 Aggregate data - NAICS industry codes, employment type and compute salary distribution.

```
# Clean employment type names for better readability
pdf["EMPLOYMENT_TYPE_NAME"] = (pdf["EMPLOYMENT_TYPE_NAME"].astype(str)
                                .str.replace(r"^\x00-\x7F+", "", regex=True)
                                )

#2.3 output
median_salaries_naics = pdf.groupby("NAICS2_NAME")["SALARY"].median()
median_salaries_employee = pdf.groupby("EMPLOYMENT_TYPE_NAME")["SALARY"].median()
display(median_salaries_naics.to_frame().head())
display(median_salaries_employee.to_frame().head())
```

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Data cleaning complete. Rows retained: 72498

NAICS2_NAME	SALARY
Accommodation and Food Services	115024.0
Administrative and Support and Waste Management and Remediation Services	115024.0
Agriculture, Forestry, Fishing and Hunting	115024.0
Arts, Entertainment, and Recreation	115024.0
Construction	115024.0

EMPLOYMENT_TYPE_NAME	SALARY
Full-time (> 32 hours)	115024.0
None	115024.0
Part-time (≤ 32 hours)	115024.0
Part-time / full-time	115024.0

```
#2.4 Visualize results box plot
# X-axis = NAICS2_NAME || Y-axis = SALARY || Group by EMPLOYMENT_TYPE_NAME.
pdf = df.select("NAICS2_NAME", "SALARY").toPandas()
fig = px.box(pdf, x="NAICS2_NAME", y="SALARY", title="Salary Distribution by Industry",
              color_discrete_sequence=["#EF553B"])
```

```

        # add nike template
#fig.update_layout(template="nike")

#fig.update_xaxes(tickangle=45)

fig.update_layout(
    template="nike",
    height=700,
    xaxis=dict(
        title=dict(text="NAICS2_NAME", standoff=40),
        tickangle=45,
        tickfont=dict(size=10),
        automargin=True
    ),
    yaxis=dict(title=dict(text="Salary")),
    margin=dict(b=150)
)

fig.show()

```

[Stage 50:>

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2 3 Salary Analysis by ONET Occupation Type (Bubble Chart)

```

import plotly.express as px
#3.1 Analyze how salaries differ across LOT_OCCUPATION_NAME occupation types.
#ONET_NAME CHANGE TO LOT_OCCUPATION_NAME

#Aggregate Data

salary_analysis = spark.sql("""
    SELECT

```

```

        LOT_OCCUPATION_NAME AS Occupation_name,
        PERCENTILE(SALARY, 0.5) AS Median_Salary,
        COUNT(*) AS Job_Postings
    FROM job_postings
    WHERE LOT_OCCUPATION_NAME IS NOT NULL
    GROUP BY LOT_OCCUPATION_NAME
    ORDER BY Job_Postings DESC
    LIMIT 10
    """ #the result only has 6 results and a null, limit to 10 is not necessary

salary_pd = salary_analysis.toPandas()
display(salary_pd.head())

#Simple plot to Analyze
figa = px.scatter(
    salary_pd,
    x="Occupation_name",
    y="Median_Salary",
    size="Job_Postings",
    title="Salary Analysis by Occupation",
    color="Occupation_name"
)
figa.update_xaxes(tickangle=45, automargin=True)
figa.show()

#3.2 Visualize results bubble chart
import plotly.express as px

fig = px.scatter(
    salary_pd,
    x="Occupation_name",
    y="Median_Salary",
    size="Job_Postings",
    title="Salary Analysis by LOT Occupation Type (Bubble Chart)",
    labels={
        "Occupation_name": "LOT Occupation",
        "Median_Salary": "Median Salary",
        "Job_Postings": "Number of Job Postings"
    },
    hover_name="Occupation_name",
    size_max=60,
    width=900,

```

```

        height=600,
        color="Job_Postings",
        color_continuous_scale="Plasma"
    )
#customize layout
fig.update_layout(

    height=700,
    font_family="Arial",
    font_size=14,
    title_font_size=25,
    title_font_color="#13007c",
    font_color="#2e2e2e",
    xaxis_title="LOT Occupation",
    yaxis_title="Median Salary",
    plot_bgcolor="#FAFDFF",
    xaxis=dict(
        tickangle=-45,
        showline=True,
        linecolor="#444"
    ),
    yaxis=dict(
        showline=True,
        linecolor="black"
    )
)

fig.show()
fig.write_image("output/Q3.svg", width=1000, height=600, scale=1)

```

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	Occupation_name	Median_Salary	Job_Postings
0	Data / Data Mining Analyst	95250.0	30057
1	Business Intelligence Analyst	125900.0	29445
2	Computer Systems Engineer / Architect	157600.0	8212
3	Business / Management Analyst	93650.0	4326
4	Clinical Analyst / Clinical Documentation and ...	89440.0	261

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3 4 Salary by Education Level

```
# Defining education level groupings
lower_deg = ["Bachelor's", "Associate", "GED", "No Education Listed", "High school"]
higher_deg = ["Master's degree", "PhD or professional degree"]

# Adding new column EDU_GROUP
df = df.withColumn(
  "EDU_GROUP",
  when(col("EDUCATION_LEVELS_NAME").rlike("|".join([f"(?i){deg}" for deg in lower_deg])),
    .when(col("EDUCATION_LEVELS_NAME").rlike("|".join([f"(?i){deg}" for deg in higher_deg]))
    .otherwise("Other")
)

# Modifying/Casting necessary columns to float
df = df.withColumn("MAX_YEARS_EXPERIENCE", col("MAX_YEARS_EXPERIENCE").cast("float"))
df = df.withColumn("Average_Salary", col("Average_Salary").cast("float"))

# df.select("MAX_YEARS_EXPERIENCE", "Average_Salary", "EDU_GROUP", "EDUCATION_LEVELS_NAME").print()

# print(df.count()) #Total 72,498 after 8074

# Filtering for non-null and positive values
df = df.filter(
  col("MAX_YEARS_EXPERIENCE").isNotNull() & col("Average_Salary").isNotNull() &
  (col("MAX_YEARS_EXPERIENCE") > 0) & (col("Average_Salary") > 0)
)

# Filtering for just the two EDU_GROUP groups
df_filtered = df.filter(col("EDU_GROUP").isin("Bachelor's or lower", "Master's or PhD"))

# Converting to Pandas for plotting
df_pd = df_filtered.toPandas()
pdf4=df.select("MAX_YEARS_EXPERIENCE", "Average_Salary", "EDU_GROUP", "EDUCATION_LEVELS_NAME").toPandas()
display(pdf4.head())
```

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	MAX_YEARS_EXPERIENCE	Average_Salary	EDU_GROUP	EDUCATION_LEVELS_NAME
0	2.0	108668.5	Bachelor's or lower	[\n "Bachelor's degree"\n]
1	3.0	108668.5	Bachelor's or lower	[\n "No Education Listed"\n]
2	7.0	108668.5	Bachelor's or lower	[\n "No Education Listed"\n]
3	2.0	92962.0	Bachelor's or lower	[\n "Bachelor's degree",\n "Mas
4	5.0	108668.5	Bachelor's or lower	[\n "Associate degree",\n "Bach

```
# Jittering and trimming
df_pd["MAX_EXPERIENCE_JITTER"] = df_pd["MAX_YEARS_EXPERIENCE"] + np.random.uniform(-0.25, 0.25, df_pd.shape[0])
df_pd["AVERAGE_SALARY_JITTER"] = df_pd["Average_Salary"] + np.random.uniform(-2500, 2500, df_pd.shape[0])
df_pd = df_pd.round(2)

# Remove outlier higher than 399K
df_pd = df_pd[df_pd["AVERAGE_SALARY_JITTER"] <= 399000]

df_pd.head()
```

	ID	LAST_UPDATED_DATE	LAST_UPDATED_TIMESTAMP
0	1f57d95acf4dc67ed2819eb12f049f6a5c11782c	9/6/2024	2024-09-06 20:32:57.352
1	0cb072af26757b6c4ea9464472a50a443af681ac	8/2/2024	2024-08-02 17:08:58.838
2	5a843df632e1ff756fa19d80a0871262d51becc0	6/21/2024	2024-06-21 07:00:00.000
3	229620073766234e814e8add21db7dfaef69b3bd	10/9/2024	2024-10-09 18:07:44.758
4	138ce2c9453b47a9b33403c364d4fd80996caa4f	8/10/2024	2024-08-10 19:36:49.244

```
#jittering and trimming
# Plot four groups
fig1 = px.scatter(
    df_pd,
    x="MAX_EXPERIENCE_JITTER",
    y="AVERAGE_SALARY_JITTER",
    color="EDU_GROUP",
    hover_data=["LOT_V6_SPECIALIZED_OCCUPATION_NAME"],
    title="<b>Experience vs Salary by Education Level</b>",
    opacity=1.0, #0.7
    color_discrete_sequence=[
        "#636EFA", # Blue
        "#EF553B", # Red
    ]
)
```

```

        "#00CC96", # Green
        "#AB63FA"  # Purple
    ]
)

fig1.update_traces(
    marker=dict(size=10, line=dict(width=1, color="black"))
)

fig1.update_layout(
    plot_bgcolor="#fcfcf0", # light grey chart background
    paper_bgcolor="#f5d9b2", # soft blue frame
    font=dict(family="Segoe UI", size=14, color="#2b2b2b"),
    title_font=dict(size=22, color="#4b3832"),
    xaxis_title="Years of Experience",
    yaxis_title="Average Salary (USD)",
    legend_title="Education Group",
    hoverlabel=dict(bgcolor="white", font_size=13, font_family="Arial"),
    margin=dict(t=70, b=60, l=60, r=60),
    xaxis=dict(
        gridcolor="#e0e0e0",
        tickmode="linear",
        dtick=1 # show every integer year clearly
    ),
    yaxis=dict(gridcolor="#cccccc")
)

fig1.show()
fig1.write_html("output/q_1a_Experience_vs_Salary_by_Education_Level.html")

```

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4 5 Salary by Remote Work Type

```

from pyspark.sql.functions import when, col, trim

#5.1 Split into three groups based on REMOTE_TYPE_NAME
df = df.withColumn(
    "REMOTE_GROUP",

```



```

    when(trim(col("REMOTE_TYPE_NAME")) == "Remote", "Remote")
    .when(trim(col("REMOTE_TYPE_NAME")) == "Hybrid Remote", "Hybrid")
    .when(trim(col("REMOTE_TYPE_NAME")) == "Not Remote", "Onsite")
    .when(col("REMOTE_TYPE_NAME").isNull(), "Onsite")
    .otherwise("Onsite")
)

#print(df.count())

#5.1 Filter valid values
df = df.filter(
    col("MAX_YEARS_EXPERIENCE").isNotNull() & col("Average_Salary").isNotNull() &
    (col("MAX_YEARS_EXPERIENCE") > 0) & (col("Average_Salary") > 0)
)

#5.1 Pandas
df_pd = df.select(
    "MAX_YEARS_EXPERIENCE", "Average_Salary", "LOT_V6_SPECIALIZED_OCCUPATION_NAME", "REMOTE_GROUP"
).toPandas()

df_pd.head()

# Jittering and trimming
df_pd["MAX_EXPERIENCE_JITTER"] = df_pd["MAX_YEARS_EXPERIENCE"] + np.random.uniform(-0.15, 0.15, df_pd.shape[0])
df_pd["AVERAGE_SALARY_JITTER"] = df_pd["Average_Salary"] + np.random.uniform(-1000, 1000, df_pd.shape[0])
df_pd = df_pd.round(2)

# Remove outlier higher than 399K
df_pd = df_pd[df_pd["AVERAGE_SALARY_JITTER"] <= 399000]

```

[Stage 56:>

(0 + 1) / 1]

```

# Plot four groups
fig5 = px.scatter(
    df_pd,
    x="MAX_EXPERIENCE_JITTER",
    y="AVERAGE_SALARY_JITTER",
    color="REMOTE_GROUP",
    hover_data=["LOT_V6_SPECIALIZED_OCCUPATION_NAME"],
    title="<b>Experience vs Salary by Remote Work Type </b>",
    opacity=1.0, #0.7
)

```

```

        color_discrete_sequence=[
            "#636EFA", # Blue
            "#EF553B", # Red
            "#00CC96", # Green
            "#AB63FA"  # Purple
        ]
    )

fig5.update_traces(
    marker=dict(size=10, line=dict(width=1, color="black"))
)

fig5.update_layout(
    plot_bgcolor="#fcfcf0", # light grey chart background
    paper_bgcolor="#f5d9b2", # soft blue frame
    font=dict(family="Segoe UI", size=14, color="#2b2b2b"),
    title_font=dict(size=22, color="#4b3832"),
    axis_title="Years of Experience",
    yaxis_title="Average Salary (USD)",
    legend_title="Education Group",
    hoverlabel=dict(bgcolor="white", font_size=13, font_family="Arial"),
    margin=dict(t=70, b=60, l=60, r=60),
    xaxis=dict(
        gridcolor="#e0e0e0",
        tickmode="linear",
        dtick=1 # show every integer year clearly
    ),
    yaxis=dict(gridcolor="#cccccc")
)

fig5.show()

```

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