Math Scores for Different Teaching Styles

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04-28-2022

Three teachers at a junior high school have different opinions about which teaching method is most effective for 8th grade math students. Ms. Wesson uses a traditional approach, while Ms. Ruger and Ms. Smith use a standards-based method. The first task is to determine which approach is more effective, based on the math scores of their current students.

In addition, it has been suggested that each teacher has strengths that will make them more effective with students in certain ethnic groups. One teacher believes that students should be divided into classes based on ethnicity. The second task is to determine if there is a difference between student performance for each teacher based on student demographics.

Another proposal was that students should be grouped according to ability within each classroom. The teacher making this suggestion referenced an article, "Math and Reading Instruction in Tracked First-Grade Classes" (Stephen M Ross, et.al). The third task is to review this study to determine if ability grouping is supported by the findings.

The data includes math scores for students in grades 7-8. More information about this data project can be found at Kaggle.com

It should be noted that this data includes only one score for each student. A more effective method for measuring the quality of instruction would be a collection of multiple scores that could be used to demonstrate student growth. Additionally, there is no recording in this data to determine the effectiveness of ability grouping within a classroom.

Load Necessary Packages and Data

```
library("tidyr")
library("dplyr")
library("foreign")
library("ggplot2")
#load data
math <- read.spss("1ResearchProjectData.sav", to.data.frame = TRUE)
```

Cleaning the Data

1. Preview Data

```
head(math)
```

```
##   Student Teacher Gender           Ethnic   Freeredu Score      wesson
## 1       1   Ruger Female            Asian Free lunch    76 Ruger_Smith
## 2       2   Ruger Female         Hispanic Paid lunch    56 Ruger_Smith
## 3       3   Ruger Female African-American Free lunch    34 Ruger_Smith
## 4       4   Ruger Female            Asian Paid lunch    59 Ruger_Smith
```

```
## 5       5   Ruger   Male         Hispanic Free lunch    73 Ruger_Smith
## 6       6   Ruger   Male        Caucasian Paid lunch    58 Ruger_Smith
```

2. Tidy Columns

```
#rename columns to better describe data

math <- math %>%
  rename(Method="wesson")

math <- math %>%
  rename(Lunch="Freeredu")
colnames(math)
```

```
## [1] "Student" "Teacher" "Gender"  "Ethnic"  "Lunch"   "Score"   "Method"
```

```
#drop word "lunch" from lunch status descriptions
math <- math %>%
  mutate(Lunch=gsub(' lunch','',Lunch))

#change Method factors Ruger_Smith = standards, Wesson = traditional
math$Method <- sub("Ruger_Smith","Standards",math$Method)
math$Method <- sub("Wesson","Traditional",math$Method)

#check results
head(math)
```

```
##   Student Teacher Gender           Ethnic Lunch Score    Method
## 1       1   Ruger Female            Asian  Free    76 Standards
## 2       2   Ruger Female         Hispanic  Paid    56 Standards
## 3       3   Ruger Female African-American  Free    34 Standards
## 4       4   Ruger Female            Asian  Paid    59 Standards
## 5       5   Ruger   Male         Hispanic  Free    73 Standards
## 6       6   Ruger   Male        Caucasian  Paid    58 Standards
```

3. Check for Duplicates and Omit Missing Values

```
#check for duplicates
math %>%
  duplicated() %>%
  table()
```

```
## .
## FALSE
##   217
```

```
#none found

#remove missing values
math <- na.omit(math)
```

Analysis

1. Inspect Population

```
#total students
pop_total <- math %>%
  summarize(count=n())
pop_total
```

```
##   count
## 1   216
```

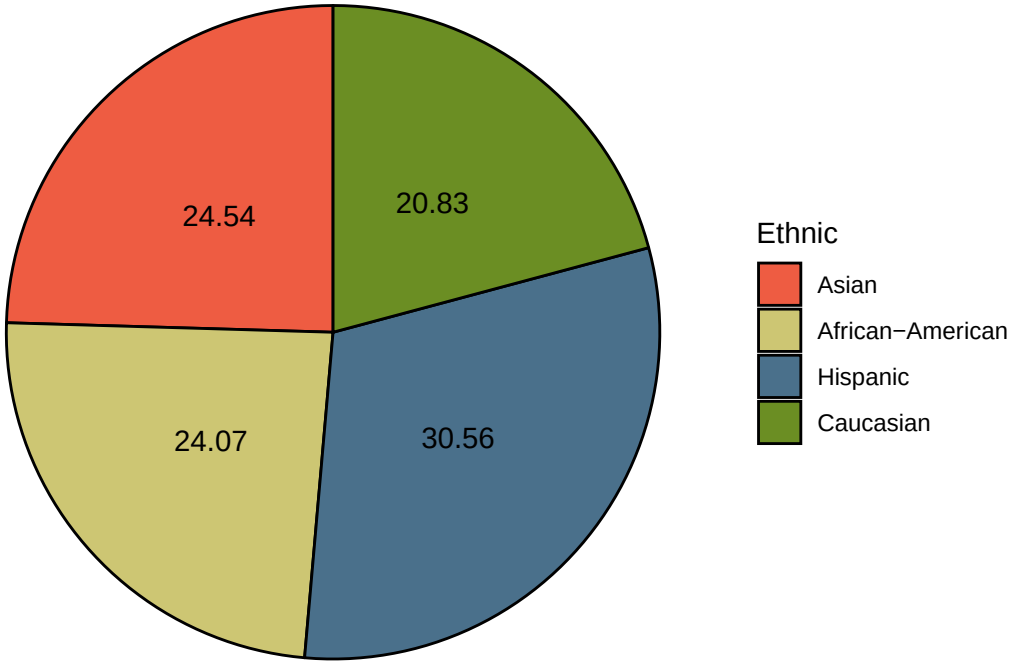
```
#student ethnicity
pop_ethnicity <- math %>%
  group_by(Ethnic) %>%
  summarize(count=n()) %>%
  mutate(Perc=(count/216)*100)
pop_ethnicity
```

```
## # A tibble: 4 x 3
##   Ethnic           count  Perc
##   <fct>            <int> <dbl>
## 1 Asian               53  24.5
## 2 African-American    52  24.1
## 3 Hispanic            66  30.6
## 4 Caucasian           45  20.8
```

```
#plot
pop_ethnicity_viz <- ggplot(pop_ethnicity,aes(x="",y = Perc, fill = Ethnic,)) +
  geom_col(color="black")+
  scale_fill_manual(values =c("tomato2","khaki3","skyblue4","olivedrab"))+
  geom_text(aes(label = round(Perc,2)),
            position = position_stack(vjust = 0.5)) +
  coord_polar(theta = "y")+
  labs(title="Percentages of Students By Ethnicity")+
  theme_void()

pop_ethnicity_viz
```

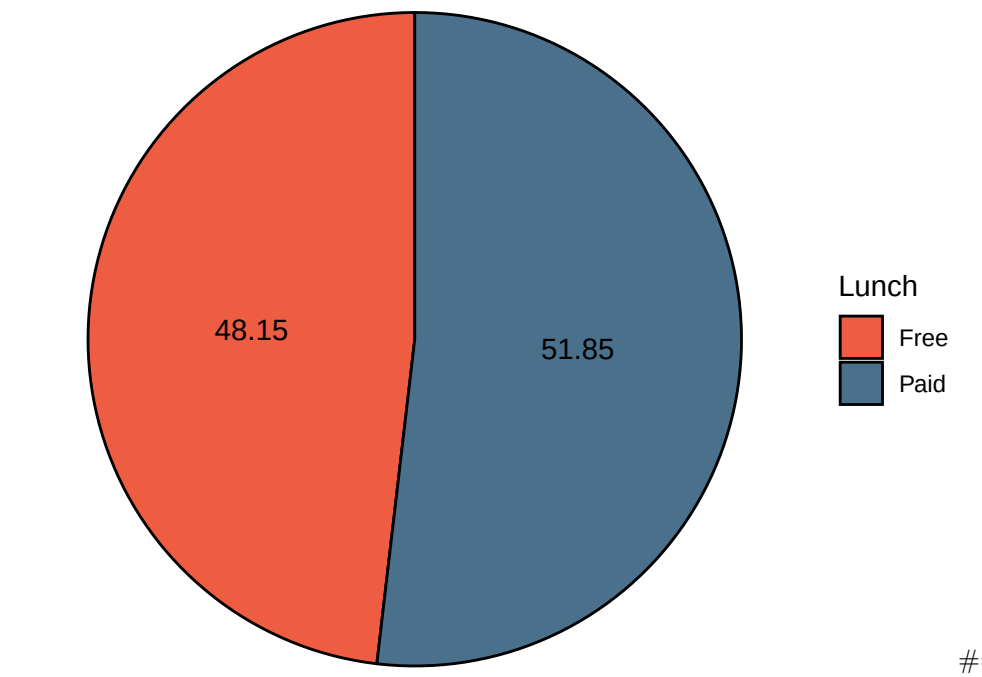
Percentages of Students By Ethnicity




```
#Lunch Status
pop_lunch_status <- math %>%
  group_by(Lunch)%>%
  summarize(count=n())%>%
  mutate(Perc=(count/216)*100)
pop_lunch_status
```

```
## # A tibble: 2 x 3
##   Lunch count  Perc
##   <chr> <int> <dbl>
## 1 Free    104  48.1
## 2 Paid    112  51.9
```

```
#plot
pop_lunch_viz <- ggplot(pop_lunch_status,aes(x="",y = Perc, fill = Lunch,)) +
  geom_col(color="black")+
  scale_fill_manual(values =c("tomato2","skyblue4"))+
  geom_text(aes(label = round(Perc,2)),
            position = position_stack(vjust = 0.5)) +
  coord_polar(theta = "y")+
  labs(title="Percentages of Students By Lunch Status")+
  theme_void()
pop_lunch_viz
```



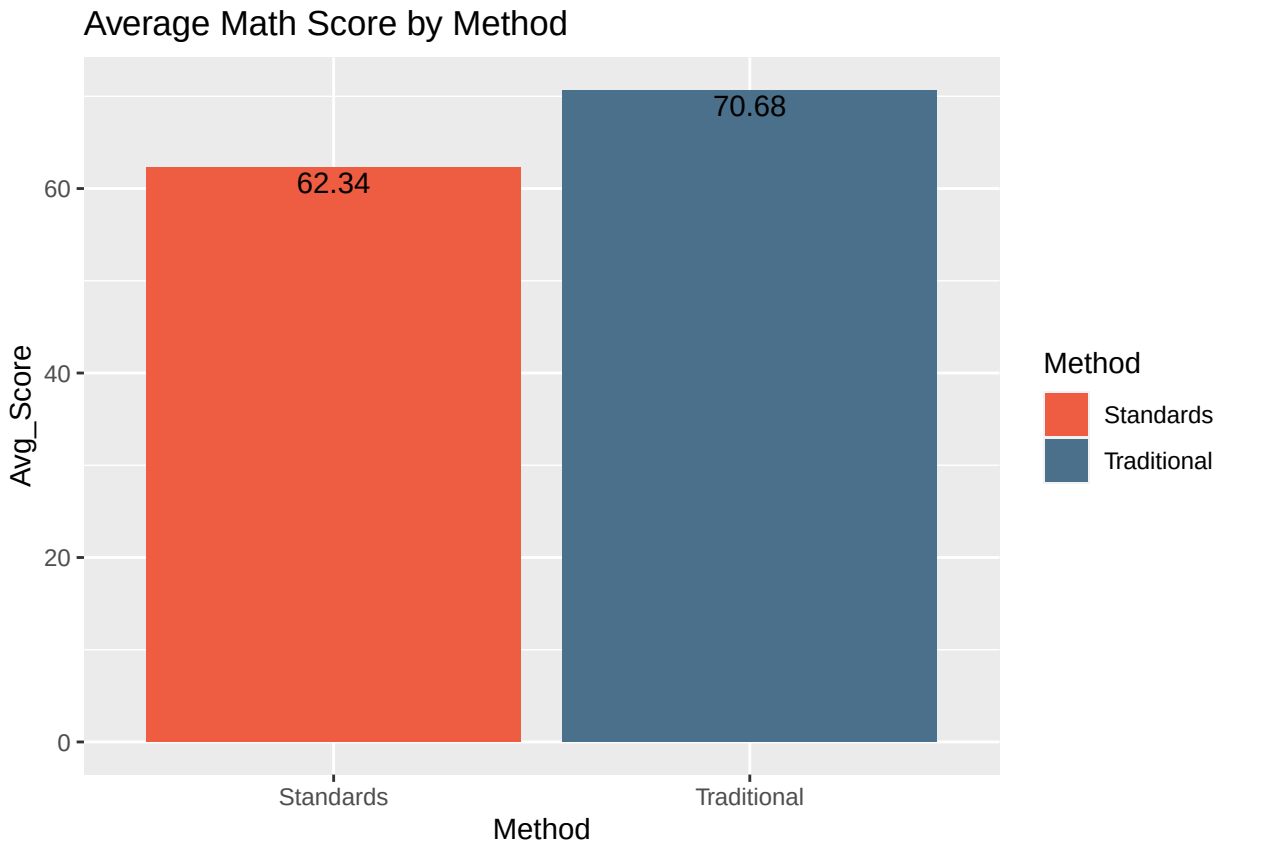
2. Compare Methods

Initial comparison of average test scores for each method show higher scores for the traditional method (70.7), compared to the standards-based method (62.3).

```
#avg score by Method
avg_score_method <- math %>%
  group_by(Method) %>%
  summarize(Avg_Score=mean(Score,na.rm=TRUE))
avg_score_method
```

```
## # A tibble: 2 x 2
##   Method      Avg_Score
##   <chr>           <dbl>
## 1 Standards        62.3
## 2 Traditional      70.7
```

```
#plot
avg_method_viz <- ggplot(data=avg_score_method,aes(x=Method,y=Avg_Score,fill=Method))+
  geom_bar(stat="identity")+
  geom_text(aes(label=round(Avg_Score,2)), vjust=1.25)+
  scale_fill_manual(values=c("tomato2","skyblue4"))+
  labs(title="Average Math Score by Method")
avg_method_viz
```



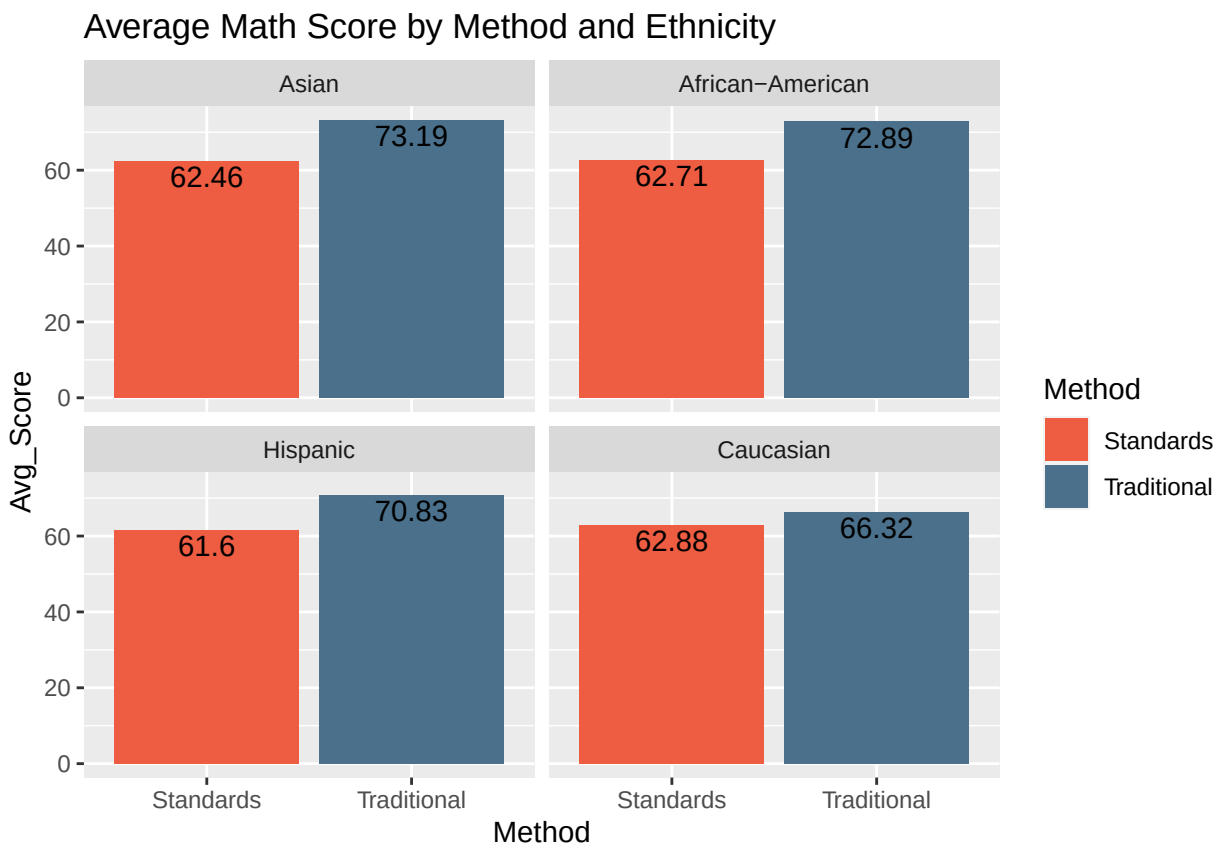
Evaluating the scores by method shows higher scores for the traditional method, with little difference between groups of students based on ethnicity or lunch status.

```
#avg score by Method and ethnicity
avg_score_method_ethnicity <- math %>%
  group_by(Method,Ethnic) %>%
  summarize(Avg_Score=mean(Score,na.rm=TRUE))
avg_score_method_ethnicity
```

```
## # A tibble: 8 x 3
## # Groups:   Method [2]
##   Method      Ethnic           Avg_Score
##   <chr>       <fct>                <dbl>
## 1 Standards   Asian                 62.5
## 2 Standards   African-American      62.7
## 3 Standards   Hispanic              61.6
## 4 Standards   Caucasian             62.9
## 5 Traditional Asian                 73.2
## 6 Traditional African-American      72.9
## 7 Traditional Hispanic              70.8
## 8 Traditional Caucasian             66.3
```

```
#plot
avg_method_ethnicity_viz <- ggplot(data=avg_score_method_ethnicity,aes(x=Method,y=Avg_Score,fill=Method
  geom_bar(stat="identity")+
  geom_text(aes(label=round(Avg_Score,2)), vjust=1.25)+
  facet_wrap(~Ethnic)+
  scale_fill_manual(values=c("tomato2","skyblue4"))+
  labs(title="Average Math Score by Method and Ethnicity")
```

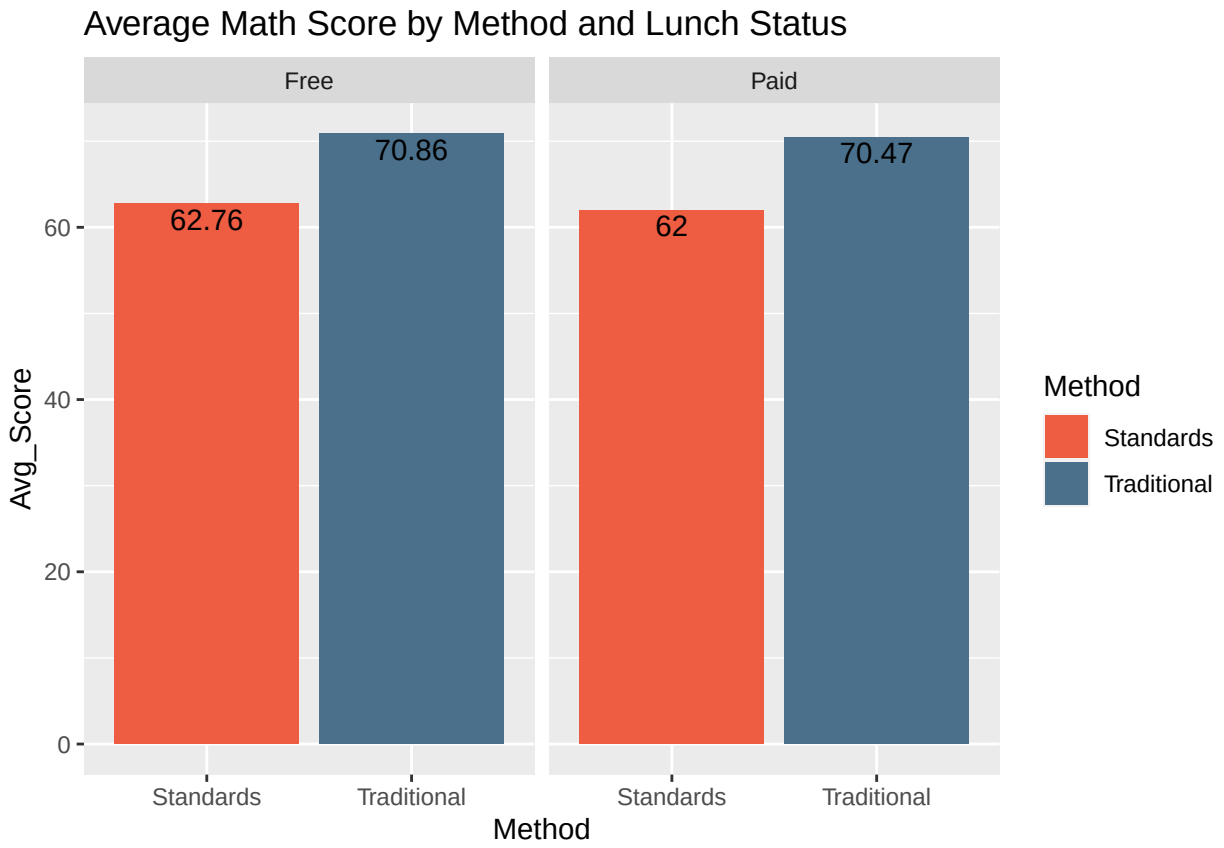
```
avg_method_ethnicity_viz
```




```
#avg score by Method and lunch status
avg_score_method_lunch <- math %>%
  group_by(Method,Lunch) %>%
  summarize(Avg_Score=mean(Score,na.rm=TRUE))
avg_score_method_lunch
```

```
## # A tibble: 4 x 3
## # Groups:   Method [2]
##   Method      Lunch Avg_Score
##   <chr>       <chr>     <dbl>
## 1 Standards   Free       62.8
## 2 Standards   Paid       62
## 3 Traditional Free       70.9
## 4 Traditional Paid       70.5
```

```
#plot
avg_method_lunch_viz <- ggplot(data=avg_score_method_lunch,aes(x=Method,y=Avg_Score,fill=Method))+
  geom_bar(stat="identity")+
  geom_text(aes(label=round(Avg_Score,2)), vjust=1.25)+
  facet_wrap(~Lunch)+
  scale_fill_manual(values=c("tomato2","skyblue4"))+
  labs(title="Average Math Score by Method and Lunch Status")
avg_method_lunch_viz
```



2. Comparing Teachers

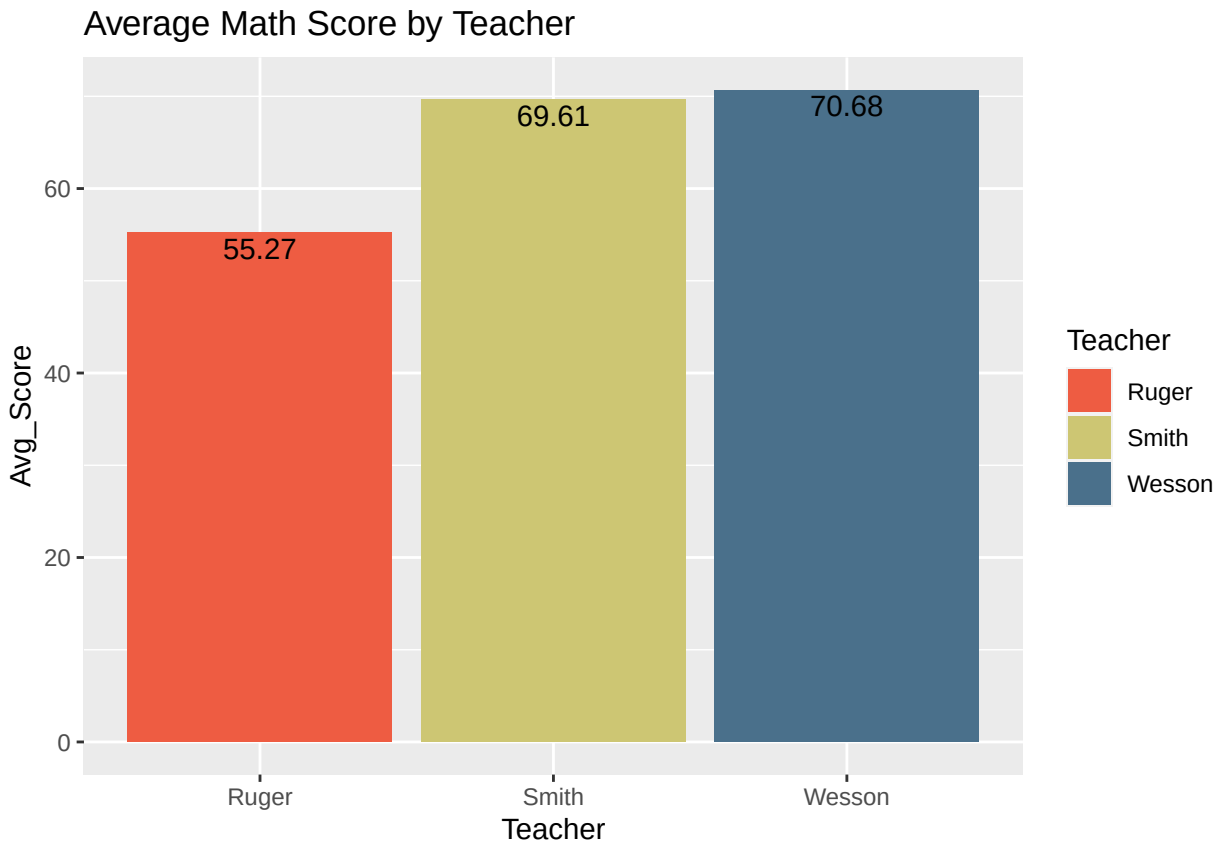
Compare student scores based on their math teacher.

Ms. Wesson and Ms. Smith have students with average scores that are very similar (70.7 and 69.6, respectively). Ms. Ruger's students average score is 55.26.

```
#avg score by teacher
avg_teacher_score <- math %>%
    group_by(Teacher) %>%
    summarize(Avg_Score=mean(Score,na.rm=TRUE))
avg_teacher_score
```

```
## # A tibble: 3 x 2
##   Teacher Avg_Score
##   <fct>       <dbl>
## 1 Ruger        55.3
## 2 Smith        69.6
## 3 Wesson       70.7
```

```
#plot
avg_teacher_viz <- ggplot(data=avg_teacher_score,aes(x=Teacher,y=Avg_Score,fill=Teacher))+
  geom_bar(stat="identity")+
  geom_text(aes(label=round(Avg_Score,2)), vjust=1.25)+
  scale_fill_manual(values=c("tomato2","khaki3","skyblue4"))+
  labs(title="Average Math Score by Teacher")
avg_teacher_viz
```



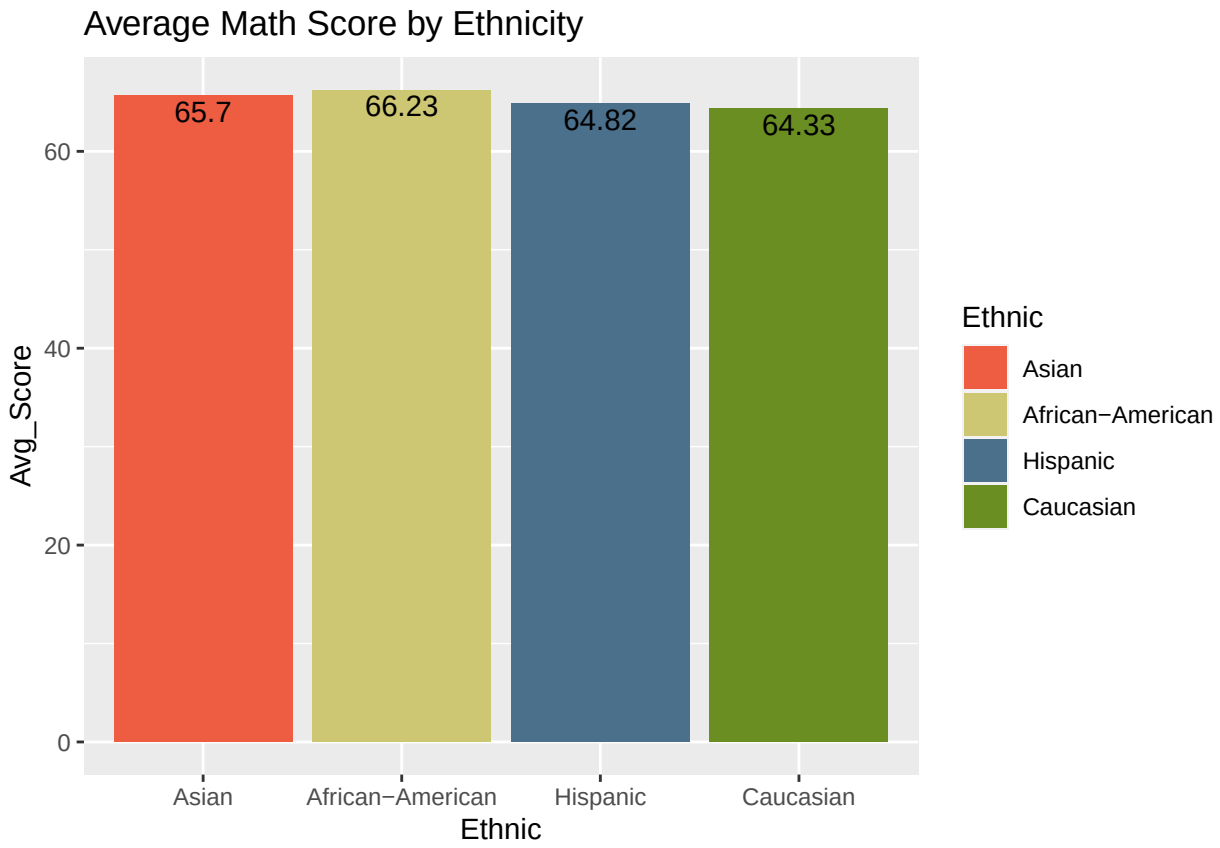
Next, examine how each teacher's students perform when grouped by ethnicity and lunch status.

There is little differences in overall performance between ethnic groups. While there are minor differences between average student scores of Ms. Smith and Ms. Wesson when grouped according to ethnicity, average student scores in Ms. Ruger's class were over 10-16 points lower than the other two student groups for all ethnic groups.

```
#avg score by ethnicity
avg_score_ethnicity <- math %>%
    group_by(Ethnic) %>%
    summarize(Avg_Score=mean(Score,na.rm=TRUE))
avg_score_ethnicity
```

```
## # A tibble: 4 x 2
##   Ethnic           Avg_Score
##   <fct>                <dbl>
## 1 Asian                 65.7
## 2 African-American      66.2
## 3 Hispanic              64.8
## 4 Caucasian             64.3
```

```
#plot
avg_ethnicity_viz <- ggplot(data=avg_score_ethnicity,aes(x=Ethnic,y=Avg_Score,fill=Ethnic))+
  geom_bar(stat="identity")+
  geom_text(aes(label=round(Avg_Score,2)), vjust=1.25)+
  scale_fill_manual(values=c("tomato2","khaki3","skyblue4","olivedrab"))+
  labs(title="Average Math Score by Ethnicity")
avg_ethnicity_viz
```

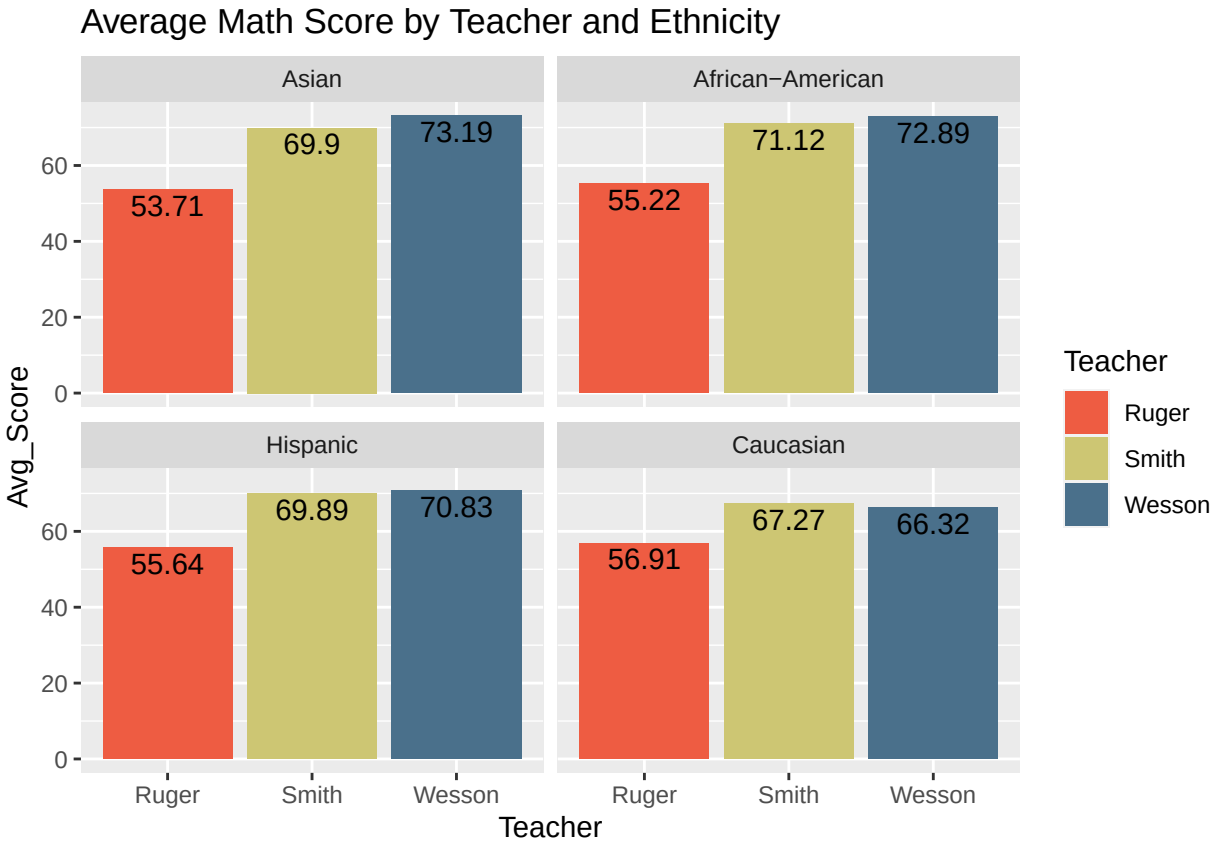



```
#avg score by teacher for each ethnicity
avg_teacher_score_ethnicity <- math %>%
  group_by(Ethnic,Teacher) %>%
  summarize(Avg_Score=mean(Score,na.rm=TRUE))
avg_teacher_score_ethnicity
```

```
## # A tibble: 12 x 3
## # Groups:   Ethnic [4]
##    Ethnic           Teacher Avg_Score
##    <fct>            <fct>       <dbl>
##  1 Asian            Ruger        53.7
##  2 Asian            Smith        69.9
##  3 Asian            Wesson       73.2
##  4 African-American Ruger        55.2
##  5 African-American Smith        71.1
##  6 African-American Wesson       72.9
##  7 Hispanic         Ruger        55.6
##  8 Hispanic         Smith        69.9
##  9 Hispanic         Wesson       70.8
## 10 Caucasian        Ruger        56.9
## 11 Caucasian        Smith        67.3
## 12 Caucasian        Wesson       66.3
```

```
#plot
avg_teacher_ethnic_viz <- ggplot(data=avg_teacher_score_ethnicity,aes(x=Teacher,y=Avg_Score,fill=Teache
  geom_bar(stat="identity")+
   geom_text(aes(label=round(Avg_Score,2)), vjust=1.25)+
  facet_wrap(~Ethnic)+
```

```
  scale_fill_manual(values=c("tomato2","khaki3","skyblue4"))+
  labs(title="Average Math Score by Teacher and Ethnicity")
avg_teacher_ethnic_viz
```

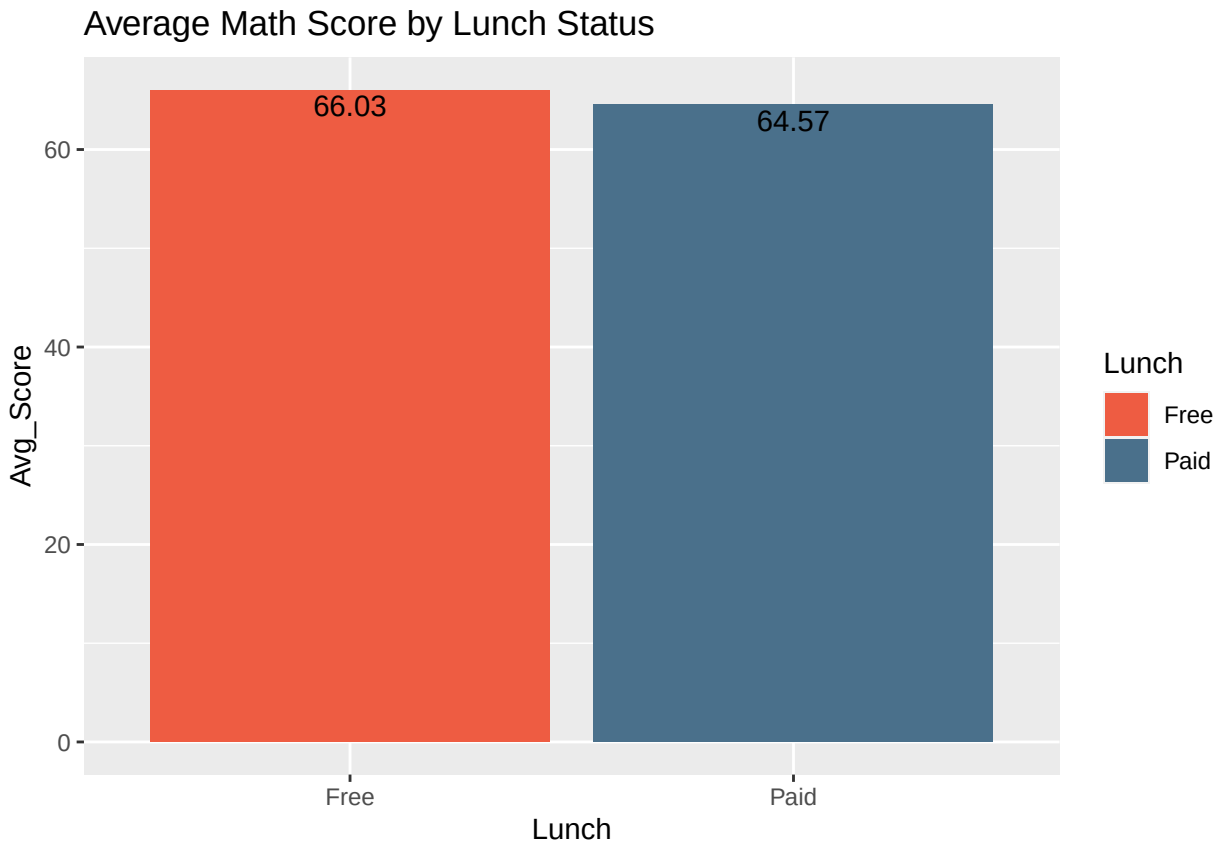


Again we find there is no large difference in performance between all students grouped by lunch status, but there remains a visible gap between the performance of students in both groups when comparing teachers.

```
#avg score by lunch status
avg_score_lunch <- math %>%
  group_by(Lunch)%>%
  summarize(Avg_Score=mean(Score,na.rm=TRUE))
avg_score_lunch
```

```
## # A tibble: 2 x 2
##   Lunch Avg_Score
##   <chr>     <dbl>
## 1 Free       66.0
## 2 Paid       64.6
```

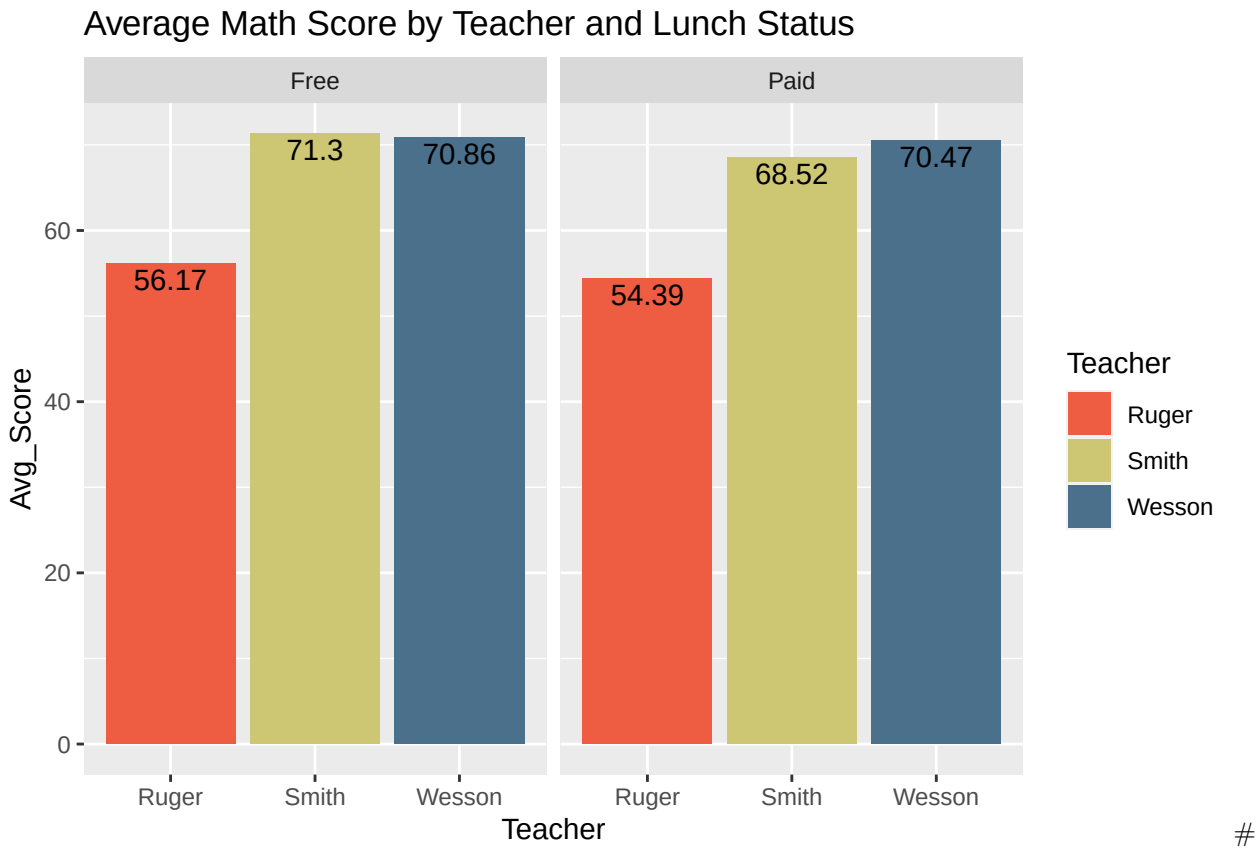
```
#plot
avg_lunch_viz <- ggplot(data=avg_score_lunch, aes(x=Lunch,y=Avg_Score,fill=Lunch))+
      geom_bar(stat="identity")+
      geom_text(aes(label=round(Avg_Score,2)), vjust=1.25)+
      scale_fill_manual(values=c("tomato2","skyblue4"))+
      labs(title="Average Math Score by Lunch Status")
avg_lunch_viz
```




```
#avg score by teacher for lunch status
avg_teacher_score_lunch <- math %>%
  group_by(Teacher,Lunch) %>%
  summarize(Avg_Score=mean(Score,na.rm=TRUE))
avg_teacher_score_lunch
```

```
## # A tibble: 6 x 3
## # Groups:   Teacher [3]
##   Teacher Lunch Avg_Score
##   <fct>   <chr>     <dbl>
## 1 Ruger   Free       56.2
## 2 Ruger   Paid       54.4
## 3 Smith   Free       71.3
## 4 Smith   Paid       68.5
## 5 Wesson  Free       70.9
## 6 Wesson  Paid       70.5
```

```
#plot
avg_teacher_lunch_viz <- ggplot(data=avg_teacher_score_lunch,aes(x=Teacher,y=Avg_Score,fill=Teacher))+
  geom_bar(stat="identity")+
   geom_text(aes(label=round(Avg_Score,2)), vjust=1.25)+
  facet_wrap(~Lunch)+
  scale_fill_manual(values=c("tomato2","khaki3","skyblue4"))+
  labs(title="Average Math Score by Teacher and Lunch Status")
avg_teacher_lunch_viz
```



#

Conclusions

When comparing traditional and standards-based methods among all students, the traditional method seems to result in higher scores. However, the difference between the scores of students taught by Ms. Wesson and Ms. Smith is less than the difference between those two classes and Ms. Ruger's students.

Ms. Wesson and Ms. Ruger both use the standards-based method, and Ms. Smith uses the traditional method. When ranking the performance of students in each class, the standards-based method ranks first and last, while the traditional method is a close second place. Considering the discrepancy between the two standards-based classrooms, we cannot definitively conclude that the teaching method is the determining factor affecting student performance.

The data does not show any benefit for students being assigned to a specific teacher according to their ethnicity or lunch status that would outweigh the ethical issues that such groupings would create. It does show that Ms. Ruger's students do not perform as well as those taught by Ms. Smith or Ms. Wesson, even when taking ethnicity and lunch status into account.

The largest difference in student performance was found when comparing teachers. The differences between student scores in each class can be seen on a graph, but may not be statistically significant. There could be other factors causing an appearance of low performance. Hypothesis testing needs to be done to determine the level of significance for these results.

The final task was to evaluate the suggestion to group students by ability within the classroom. While the data set provided does not address this question, a careful read of the article cited by the teacher reveals that the data does not support the teacher's suggestion. The study observed the impact of grouping whole classes by ability, but did not address student grouping within a classroom. The paper showed no significant difference in teacher behavior or student performance between classes that were ability-tracked. There were negative differences in teacher attitude towards students in low-ability classrooms.

To find answers, it is necessary to look at other data. In his paper, "Ability Grouping in Mathematics Classrooms: A Bourdieuian Analysis," Robyn Zevenbergen found that ability grouping within the classroom

can have a negative impact on how students perceive themselves and the subject of mathematics in general.

Further, "Within-Class Grouping: A Meta-Analysis" (Yiping Lou, et.al) found that, while small-group instruction within a classroom is preferable to whole-class instruction, the effect was largest if the teacher received training to adapt instructional delivery to each group. When comparing homogeneous or heterogeneous grouping within the classroom, the analysis found homogeneous groups benefit students with medium ability, but not low- or high-ability students. Additionally, the a significant benefit of ability grouping was found in reading, but not in mathematics. In summary, "Larger effects occurred when the group formation was based on mixed sources and involved more considerations than ability alone."

These findings do support the use of small-group instruction with teacher training in adaptive methods for each group. They do not, however support using ability as the exclusive criteria for forming small groups.

Recommendations

1. Allow teachers to continue using their preferred method. Collect more data that includes beginning and post-instruction scores to demonstrate growth, then reevaluate based on future data.
2. Do not group classes according to ability, ethnicity, or socioeconomic status.
3. Encourage small-group instruction, and provide training to teachers on how to adapt instruction for each group. Small group criteria can include, but should not be limited to, mathematical ability.
4. If the difference between student scores proves to be statistically significant, the school administration should consider evaluating and offering professional development support for Ms. Ruger.