Education Statistics - What does it say about equality and quality?

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Content:

Abstract and Motivation

Personal motivation: In most developing countries a large portion of the youth does not have access to primary and secondary education even today.

"In 40 out of 93 countries, fewer than 50% of the poorest children have completed primary school".[6]

Without proper education, it is hard for individuals from poor families to seek employment pays well and rise above the poverty. This in turn affects their quality of life and that of their future generations. It was this passion towards education and it's access for all that led me to join an NGO - Make a Difference (https://makeadiff.in/) (MAD) during my undergraduate and as a part MAD, I educated and facilitated the education of orphaned and underprivileged children.

In this project, I intend to analyze, investigate and study the Education data from World Bank. The data contains several indicators of the access and quality of education. Apart from recorded data, it also possesses projected numbers for these. As someone passionate about education, I wish to perform this exploratory research with an open mind in order to find patterns and explanations for them.

Access to education has for long been an important factor in the improvement of the quality of life as well as the economy of a country. While many countries have taken steps to ensure access to education I wish to investigate the success and effects of this. Is there any bias in the data that suggests unfair practices towards people of a certain race, ethnicity, gender and region.

Apart from improving the lifestyle of individuals, education helps people find their purpose in life, encourages inquisitiveness and introspection, motivates people to be better, broads perspective and improves reasoning skills and creativity.

Research Questions

While I intend keep an open mind during the study there are a few **Research Questions** I wish to answer (Divided into 4 major themes):

1. **Education and Income**
   A. Is there is a correlation between the number of youth attending school and the level of income? My focus was drawn to this by this statement:

   "Children living in a low income countries are twice as likely to be out of school than those children in high income countries. Additionally, children from the wealthiest 20% of the population are 4 times more likely to be in school than the poorest 20%."[5]
2. **Gender**
   A. Does gender impact the enrollment, level and quality of education received?

   This article - Why girls in India are still missing out on the education they need (https://www.theguardian.com/education/2013/mar/11/indian-children-education-opportunities) talks about the problem in India.

   "India is no longer considered a poor country and yet many children do not receive a good education." - Rachel Williams"[11]

   I intend to test if this is true for other countries with better/worse economies.
3. **Government's role in Education**
   A. Do governments change their investment in education over time? Is it related to their annual GDP?
   B. In what components of education does the government invest more in and which does it invest less?
4. **Quality of Education**

A. Is the learning outcomes of different subjects negatively correlated i.e. does performing well in one subject correlate with performing badly in another subject?
B. Which subjects have seen improvements over time in terms of scores? Has the academic curriculum become harder in the recent years?

Human-Centered Design Considerations

I have decided to include the following Human-Centered design considerations:

1. Knowledge of current affairs impacting education
2. Qualitative analysis based on additional data about perceived attitude towards education
3. In the manner of the Research Questions asked in the study
4. Incorporating visualizations and qualitative analysis when possible

Data (Source and Schema)

The Education Statistics (https://datacatalog.worldbank.org/dataset/education-statistics) dataset being used in this assignment is downloaded from the World Bank (http://www.worldbank.org/). The dataset sources it's data from:

1. UIS (UNESCO Institute for Statistics (http://uis.unesco.org/)) - Administrative country data
2. Several International and Regional learning assessments
3. World Bank Education Projects Database (http://datatopics.worldbank.org/education/wQueries/qprojects) - activities, components and sub-sectors of WB Education projects since 1998
4. World Bank Education Expenditures Database (http://datatopics.worldbank.org/education/wQueries/qexpenditures) - Education expenditure data

The datasets have been downloaded and added to the `data` (https://github.com/CoderHam/data-512-final-project/tree/master/data) directory and consists of 5 parts that have been described below, plus one additional dataset for income groups:

1. **EdStatsCountry.csv** (https://github.com/CoderHam/data-512-final-project/tree/master/data/EdStatsCountry.csv)

Column	Datatype	Description
Country Code	text	a three digit unique code to represent a country
Short Name	text	short name for the country
Table Name	text	the name being used in this table
Long Name	text	full name of the country
2-alpha code	text	alphanumeric code of length 2 for the country
Currency Unit	text	currency of the country
Special Notes	text	additional notes about the country
Region	text	region where the country is location
Income Group	text	which income group the country belongs to
WB-2 code	text	World Bank 2 letter code
National accounts base year	numeric	base year used for country accounts
National accounts reference year	numeric	reference year for the country accounts
SNA price valuation	text	System of National Accounts (SNA) valuation of currency
Lending category	text	the lending agency for that country as decided by World Bank
Other groups	text	other World Bank/UN groups that the country belongs to
System of National Accounts	text	the year of SNA methodology the country uses
Alternative conversion factor	text	the DEC alternative conversion factor OR the official exchange rate reported by IMF's International Financial Statistics (IFS)
PPP survey year	numeric	survey year for the nation's Purchasing power parity (PPP)
Balance of Payments Manual in use	text	the IMF balance of payments manual used by the country
External debt Reporting status	text	the type of the external debt reported
System of trade	text	the type of trade system the nation uses
Government Accounting concept	text	the type of accounting the central government uses
IMF data dissemination standard	text	the data dissemination standard used by IMF for that nation
Latest population census	numeric	the last year the nations population census was reported
Latest household survey	text	the last year the nations household survey was reported
Source of most recent Income and expenditure data	text	the source and last year the nations income and expenditure data was reported
Vital registration complete	categorical	has the nation completed vital registration
Latest agricultural census	numeric	the last year the nations agricultural data was reported

Column	Datatype	Description
Latest industrial data	numeric	the last year the nations industrial data was reported
Latest trade data	numeric	the last year the nations trade data was reported
Latest water withdrawal data	numeric	the last year the nations water withdrawal data was reported

2. **EdStatsCountry-Series.csv** (https://github.com/CoderHam/data-512-final-project/tree/master/data/EdStatsCountry-Series.csv)

Column	Datatype	Description
CountryCode	text	a three digit unique code to represent a country
SeriesCode	text	the code for the data series
Description	text	source of data / estimates

3. **EdStatsData.csv** (https://github.com/CoderHam/data-512-final-project/tree/master/data/EdStatsData.csv)

Column	Datatype	Description
Country Name	text	the name of the country
Country Code	text	a three digit unique code to represent a country
Indicator Name	text	the name of the indicator being listed
Indicator Code	text	the indicator code for the indicator being listed
{Value for the Year} (1970 to 2017 as with 5 year binned projections till 2100)	numeric	the value of the indicator for that code

4. **EdStatsSeries.csv** (https://github.com/CoderHam/data-512-final-project/tree/master/data/EdStatsSeries.csv)

Column	Datatype	Description
Series Code	text	the code for the data series
Topic	text	topic category the series belongs to
Indicator Name	text	name of the indicator
Short definition	text	a short definition of the indicator
Long definition	text	a detailed definition of the indicator
Unit of measure	text	the unit of measure for the indicator
Periodicity	numeric	time between successive recordings of for the indicator
Base Period	numeric	the year used as reference for the base value for the indicator
Other notes	text	additional details about the indicator
Aggregation method	text	how the indicator was recorded or inferred
Limitations and exceptions	text	details about the limits and expectations for the indicator
Notes from original source	text	notes from- the source of the indicator
General comments	text	comments about citations or use of this data
Source	text	source of the indicator data
Statistical concept and methodology	text	The method or study used to find the value of the indicator
Development relevance	text	additional information about the collection of the indicator
Related source links	text	link to source of the data
Other web links	text	additional links for the data
Related indicators	text	related indicators in the dataset
License Type	text	license type for the indicator

5. **EdStatsFootNote.csv** (https://github.com/CoderHam/data-512-final-project/tree/master/data/EdStatsFootNote.csv)

Column	Datatype	Description
CountryCode	text	a three digit unique code to represent a country
SeriesCode	text	the code for the data series
Year	numeric	the year for which the data is collected
Description	text	the method of collection/estimation of the indicator

6. **income_group.csv** (https://github.com/CoderHam/data-512-final-project/tree/master/data/income_group.csv)

I added data for the current income levels, as classified by World Bank [7].

Column	Datatype	Description
Economy	text	the name of the country
Code	text	a three digit unique code to represent a country

Column	Datatype	Description
Region	text	region where the country is location
Income group	text	which income group the country belongs to
Lending category	text	the lending agency for that country as decided by World Bank
Other	text	other World Bank/UN groups that the country belongs to

Licenses

The datasets are classified **Public** and is licensed under the **CC-BY 4.0** (https://datacatalog.worldbank.org/public-licenses#cc-by). A short summary of CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/) is that under this license, individuals are free to copy and redistribute data in any medium as well as modify and build upon the data for all purposes including commercially.

Data Pre-processing and Preparation

The Education Statistics data was distributed across five csv files and has many missing values, extra details and incorrect formatting. This involved me to manually go through the dataset, pick specific countries and indicators that both conveyed the problem as well as did for offer a biased view of the dataset.

There was no exhaustive description of each column and domain specific phrases and the same must be studied and inferred by referring to relevant literature and the UNIS and World Bank website. For this I referred to the UNIS and World Bank websites.

I have worked with 12 countries - 4 High Income, 2 Upper Middle Income, 2 Lower Middle Income and 4 Lower Income. Thereby reducing both clutter in the visualizations, loss of information by aggregration and equal representation of each category.

I chose to keep the temporal domain to display the lack of missing values and convey temporal effects even for countries with several missing values.

Considerations for Gender

The dataset treats gender and sex as the same i.e. either male or female and while I do not agree that one should be forced to identify between either of the two, I was unable to find relevant education data for non-binary genders.

Stating this as a limitation of the dataset, I proceeded to search for data on non-binary genders. from other sources, enrich this dataset and was appalled at the lack of one thereof.

Data Limitations

Apart from the data being reported by multiple agencies to the World Bank Group and the UN, there are several missing values. There is an an important gender limitation in that the dataset since it assumes binary gender. The projections in the data are absent in many cases and those that are present may not be accurate. Hence I refrain from using these projected values for the same reason.

Final Note

There are several claims made online regarding inequality in educations, bias against female education [11] and relation between income and education. I wish to investigate these claims and find other such trends in the dataset.

Experiments and Conclusions

Importing necessary libraries.

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib notebook

import seaborn as sns
sns.set()
# PS: uncomment the next line if mplcursors is not already installed
# !pip install mplcursors
# Used for interactive tooltip (Required investigation of visualizations)
import mplcursors
np.random.seed(4)

from operator import itemgetter
```

Loading the motherload csv file (300+ MB)

In [2]:
```
df = pd.read_csv("data/EdStatsData.csv")
# drop the unnecessary column
df = df.drop('Unnamed: 69',axis=1)
```

1. Education and Income - Enrollment in schools based on income groups

Question: Is there is a correlation between the number of youth attending school and the level of income?

In [55]:
```
# load the income level data from file
ig_df = pd.read_csv("data/income_groups.csv")

# print the different types of income groups
print("Types of income groups:",set(ig_df['Income group']))

# create a dictionary with income group corresponding to each country
income_group = dict(zip(ig_df['Economy'],ig_df['Income group']))

# every country gets a unique color
color_hash = dict(zip(ig_df['Economy'],np.random.rand(len(ig_df['Economy'].values),3)))
```

```
Types of income groups: {'High income', 'Lower middle income', 'Low income', 'Upper middle income'}
```

In [4]:
```
measure = "Adjusted net enrolment rate, "
school_level = ['primary', 'lower secondary', 'upper secondary']
gender_type = ['both sexes \(\%\)', 'female \(\%\)', 'gender parity index \(GPI\)', 'male \(\%\)']
```

In [5]:
```
# function to get the values for the specific indicator from the entire dataset

def get_vals_indicator(indicator):
    subset = df[df['Indicator Name'].str.contains(indicator)]
    country = list(subset['Country Name'].values)
#     country_code = subset['Country Code'].values
    indicator_code = subset['Indicator Code']
    val_df = pd.DataFrame()
    # between 2000 and 2016 (inclusive)
    for i in range(2000,2017):
        val_df[str(i)] = subset[str(i)]
    vals = val_df.values
    del val_df
    return vals, country
```

In [56]:
```
# function to visualize the values for the specific indicator from the entire dataset
# (on a filtered subset of countries)

def plot_indicator(indicator,filtered,eco_color=True):
    vals, country = get_vals_indicator(indicator)
    filtered_index = [country.index(f) for f in filtered]
    years = np.arange(2000,2017)

    vals = np.array(itemgetter(*filtered_index)(vals))
    country = itemgetter(*filtered_index)(country)
    if eco_color:
        colors = [color_levels[income_group[c]] for c in country]
    else:
        colors = [color_hash[c] for c in country]

    fig = plt.figure(figsize=(15, 6), dpi= 80, facecolor='w', edgecolor='k')
    ax = fig.add_axes([0.05, 0.05, 0.5, 0.9])
    for i,c,l in zip(vals,colors,country):
        sns.lineplot(years,i,color=c,label=l)
        plt.legend(country)
    plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
    plt.xlabel("Time (years)")
    plt.ylabel(indicator.replace('\\',''))
    plt.title(indicator.replace('\\','')+" vs Time (years)")

    mplcursors.cursor().connect(
    # mplcursors.cursor(hover=True).connect(
        "add", lambda sel: sel.annotation.set_text(sel.artist.get_label()\
                            +" - "+income_group[sel.artist.get_label()]))

    plt.show()
```

In [7]:
```
# function to calculate the correlation coefficient between the indicator and the income groups
# (on a filtered subset of countries)

def get_clean_corrcoef_income(indicator,filtered):
    vals, country = get_vals_indicator(indicator)
    filtered_index = [country.index(f) for f in filtered]
    vals = np.array(itemgetter(*filtered_index)(vals))
    country = list(itemgetter(*filtered_index)(country))

    # ignore axis where all are nans (sorted reverse for deletion), for all except those, take the
mean
    all_nans = sorted(np.where(np.min(np.isnan(vals),axis=1)==True)[0],reverse=True)
    for ind in all_nans:
        vals = np.delete(vals,ind,0)
        del country[ind]

    ranks = list(color_levels.keys())[::-1]
    class_label = [ranks.index(income_group[c]) for c in country]

    return np.corrcoef(np.nanmean(vals,axis=1),class_label)[1,0]
```

Below is the list of 12 countries and their income groups:

- Higher Income -> United States, Australia, United Kingdom, Canada
- Middle Income -> Malaysia, Russian Federation , Vietnam, India (2 lower middle and 2 higher middle income)
- Lower Income -> Ethiopia, Republic of Yemen, Niger, Mozambique

In [8]:
```
hinc = ['United States','Australia','United Kingdom','Canada']
# 2 lower middle and 2 higher middle income
minc = ['Malaysia','Russian Federation','Vietnam','India']
linc = ['Ethiopia','Yemen, Rep.','Niger','Mozambique']

color_levels = {'High income' : 'g',
    'Upper middle income' : 'b',
    'Lower middle income': 'y',
    'Low income' : 'r'}
```

Legend for income levels:

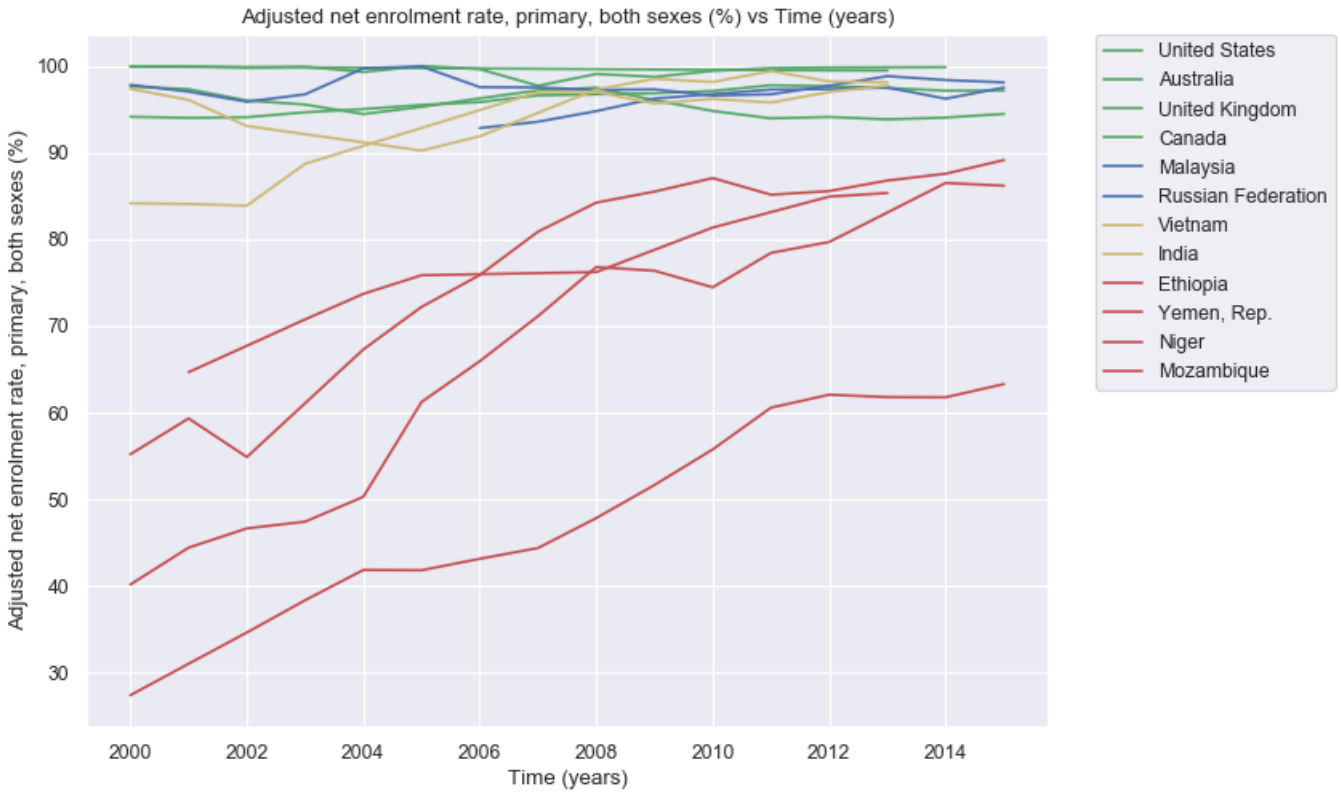
- Green -> High Income
- Blue -> Higher Middle Income
- Yellow -> Lower Middle Income
- Red -> Low Income

We will look at the Net enrolment rate (%) for primary, lower secondary and higher secondary schools for each of the 12 countries.

PS: Please run the notebook with mplcursors for country tooltip.

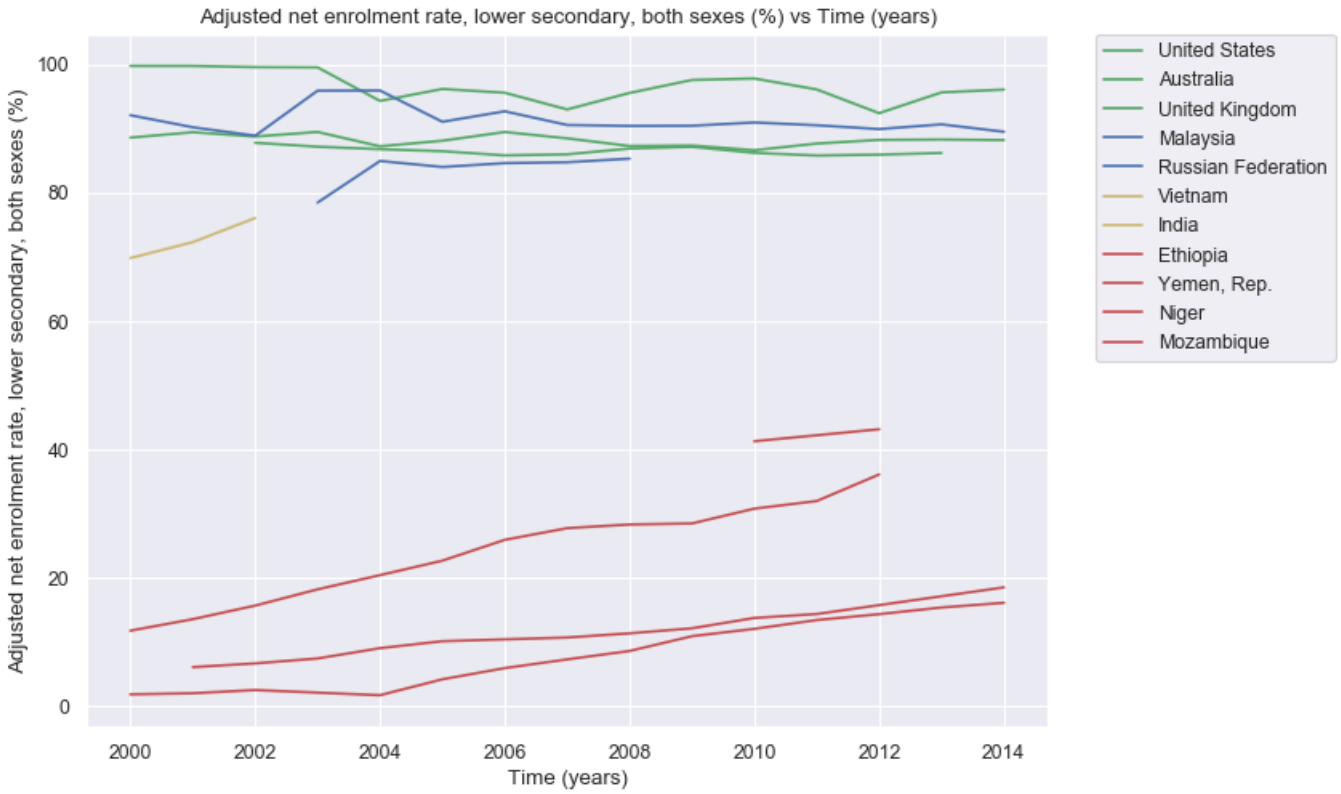
Net enrolment rate in Primary schools (%)

In [9]:
```
indicator = measure+school_level[0]+", "+gender_type[0]
plot_indicator(indicator,hinc+minc+linc)
```



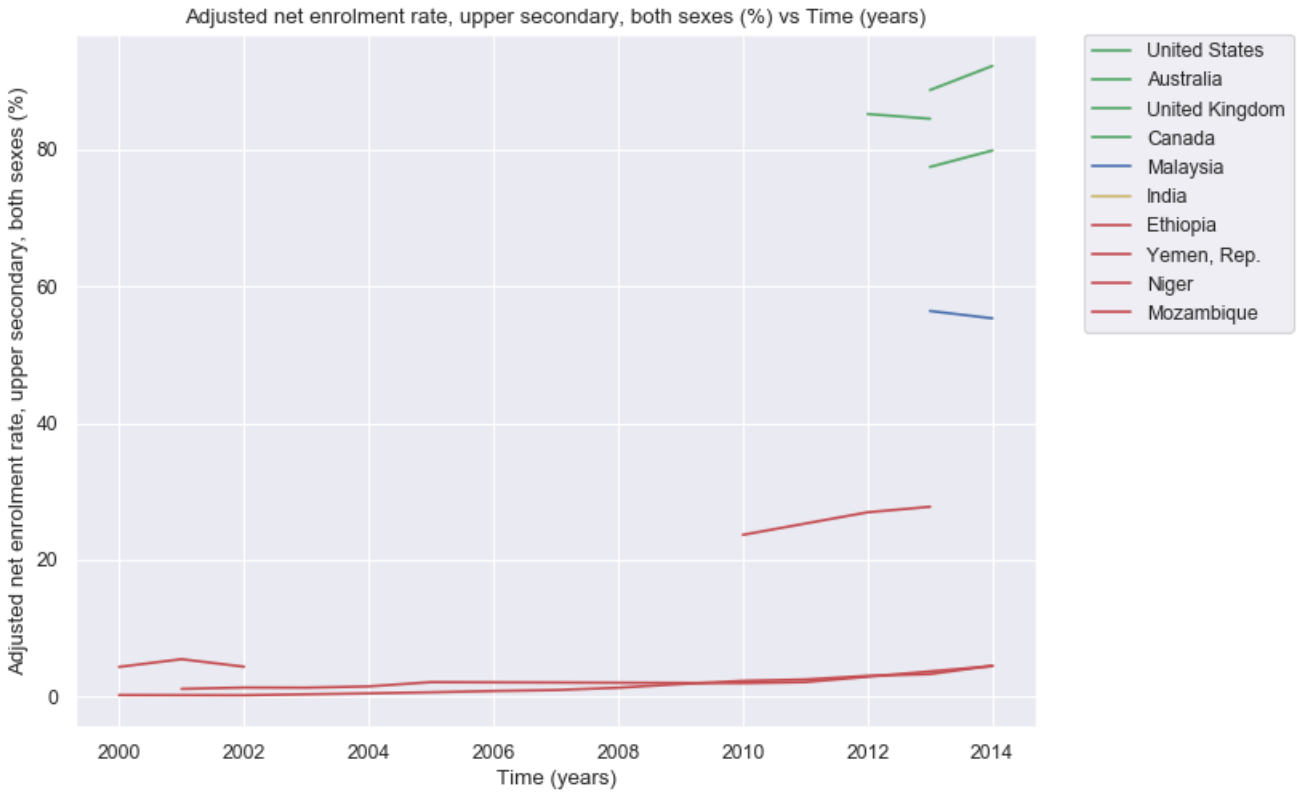
Net enrolment rate in Lower Secondary schools (%)

In [10]:
```
indicator = measure+school_level[1]+", "+gender_type[0]
plot_indicator(indicator,hinc+minc+linc)
```



Net enrolment rate in Higher Secondary schools (%)

In [11]:
```
indicator = measure+school_level[2]+", "+gender_type[0]
plot_indicator(indicator,hinc+minc+linc)
```



In [12]:
```
for gen in (0,1,3):
    print("Correlation coefficient between net enrollment rate (primary school) for",\
          gender_type[gen].replace('\\',''),"and income:",
          get_clean_corrcoef_income(measure+school_level[0]+", "+gender_type[gen],hinc+minc+linc))
```

```
Correlation coefficient between net enrollment rate (primary school) for both sexes (%) and income:
0.7905442132607237
Correlation coefficient between net enrollment rate (primary school) for female (%) and income: 0.84
43040775001447
Correlation coefficient between net enrollment rate (primary school) for male (%) and income: 0.7498
585815189364
```

In [13]:
```
for gen in (0,1,3):
    print("Correlation coefficient between net enrollment rate (lower secondary school) for",\
          gender_type[gen].replace('\\',''),"and income:",
          get_clean_corrcoef_income(measure+school_level[1]+", "+gender_type[gen],hinc+minc+linc))
```

```
Correlation coefficient between net enrollment rate (lower secondary school) for both sexes (%) and
income: 0.8864870804399166
Correlation coefficient between net enrollment rate (lower secondary school) for female (%) and inco
me: 0.9241009345919866
Correlation coefficient between net enrollment rate (lower secondary school) for male (%) and incom
e: 0.893380541198392
```

In [14]:
```
for gen in (0,1,3):
    print("Correlation coefficient between net enrollment rate (higher secondary school) for",\
          gender_type[gen].replace('\\',''),"and income:",
          get_clean_corrcoef_income(measure+school_level[2]+", "+gender_type[gen],hinc+minc+linc))
```

```
Correlation coefficient between net enrollment rate (higher secondary school) for both sexes (%) and
income: 0.9709843448629143
Correlation coefficient between net enrollment rate (higher secondary school) for female (%) and inc
ome: 0.9816838774687192
Correlation coefficient between net enrollment rate (higher secondary school) for male (%) and incom
e: 0.9572617759475552
```

School Level	Correlation Coef.
Primary	0.75
Lower Secondary	0.88
Higher Secondary	0.97

Conclusion:

As we can see, there if definitely a **strong correlation between (%) of youth enrolled in schools and the income level** of that country. In fact, as we break this for the three different school groups, we see that the **correlation becomes stronger as the education level progresses**.

This can be attributed to the fact that **education costs become less affordable** for lower (and middle) income groups as the youth move from primary to lower secondary and higher secondary schools.

2. Education and 'Gender' - Enrollment rate in schools based on gender

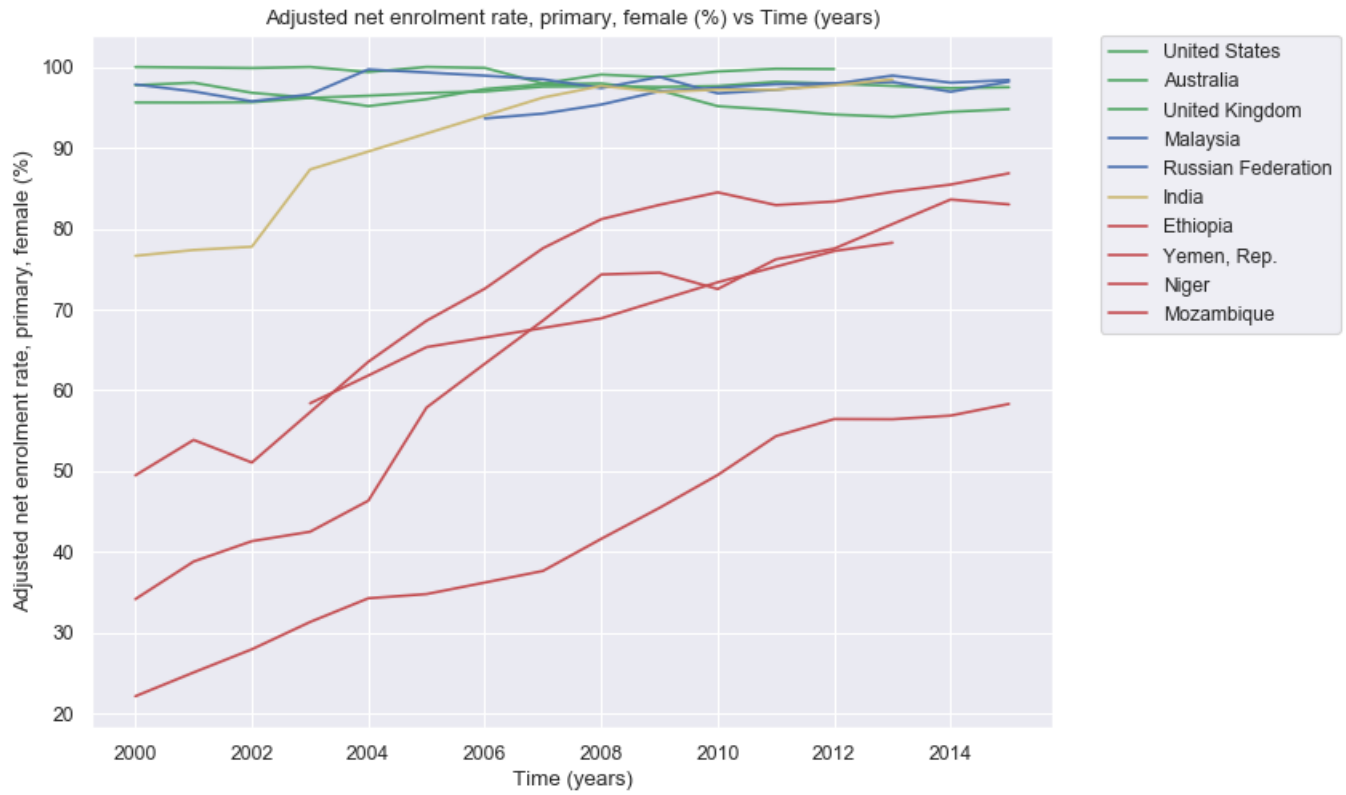
We will look at the enrollment rate in primary schools for both of the genders provided in the dataset.

Why primary school?

Because that is the first level of schooling and directly effects the enrollment rate in secondary and tertiary school levels.

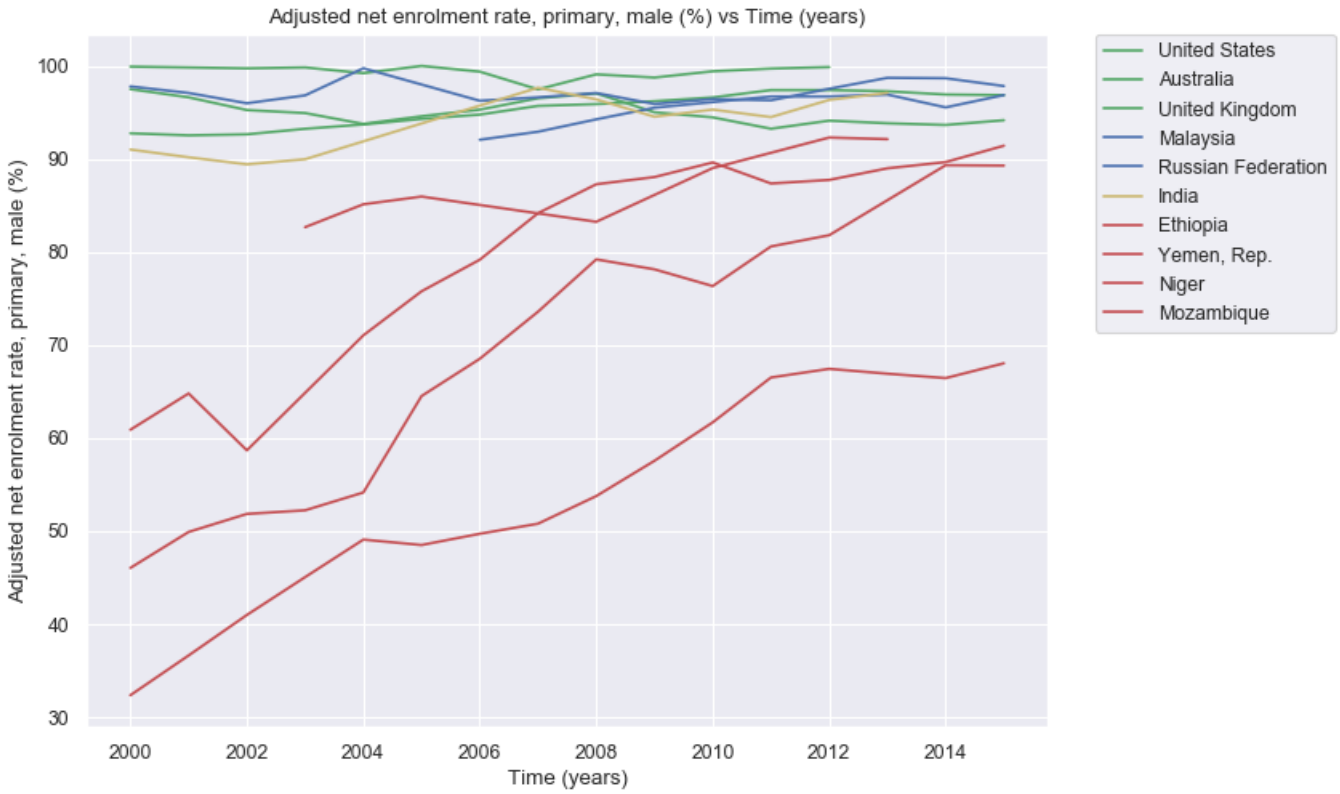
Enrollment rate of Females in primary schools (%)

In [15]:
```
indicator = measure+school_level[0]+", "+gender_type[1]
plot_indicator(indicator,hinc+minc+linc)
```



Enrollment rate of Males in primary schools (%)

In [16]:
```
indicator = measure+school_level[0]+", "+gender_type[3]
plot_indicator(indicator,hinc+minc+linc)
```



In [17]:
```
# function to calculate the correlation coefficient between the indicator and gender
# (on a filtered subset of countries)

def get_clean_corrcoef_gender(sch_level,filtered):
    vals_male, country_male = get_vals_indicator(measure+sch_level+", "+gender_type[3])
    vals_female, country_female = get_vals_indicator(measure+sch_level+", "+gender_type[1])
    filtered_index = [country_male.index(f) for f in filtered]

    vals_male = np.array(itemgetter(*filtered_index)(vals_male))
    country_male = list(itemgetter(*filtered_index)(country_male))
    vals_female = np.array(itemgetter(*filtered_index)(vals_female))
    country_female = list(itemgetter(*filtered_index)(country_female))

    # ignore axis where all are nans (sorted reverse for deletion), for all except those, take the
mean
    all_nans = sorted(np.where(np.min(np.isnan(vals_male),axis=1)==True)[0],reverse=True)
    for ind in all_nans:
        vals_male = np.delete(vals_male,ind,0)
        del country_male[ind]

    all_nans = sorted(np.where(np.min(np.isnan(vals_female),axis=1)==True)[0],reverse=True)
    for ind in all_nans:
        vals_female = np.delete(vals_female,ind,0)
        del country_female[ind]

    class_label = [0]*len(country_male) + [1]*len(country_female)

    return np.corrcoef(np.nanmean(np.append(vals_male,vals_female,axis=0),axis=1),class_label)[1,0]
```

Let us do calculate the correlation coef. on the basis of income levels. **We will focus on high and low income levels to highlight the impact of income levels.**

For **low income**:

In [18]:
```
for sc in (0,1,2):
    print("Correlation coefficient between net enrollment rate ("+school_level[sc]+" school) and
gender:",
          get_clean_corrcoef_gender(school_level[sc],linc))
```

```
Correlation coefficient between net enrollment rate (primary school) and gender: -0.3995971749509495
Correlation coefficient between net enrollment rate (lower secondary school) and gender: -0.23501840
39235554
Correlation coefficient between net enrollment rate (upper secondary school) and gender: -0.15949020
570650704
```

As we can see, there if definitely a **significant negative correlation between (%) of youth enrolled in schools and their gender**.

(Negative sign shows that a higher % of men are enrolled than women in low income countries)

For **high income**:

In [19]:
```
for sc in (0,1,2):
    print("Correlation coefficient between net enrollment rate ("+school_level[sc]+" school) for and gender:",
          get_clean_corrcoef_gender(school_level[sc],hinc))
```

```
Correlation coefficient between net enrollment rate (primary school) for and gender: 0.2672277228673321
Correlation coefficient between net enrollment rate (lower secondary school) for and gender: 0.28495045723031975
Correlation coefficient between net enrollment rate (upper secondary school) for and gender: 0.3254144579257231
```

School Level	Low Income	High Income
Primary	-0.40	0.27
Lower Secondary	-0.23	0.28
Higher Secondary	-0.16	0.32

Conclusion:

As we can see, there if definitely a **significant positive correlation between (%) of youth enrolled in schools and their gender**. (Positive sign shows that a higher % of women are enrolled than men in high income countries)

Essentially, for **low income countries, a higher % of men go to (are enrolled in) schools than women** and **for high income countries, a higher % of women go to (are enrolled in) schools than men**.

It is interesting to see how the results are so different. This can be attributed to women empowerment and subsidized education for the female population in high income countries and the lack of the same thereof in low income countries. It appears to be true that there is a bias against female education in low income countries that most likely stems from cultural and social beliefs that have propagated down the ages.

This article - [Why girls in India are still missing out on the education they need (https://www.theguardian.com/education/2013/mar/11/indian-children-education-opportunities)](https://www.theguardian.com/education/2013/mar/11/indian-children-education-opportunities) tries to explain the same problem in some detail.

"While girls attend primary school in roughly equal numbers to boys, the gap widens as they get older and more are forced to drop out to help with work at home or get married."

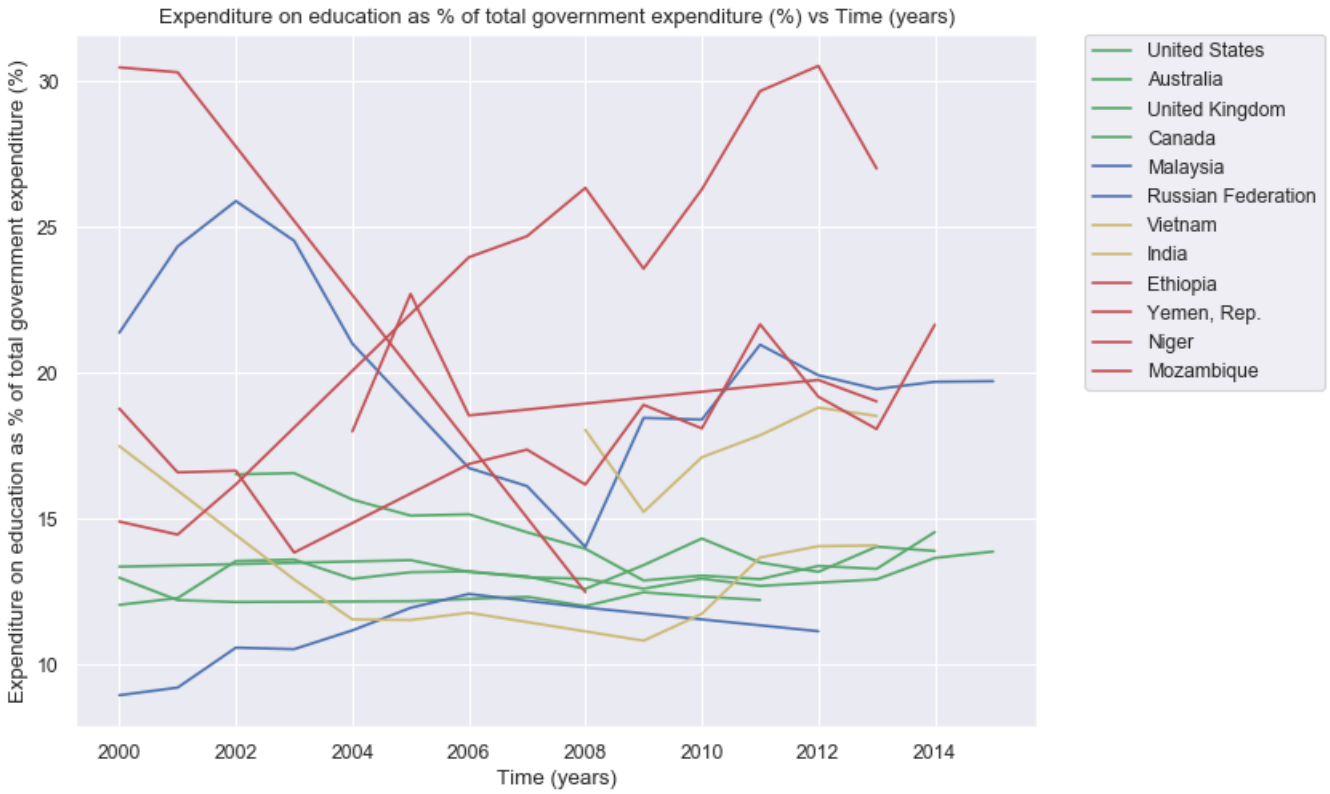
3. Goverments role in Education - Education expenditure

Question: Do governments change their investment in education over time? Is it related to their annual GDP?

In [20]:
```
gov_indicator = "Expenditure on education as \% of total government expenditure \(\%\)","Government expenditure on education as \% of GDP \(\%\)"
```

First, I analysed the **Edcucation expense as a % of the total government expenditure** from 2000 to 2017, hoping if I correlated this with income level of the country, I would be able to understand if countries with different income levels invest a higher or lower % of their expenditure on Education.

In [21]:
```
plot_indicator(gov_indicator[0],hinc+minc+linc)
```



In [22]:
```
print("Correlation coefficient between ",gov_indicator[0].replace('\\','''),"and
income:",get_clean_corrcoef_income(gov_indicator[0],hinc+minc+linc))
```

```
Correlation coefficient between  Expenditure on education as % of total government expenditure (%) a
nd income: -0.7391787899589942
```

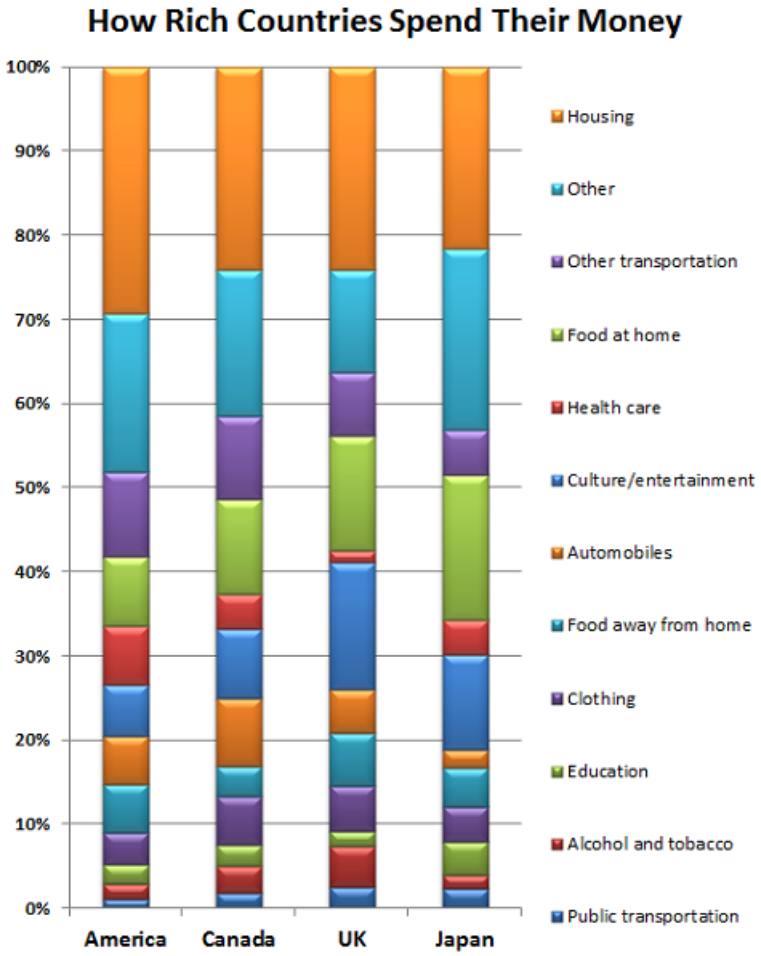
Conclusion:

Counter to my intuition, it appears that income negatively correlated with the % of total expenditure that governments invested in Education. The World Bank published an article (http://blogs.worldbank.org/education/why-education-matters-economic-development) that suggested High Income countries have a motivation to invest more money in Education. The article states that:

"In a nutshell, the Human Capital Theory posits that investing in education has a payoff in terms of higher wages."

I expected Low Income countries would be unable to spend large portions of their expenditure on Education and thereby see a positive correlation between income and % expenditure on Education. I was wrong and the observation was the exact opposite.

I found a chart from this article (https://www.fool.com/investing/general/2012/04/13/how-rich-countries-spend-their-money.aspx) that described how rich countries spend their money:

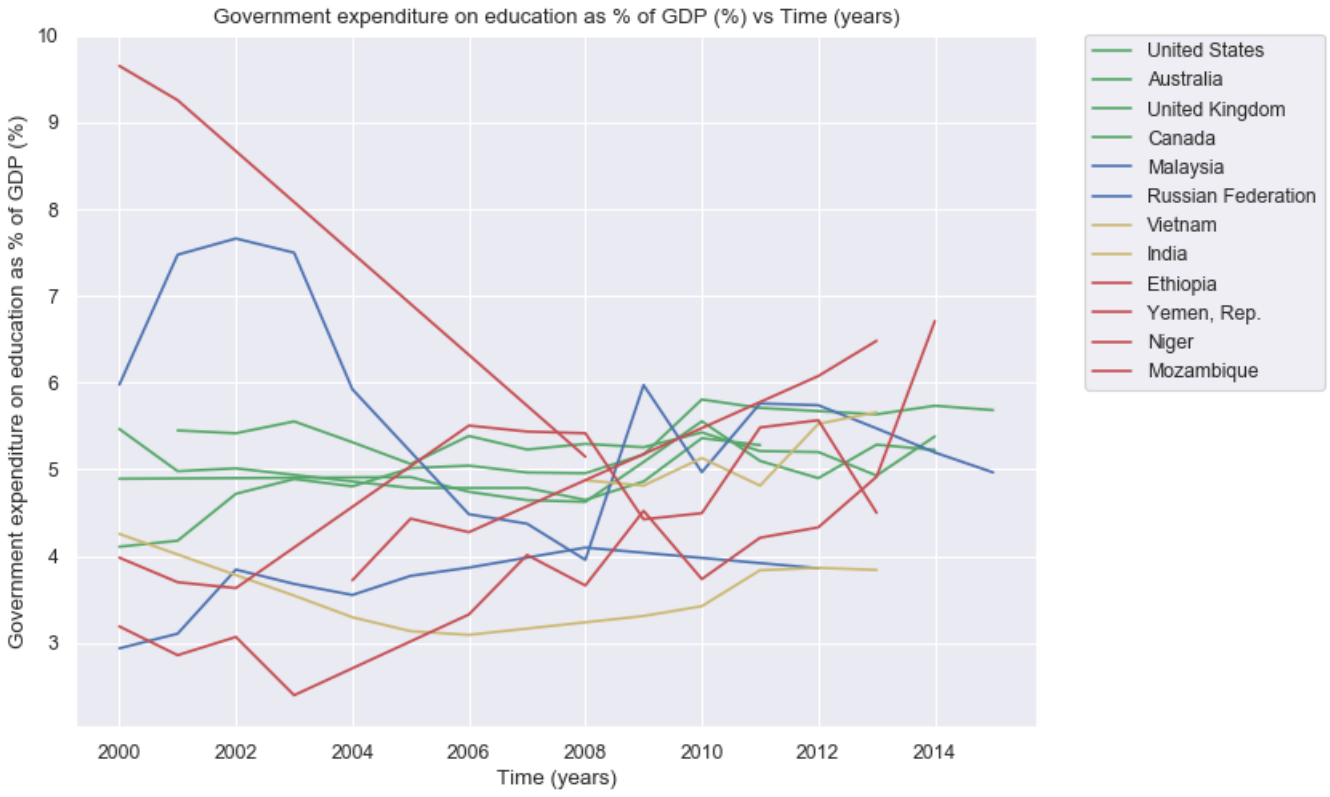


The article and chart explain that a small portion of money is invested in Education in High Income countries and the larger portions go to Housing, Culture/Entertainment, Healthcare etc. as they focus more on providing a better living healthcare and social infrastructure and less on Education.

I wanted to verify that this indeed was the case and thus I followed by analyzing the **Education expense as a % of the total GDP** from 2000 to 2017. This would help me understand if countries with different income levels invest a higher or lower % of their GDP on Education.

Why GDP? -> Government expenditure is a small part of GDP and while their GDP grows, government expenditure may not. This means that Education expenditure is scaled by GDP, a more accurate measure of how well the country is performing economically.

In [23]:
```
plot_indicator(gov_indicator[1],hinc+minc+linc)
```



In [24]:
```
print("Correlation coefficient between ",gov_indicator[1].replace('\\','''),"and
income:",get_clean_corrcoef_income(gov_indicator[1],hinc+minc+linc))
```

```
Correlation coefficient between  Government expenditure on education as % of GDP (%) and income: -0.
0944659285247055
```

Education Expenditure as % of (?)	Corr. Coeff.
Government Expenditure	-0.74
GDP	-0.09

Conclusion:

There is negligible correlation between % of GDP invested in education and income level of the country. Thus, we see that the education expenditure is not significantly effected by the income level of the country i.e. **In general, both rich and poor countries invested similar portions of their GDP in education.**

There seems to be very less variability (of % of GDP invested in education) between High Income countries and more as we move towards the Low income countries. This is probably because high income countries have a GDP large enough to invest consistently and easily in education, while lower income countries struggle to do so as they are forced to shift priorities between sectors based on requirements.

Answer:

1. **Percentage investment of GDP in education is stable in High Income countries (more or less constant over the years) and volatile in Low Income countries (changes a lot over the years).**
2. **Governments try to invest an amount in education that is proportional to their GDP.**

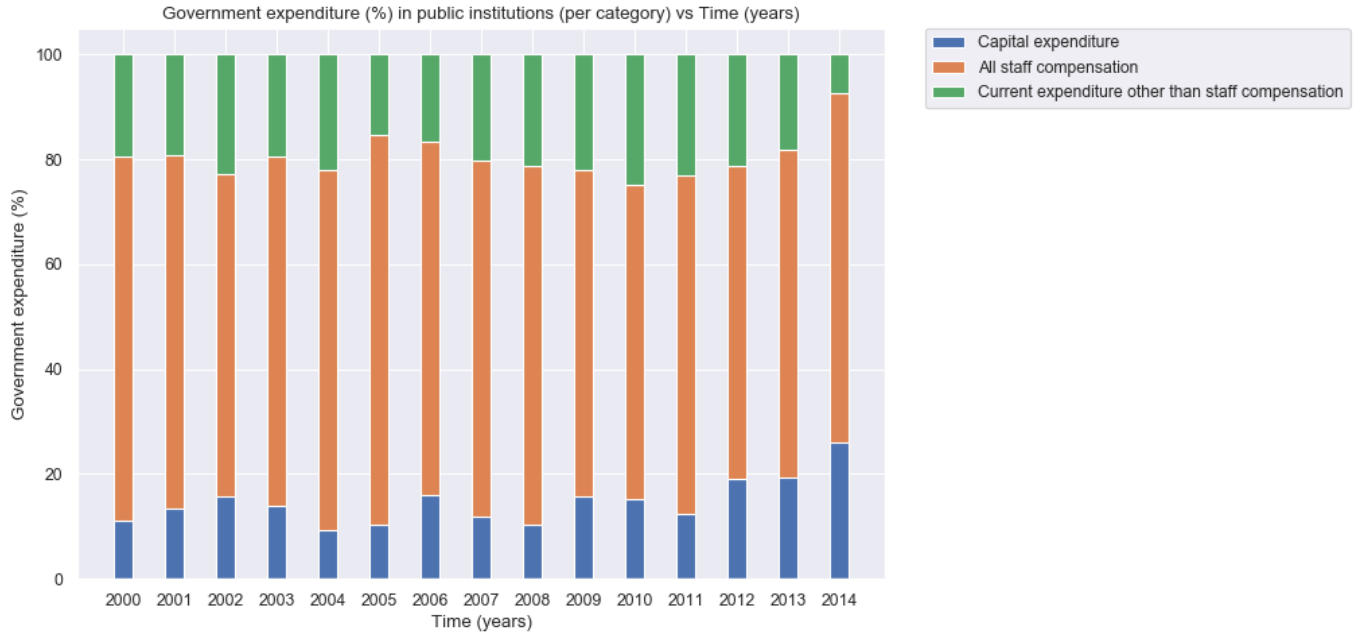
Question: In what components of education does the government invest more in and which does it invest less?

In [25]:
```
comp_indicator = ["Capital expenditure as \% of total expenditure in public institutions \
(\%\)","All staff compensation as \% of total expenditure in public institutions \(\%\)", "Current
expenditure other than staff compensation as \% of total expenditure in public institutions \
(\%\)",]
```

In [27]:

```
# function to plot the values of a specific indicator based on year or country
# (on a filtered subset of countries)

width = 0.35
def plot_indicator_stack_bar(indicators,filtered,by_year=False):
    mega_vals = [0]*len(indicators)
    mega_ctry = [0]*len(indicators)
    p = [0]*len(indicators)
    if not by_year:
        filtered = filtered[:9]+filtered[10:]
    for i, indicator in enumerate(indicators):
        vals, country = get_vals_indicator(indicator)
        filtered_index = [country.index(f) for f in filtered]
        years = np.arange(2000,2015)

        vals = np.array(itemgetter(*filtered_index)(vals))
        country = itemgetter(*filtered_index)(country)
        mega_vals[i] = vals[:,:-2]
        mega_ctry = country

    fig = plt.figure(figsize=(15, 6), dpi= 80, facecolor='w', edgecolor='k')
    ax = fig.add_axes([0.05, 0.05, 0.5, 0.85])

    if by_year:
        p[0] = plt.bar(years, np.nanmean(mega_vals[0],axis=0), width)
        p[1] = plt.bar(years, np.nanmean(mega_vals[1],axis=0), width,
bottom=np.nanmean(mega_vals[0],axis=0))
        p[2] = plt.bar(years, 100 -
(np.nanmean(mega_vals[0],axis=0)+np.nanmean(mega_vals[1],axis=0)), width, \
                       bottom=np.nanmean(mega_vals[0],axis=0) + np.nanmean(mega_vals[1],axis=0))
        plt.xticks(years,years)
        plt.xlabel("Time (years)")
        plt.title("Government expenditure (%) in public institutions (per category) vs Time
(years)")

        plt.legend(indicators)
        plt.legend((p[0][0], p[1][0], p[2][0]), ('Capital expenditure', 'All staff compensation', \
                                                 'Current expenditure other than staff
compensation'), \
                   bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
        plt.ylabel("Government expenditure (%)")
    else:
        p[0] = plt.barh(mega_ctry, np.nanmean(mega_vals[0],axis=1), width)
        p[1] = plt.barh(mega_ctry, np.nanmean(mega_vals[1],axis=1), width,
left=np.nanmean(mega_vals[0],axis=1))
        p[2] = plt.barh(mega_ctry, 100-
(np.nanmean(mega_vals[0],axis=1)+np.nanmean(mega_vals[1],axis=1)), width,\
                       left=np.nanmean(mega_vals[0],axis=1) + np.nanmean(mega_vals[1],axis=1))

        plt.yticks(mega_ctry,mega_ctry,rotation=350)
        plt.xlabel("Country")
        plt.title("Government expenditure (%) in public institutions (per category) by Country")

        plt.legend(indicators)
        plt.legend((p[0][0], p[1][0], p[2][0]), ('Capital expenditure', 'All staff compensation', \
                                                 'Current expenditure other than staff
compensation'), \
                   bbox_to_anchor=(1.15, 1), loc=2, borderaxespad=0.)
        plt.ylabel("Country")
        plt.gcf().subplots_adjust(top=0.55)
        ax.xaxis.set_label_position('top')
        ax.set_xlabel("Government expenditure (%)", fontsize=12)
        ax.yaxis.set_ticks_position('right')
        plt.show()
```

In [28]:
```
plot_indicator_stack_bar(comp_indicator,hinc+minc+linc,by_year=True)
```



Conclusion:

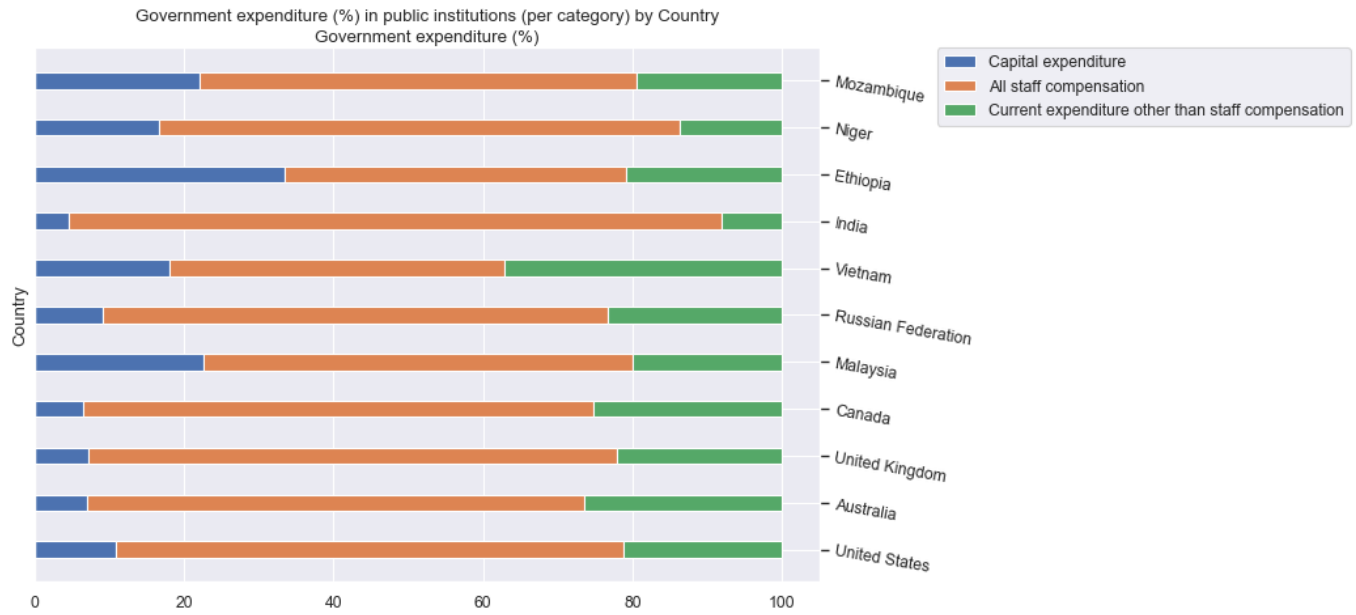
Aggregated across 12 countries (uniformly selected from each income group), there seems to be very small changes in the education components that governments invest in.

There is a significant increase in the percentage of Capital expenditure around the world and this can be explained by the fact that schools are working to provide better infrastructure and facilities.

The percentage of non-staff expenditure however has gone down and the percentage of staff wages have stayed constant. The parts of education that can be automated and simplified are being done and as technology is being embraced, there is a fall in current non-staff expense.

As we can see, staff wages are still the majority amounting to around 65% on average, while capital expense and non-staff current expense varies between 10% and 25%.

In [29]:
```
# removed Yemen (Bottom to top the income group falls from high to low)
plot_indicator_stack_bar(comp_indicator,hinc+minc+linc)
```



Conclusion:

Staff wages remain similar across all 12 countries but current non-staff expense falls in low income group and capital expense increases. This correlates with the slow adoption of technology for automation and simplification that cause increased non-staff expense and lower investment in infrastructure and facilities that cause decreased capital expense.

4. Quality of Education

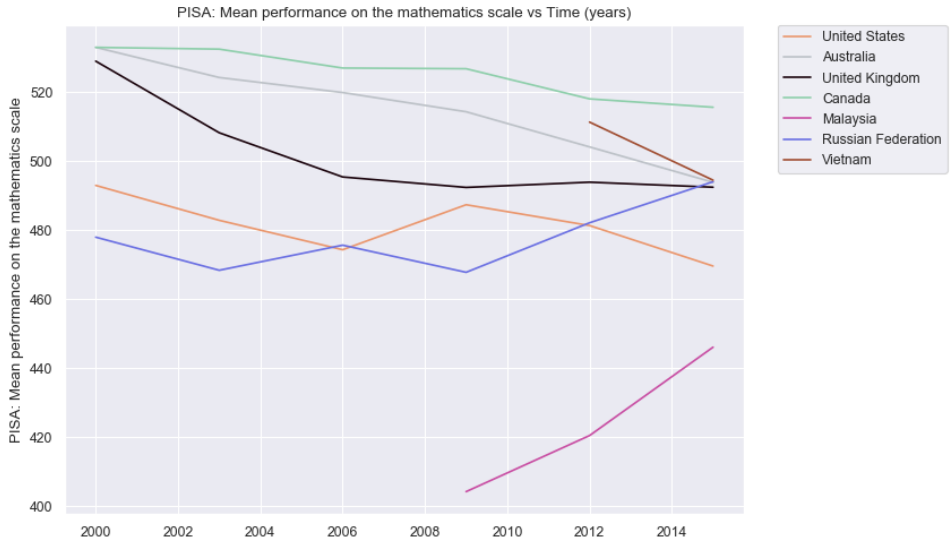
Question: Is the learning outcomes of different subjects negatively correlated i.e. does performing well in one subject correlate with performing badly in another subject?

I used the PISA (http://www.oecd.org/pisa/data/) test scores as metric of comparison. The test is a 3 hours with three sections - **mathematics, science and reading**.

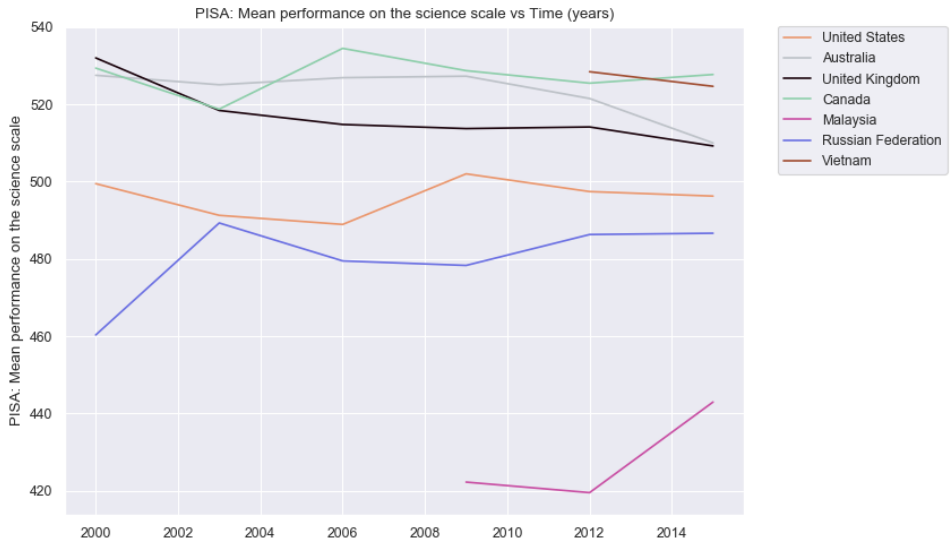
The Programme for International Student Assessment (PISA) is a triennial international survey which aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students.

The data is issued by the Organisation for Economic Co-operation and Development (OECD (http://www.oecd.org/about/)).

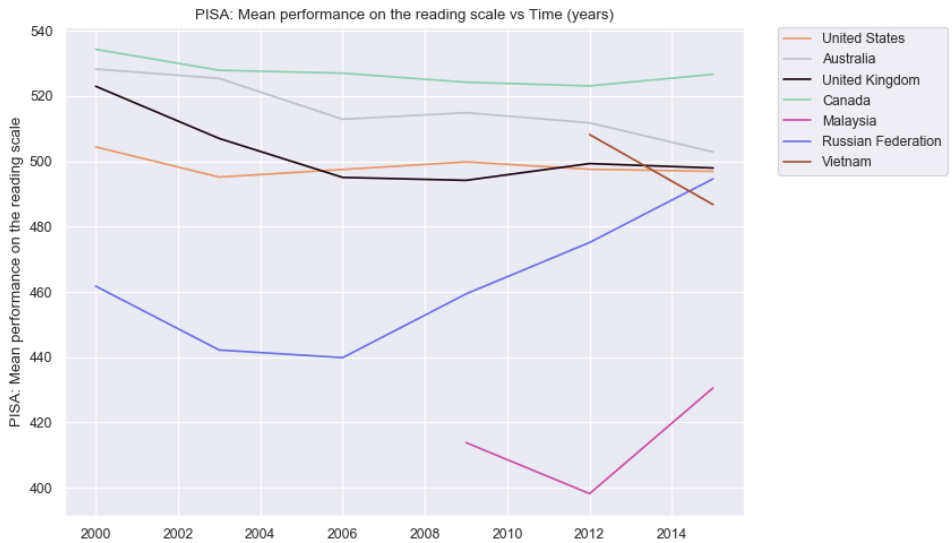
In [62]:
```
plot_indicator("PISA: Mean performance on the mathematics scale",hinc+minc+linc,eco_color=False)
```



In [57]:
```
plot_indicator("PISA: Mean performance on the science scale",hinc+minc+linc,eco_color=False)
```



In [58]:
```
plot_indicator("PISA: Mean performance on the reading scale",hinc+minc+linc,eco_color=False)
```



In [95]:
```
# calculate the correlation coefficient between the subject scores
# (on a filtered subset of countries)

hnm_inc = ['United States','Australia','United Kingdom','Canada','Malaysia','Russian
Federation','Vietnam']
score = dict()
category = ["reading","mathematics","science"]

for cat in category:
    vals, country = get_vals_indicator("PISA: Mean performance on the "+cat+" scale")
    filtered_index = [country.index(f) for f in hnm_inc]

    vals = np.array(itemgetter(*filtered_index)(vals))
    country = itemgetter(*filtered_index)(country)
    score[cat] = np.nanmean(vals,axis=1)
```

In [109]:
```
for c1, c2 in [('mathematics', 'reading'),('mathematics', 'science'),('science', 'reading')]:
    print("Correlation between performance in",c1,"and",c2,":",np.corrcoef(score[c1],score[c2])
[1,0])
```

```
Correlation between performance in mathematics and reading : 0.966594035862404
Correlation between performance in mathematics and science : 0.9759302684439629
Correlation between performance in science and reading : 0.9588064863133359
```

Conclusion:

We see a positive correlation between mathematics, science and reading and this explains that good scores in one subject are not correlated with bad scores on another. **Countries that do good in one subject tend to do good in the others as well**. This shows that none of the three fields gets a special focus/preference (till the age of 15) that negatively impacts the other subjects.

Question: Which subjects have seen improvements over time in terms of scores? Has the academic curriculum become harder in the recent years?

In [122]:
```
hnm_inc = ['United States','Australia','United Kingdom','Canada','Malaysia','Russian
Federation','Vietnam']
category = ["reading","mathematics","science"]

for cat in category:
    vals, country = get_vals_indicator("PISA: Mean performance on the "+cat+" scale")
    filtered_index = [country.index(f) for f in hnm_inc]

    vals = np.array(itemgetter(*filtered_index)(vals))
    print("Correlation between performance in",cat,"and time (years):", \
          np.corrcoef(np.nanmean(vals,axis=0)[~np.isnan(np.nanmean(vals,axis=0))], \
                np.arange(2000,2017)[~np.isnan(np.nanmean(vals,axis=0))])[1,0])
```

```
/home/hemant/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:12: RuntimeWarning: Mean of
empty slice
  if sys.path[0] == '':
/home/hemant/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:13: RuntimeWarning: Mean of
empty slice
  del sys.path[0]

Correlation between performance in reading and time (years): -0.8108364047699489
Correlation between performance in mathematics and time (years): -0.8866552151879683
Correlation between performance in science and time (years): -0.7940151172423099
```

Conclusion:

We see that **the scores correlate negatively with time**. This means that as time progresses, the PISA scores in all three subjects tend to fall. This can be explained by the increasing difficulty of the test, which is designed to represent a standard test for proficiency in that subject.

By extension, this can be one of two things:

1. **Academic curriculum around the world have become harder/more competitive** and so has the PISA test and thus we see scores falling i.e. the proficiency requirements keep increasing every year.
2. **Academic curriculum has become simpler while the PISA Test has evolved.** Thus causing students to get a relatively lower score as the bar is set higher for them.

Summary of Conclusions

Education and Income:

- As we can see, there if definitely a **strong correlation between (%) of youth enrolled in schools and the income level** of that country. In fact, as we break this for the three different school groups, we see that **the correlation becomes stronger as the**

education level progresses.
- This can be attributed to the fact that **education costs become less affordable** for lower (and middle) income groups as the youth move from primary to lower secondary and higher secondary schools.

'Gender' Bias:

- Essentially, **for low income countries, a higher % of men go to (are enrolled in) schools than women and for high income countries, a higher % of women go to (are enrolled in) schools than men**.
- It is interesting to see how the results are so different. This can be attributed to **women empowerment and subsidized education for the female population in high income** countries and the **lack of the same thereof in low income** countries.
- It appears to be true that there is a bias against female education in low income countries that most likely stems from cultural and social beliefs that have propagated down the ages.

Government's role in Education:

- Percentage of total expenditure that governments invested in Education negatively correlated with the Income level.
- There is negligible correlation between % of GDP invested in education and income level of the country
- Percentage investment of GDP in education is stable in High Income countries (more or less constant over the years) and volatile in Low Income countries (changes a lot over the years).
- Governments try to invest an amount in education that is proportional to their GDP.

Quality of Education:

- We see a positive correlation between mathematics, science and reading and this explains that good scores in one subject are not correlated with bad scores on another. Countries that do good in one subject tend to do good in the others as well. This shows that none of the three fields gets a special focus/preference (till the age of 15) that negatively impacts the other subjects.
- We see that all three scores correlate negatively with time. This means that as time progresses, the PISA scores in all three subjects tend to fall. This can be explained by the increasing difficulty of the test, which is designed to represent a standard test for proficiency in that subject.
- By extension, this can be one of two things:
    1. Academic curriculum around the world has become tougher/more competitive and so has the PISA test. Thus we see scores falling as the proficiency requirements keep increasing every year.
    2. Academic curriculum has become simpler while the PISA Test has evolved. Thus causing students to get a relatively lower score as the bar is set higher for them

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