The influence of teaching styles on students' math score

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Abstract. There is a researching that three teachers with two different teaching methods in a junior high school, where students came from four different ethnic groups. Ruger and Smith used the standards-based method and Wesson used the traditional method, they were suggested to use the same teaching approach and the same textbook. The study aims to understand fully which teacher is best fitted for which ethnic group and which teaching approach is better. This research used statistical methods such as pie charts and bar plots to analyze data and used linear regression to investigate the relationships between the teaching methods and the students' performance. The results showed that students who were taught by Ruger achieved the lowest math scores across all ethnics; Smith's teaching method suits Caucasian students; the traditional method resulted in higher math scores for students of African-American, Asian and Hispanic; and students who learnt using traditional method got higher scores compared to students learnt using standards-based method in average. Although each method has its own benefit, these results suggest that the traditional method is better than the standards-based method and these teachers should use the same teaching approach.

Keywords: standards-based method, traditional method, junior high school, diverse socioeconomically.

1. Introduction

Ruger (African-American), Smith (Caucasian who is good at Spanish) and Wesson (Caucasian) are three math teachers in a diverse socioeconomically junior high school, all of them have been assigned to teach math for the past three years, each using different teaching methods and chooses their own textbook respectively. Ruger and Smith's teaching approach was standards-based method, which adhered to give literal interpretations of well-written standards: facilitates learning in a constructivist environment and letting students explore, develop, speculate and test their conjectures within the confines of the standard; Wesson's teaching approach was traditional method, which adhered to the top-down approach: knowledge originates from teachers and relays to students. Some researchers have shown that most children in standards-based classrooms will learn more and deeper math and then become better problem solvers; researches have also shown that in traditional classrooms, some behavioral problems are minimized, thus producing effective and direct teaching.

Approximately 500 students in grades 7 and 8 were assigned to these three teachers randomly with a relatively diverse ethnic composition, mainly composed of African-American, Hispanic, Asian, and Caucasian students. During a math department meeting, it was suggested that three math teachers should use the same teaching approach and textbook, but the three teachers had different dissents.

Wesson strongly believes that her teaching method was the better one because of students' different ethnic and social backgrounds, she suggested that groups should be made among the three teachers based on the ethnicity of the students (Ruger teaches African-American students, Smith teaches Hispanic students and Wesson teaches Asian and Caucasian students), also stated that math teachers should be allowed to teach their students using the methods they are most comfortable with. However, Smith disagreed with Wesson's suggestion, her opinion was based on a research article,

which states that students in traditional classrooms were lack of creativity to solve problems [1], then Smith suggested that all three teachers should use the standards-based method. According to another journal, it states the standards-based method that children find how to solve the problem after the teacher gives some primary samples can contribute to children a sense of success so that the desire of learning will increase [2].

The dataset regarding students' performance in the traditional method or the standards-based method used for this research was from Kaggle, which includes students' math scores from four ethnic groups taught by these three teachers, who were randomly assigned.

Because of the development of education and people's point of view, the teaching method has a relatively great proportion of education. People start to think about how they can make children study efficiently, therefore, the traditional method and the standard method have conflicts. And according to a book, it actually did some experiments to investigate whether traditional and reform-oriented teaching methods can have effects on some hands like achievement and attitude on students [3]. The experiment takes three years to investigate through interviews, observations, and assessments. It is true that different teaching methods change the development of students in the long run. There are some studies supported that the traditional method is a better way of studying mathematics: an article talked about student's perception of their teacher's teaching styles [4] have shown that the general student learning experience for mathematics learning model that has been taught is still teacher-centered; another article indicated that the learning style of theorist students was the most advantageous group of learning mathematics [5]. These coincide with what the traditional method adhered to.

However, according to relevant studies, the overall proportion of students preferring traditional classes is lower than students preferring non-traditional classes [6], and more students prefer to learn in an active atmosphere rather than in a traditional lecture [7]. For example, an article stated that the Activist-Reflector style showed better performance in solving math problems and which is the most frequently preferred learning style than other styles [8], where this type of style comprised willingness to be dominated by instant experiences and stand back to consider experiences then used many different perspectives to observe them, which looks more like what the standards-based method adhered. Another study also reveals that students taught by the standards-based method do not only perform better in their academic mathematical ability but also are generally more successful than those who learn in a traditional teaching environment [9]. Nevertheless, there is another article focusing on the effect of teaching methods on mathematics achievement and motivation suggests that students taught by the traditional methods have better performance on the novice-level, advanced-level, and overall-hard subscales which shows the traditional method is the better choice [10].

More specifically, this research aims to find out which teaching method (traditional or standards-based) works better for this diverse socioeconomically junior high school and to verify whether these teachers should use the same teaching approach and textbook in the future or not.

2. Methodology

To decide which teaching method is better, this research used statistical methods to analyze the data from Kaggle [11]. Load the dataset and remove the missing values in the dataset at the beginning, then add method columns for each teacher. After that, can use the codes to make descriptive statistics and use SPSS to perform linear regression.

The sample in this research is 500 students from grades 7 and 8 who were randomly assigned to these three teachers and came from four different ethnic groups. After removing the missing values, the sample was left with 216 valid groups of data, representing 216 observed individuals, namely students. Each group of data contains 5 measurements, which are: "Teacher" - categorical feature with 3 levels, each representing the student is taught by one of 3 teachers; "Gender" - categorical feature with 2 levels labelling students' gender; "Ethnic" - categorical feature with 4 levels representing students' ethnicities; "Score" - continuous feature reflects students' academic

performance in mathematics; "Wesson" - categorical feature with 2 levels indicates the teaching method that student received is traditional or standard-based.

2.1. Descriptive statistics

The pie chart is a circular statistical graphic, which illustrates numerical proportion by dividing a circle into slices. This research used one pie chart to examine the percentages of students according to their ethnicity in the dataset.

The bar plot presents categorical data with rectangular bars with heights or lengths that are proportional to the values of the dataset, which can be plotted vertically or horizontally. This research used several bar plots to examine the demographic of each ethnic with genders, calculated the average scores of each ethnicity with genders and the average scores in different methods (standards-based & traditional), also drew average scores with or without their ethnics by each teacher and students' performance compared to each teacher.

The box plot shows the five-number summary (minimum, first quartile, median, third quartile, and maximum) of a set of data. This research used one box plot to compare the overall average math score with each ethnicity and gender.

2.2. Linear regression models

Linear regression is a linear approach for modelling the relationship between one or more input variables (explanatory/predictor variables x) and the single output variable (response/dependent variable y), assumed that the mean of Y depends on X in a linear way but there will be variation about this line, used the equation as seen in (1)

$$Y = \beta_0 + \beta_1 \times X + \varepsilon \tag{1}$$

where β_0 is the true intercept, β_1 is the true slope and is a random error (assumed that $\varepsilon \sim$Normal $(0, \sigma)$). This research used linear regression in order to quantify the relationship between teaching methods and students' performance and then analyze the relative effects. The linear regression model in SPSS includes model summary, ANOVA table and coefficients table.

The model summary includes R, R square, adjusted R square and standard error of the estimate. The R square and the adjusted R square always is a number between 0 and 1 ($0 \leq R^2 \leq 1$), where R^2 often impressed as a percentage. If R^2 closer to 1, the linear relationship is very strong, so the variability of the line is not much; if R^2 closer to 0, there is still a substantial amount of variability of the line.

The ANOVA (analysis of variance) table is used to analyze the differences among means. If the significance level of the ANOVA table is less than 0.05, which implies at least 2 populations have different means.

The coefficients table also focused on the significance level in this research. If all the significance levels in the table are less than 0.05, that implies the predictor variable has significantly affected the dependent variable.

3. Results and Discussion

Since the missing values in the dataset have been removed in the first step of the analysis, the total number of students in the sample changed to 216 for further calculation in this research, and the sample size was reduced. By using a pie chart (see Figure 1), the majority of the students in this high school are Hispanic, with 30.6%, and the other ethnicities are Asian with 24.5%, African-American with 24.1% and Caucasian with 20.8%. Hispanic has the biggest proportion and Caucasian has the smallest, however, their proportions are relatively close.

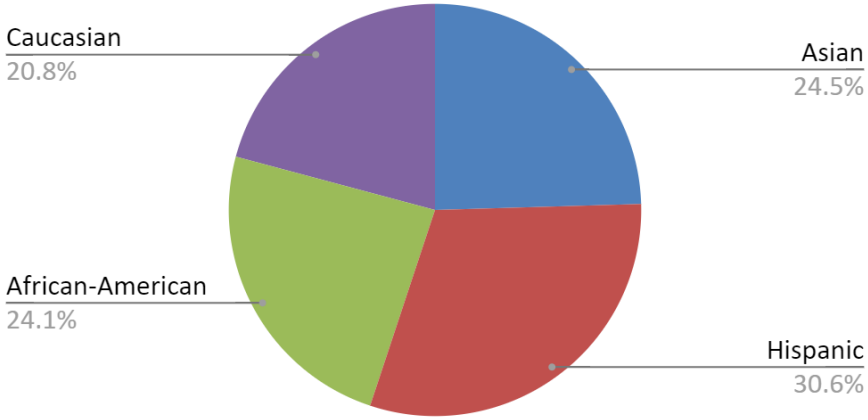

Figure 1. Percentages of students according to ethnicity.

Then by the table (see Table 1), inside the sample dataset, there are 52 African-American students with 32 males and 20 females, 66 Hispanic students with 35 males and 31 females, 53 Asian students with 27 males and 26 females, 45 Caucasian students with 26 males and 19 females.

Table 1. Number of students in all ethnics with genders.

	Male	Female
African-American	32	20
Hispanic	35	31
Asian	27	26
Caucasian	26	19

Also, by the bar plot (see Figure 2) below, obviously there are fewer female students than male students in this sample for all ethnicities, especially African-American. Where the African-American students had the largest difference between males and females (12 students), and the Asian students had the lowest difference (1 student).

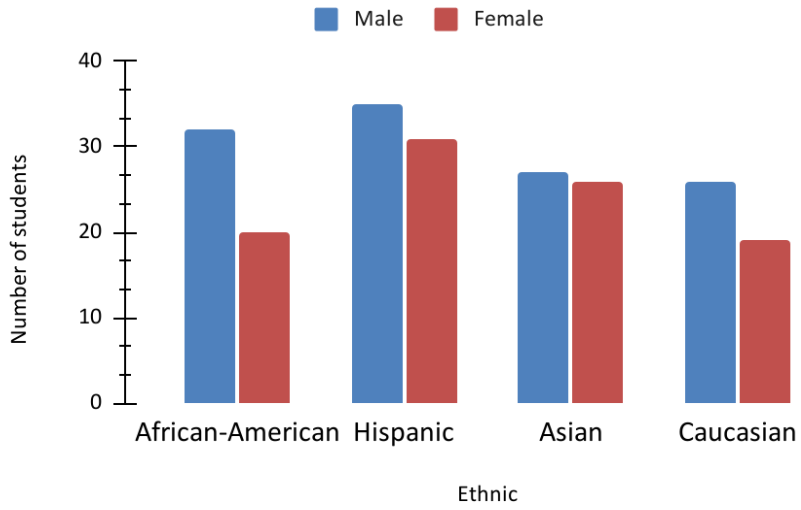

Figure 2. Number of students in all ethnicities.

Then by comparing the overall average math score with each ethnicity and gender (see Figure 3), generally female students achieved better scores overall than male students for all ethnics (especially the Caucasian students) except African-American, with males 65.54 and females 66.26 for Hispanic, males 63.11 and females 68.38 for Asian, males 59.73 and females 70.63 for Caucasians.

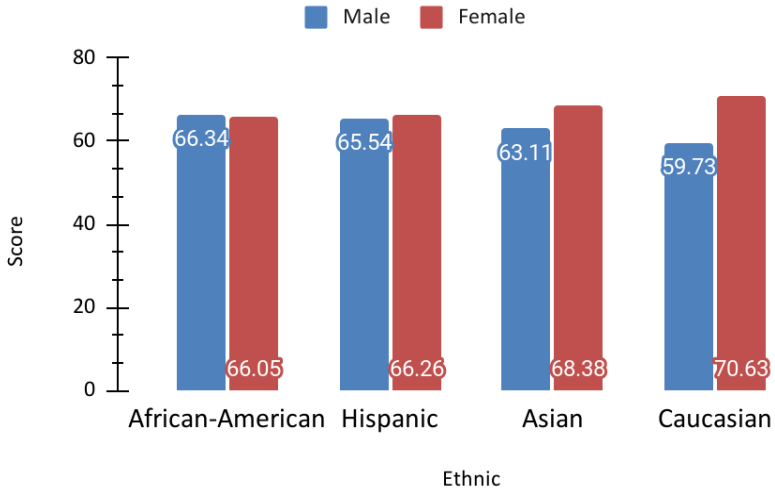

Figure 3. Average math scores by ethnicity.

The box plot was created by RStudio (see Figure 4), where for the x-axis, 1 represents Asian, 2 represents African-American, 3 represents Hispanic and 4 represents Caucasian; for genders, 1 represents the female and 2 represents the male. From the boxplot, it is also noticeable that the upper quantile of female Caucasians' score exceed males' considerably. The average math scores are very close between genders for African-American, with males 66.34 and females 66.05. What noticeable is that males and females Caucasian have the largest difference in the average math score which is roughly 10.9.

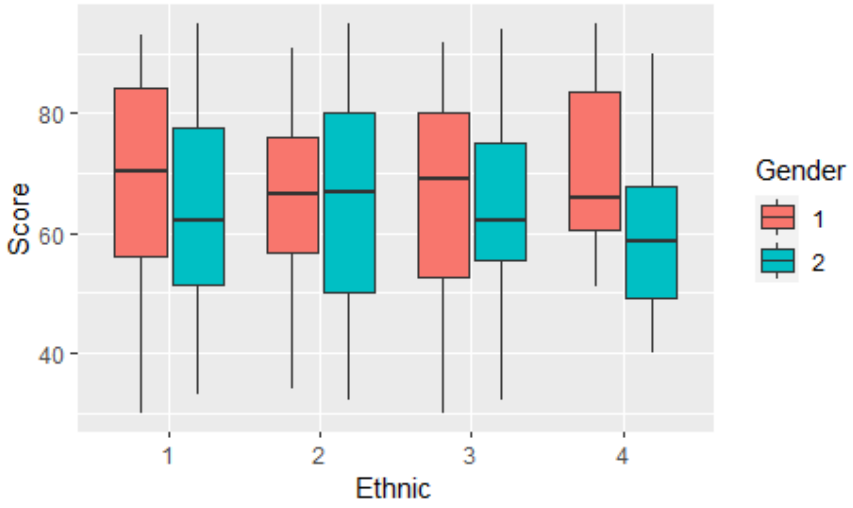

Figure 4. Average scores of four ethnic groups by gender.

For each method, using 2 bar plots respectively to figure out which method works better for which type of ethnicity. It is apparent to see Caucasian students achieved the lowest average math scores and Asian achieved the highest average math scores for traditional method (see Figure 5); Hispanic students achieved the lowest average math scores, and Caucasians achieved the highest average math scores for standards-based method (see Figure 6). These two plots indicate that Asians are more adaptive to the traditional teaching method. The average math score of Caucasian shows a completely extreme result in two different teaching methods, which get the lowest mark using the traditional method and the highest mark using the standards-based method. And this means the Caucasian is the most adaptable when using the standards-based method among four ethnicities. The average scores of four ethnic students taught by the standards-based method are almost the same. Also, the majority of the students who used traditional method got average math scores above 70 except for Caucasian students and all the students who used standards-based method got average math scores above 60.

Overall, can say on average, students who used traditional method got higher scores than students who used standards-based method.

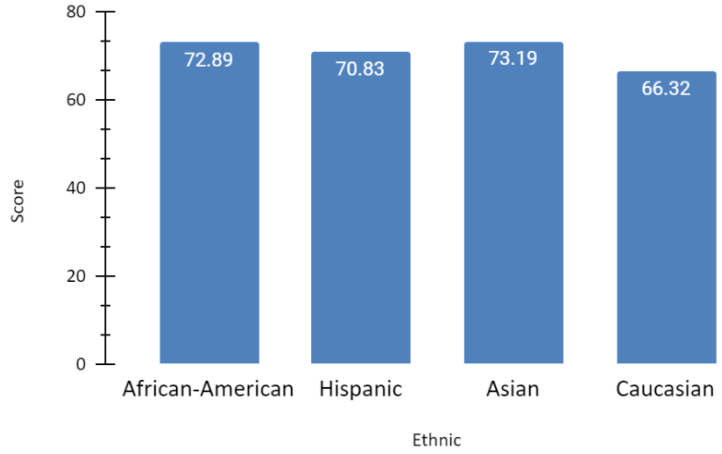

Figure 5. Average math scores using traditional method.

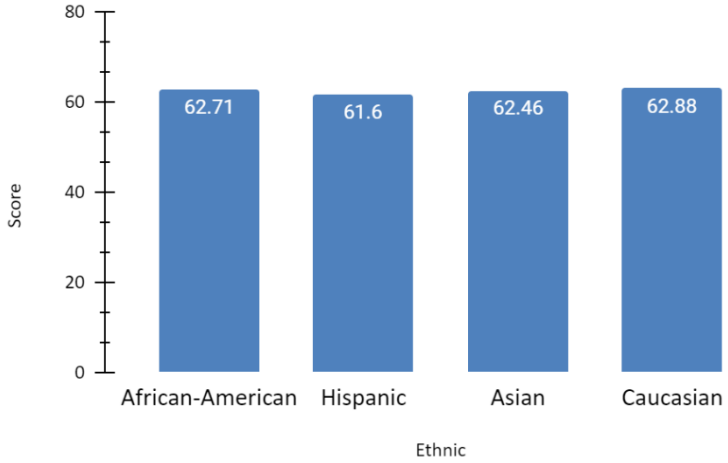

Figure 6. Average math scores using standards-based method.

Compare the average math scores of each method, can get the average score using traditional method is 70.68 and the average score using standard method is 62.34. Also, the number of students who are taught by the standards-based method is higher than students who are taught by the traditional method in total. This means overall, students who taught by traditional method tend to have a higher average math score than students who taught by standards-based method (see Figure 7), which also means students taught by Wesson contributed better performance than students who were taught by Ruger and Smith, which gave the same result as in last figures.

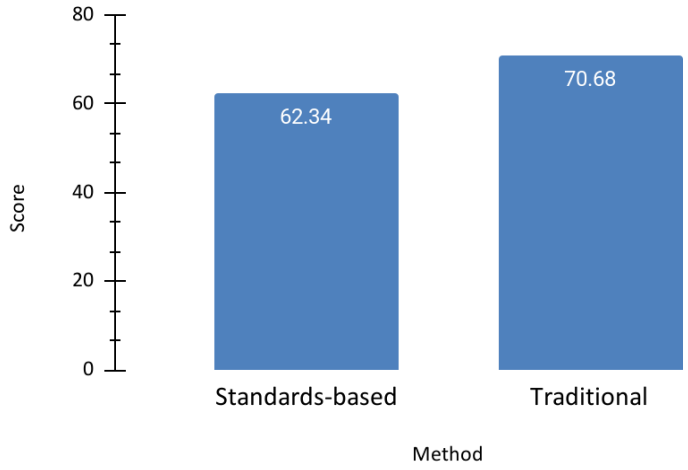

Figure 7. Average math scores of each method.

Then for analyzing which teacher's teaching approach works better, comparing the average scores for each teacher (see Figure 8). It is clear to see that Ruger's teaching method gives the lowest average score (55.27) and Wesson's teaching method gives the highest average score (70.68). Interestingly, Ruger's average score was significantly lower than the other 2 teachers, which implies students may be confused about what she taught during the class. Moreover, this result also suggests that Wesson who teaches students in the traditional way has better feedback than the other two teachers who would like to teach students in standard-based method.

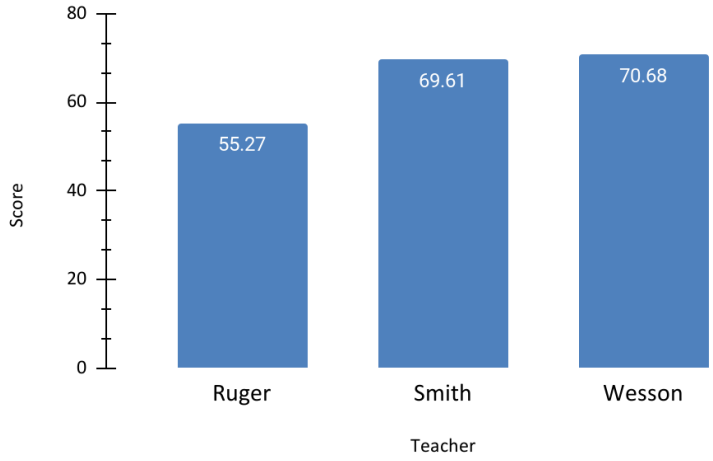

Figure 8. Average math scores by each teacher.

After that, compare the average math score in each ethnic by each teacher (see Figure 9), in order to find which teacher's teaching approach works the best for students came from which ethnic. Generally, students of all ethnicities obtain their best scores under Wesson's teaching with one exception – the scores of Smith's Caucasian students are slightly higher than Wesson's. Meanwhile, students who were taught by Ruger have a considerable gap in academic performance, compared to her colleagues. Can tell Ruguer was relatively adaptable at teaching Caucasian students, although across all ethnics, students who were taught by Ruger achieved lower average math scores; Smith's teaching method works the best for Caucasian students since the average math score for hers is the highest; Wesson's teaching approach works better for African-American, Hispanic and Asian students.

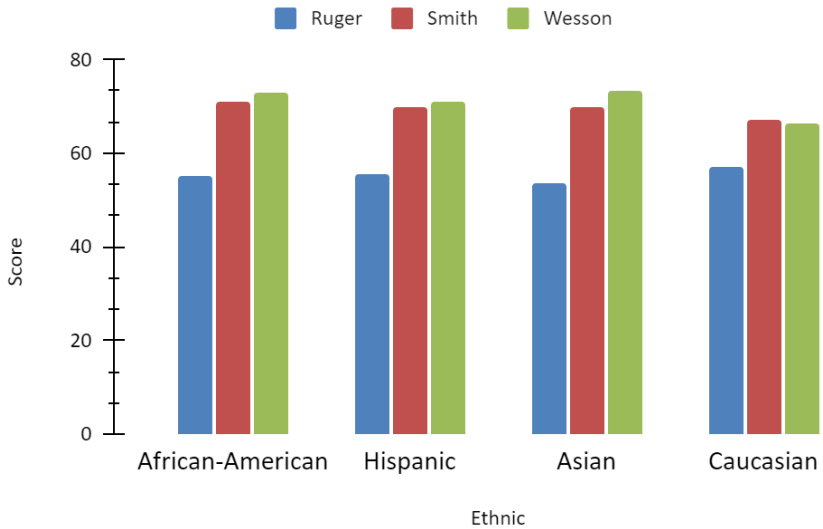

Figure 9. Students' performance compared to each teacher.

In the end, using SPSS to perform linear regression to test how the predictor variable (teachers' teaching approaches) affected the dependent variable (student score). According to the model summary (see Table 2), since the R square and adjusted R square are not close to 1, which implies that the linear dependence of variables is not very strong and there is still a substantial amount of

variability uncovered. By ANOVA table (see Table 3), the significance level is less than 0.001, strongly suggesting to reject the null hypothesis, which implies at least 2 teacher's teaching approaches have different means. Also, by the coefficients table (see Table 4), since both significance levels are less than 0.05, which means the predictor variable has significantly affected the dependent variable. That is, students' math scores were depend on teachers' teaching methods, and can draw further conclusion based on the known data and the descriptive statistics.

Table 2. Linear regression model summary.

Model	R	R Square	Adjusted R Square	Standard Error of the Estimate
1	0.386[a]	0.149	0.145	15.130

a. Predictors: (Constant), Teacher

Table 3. Linear regression ANOVA[b] table

Model		Sum of Squares	df	Mean Square	F	Significance Level
1	Regression	8564.998	1	8564.998	37.414	< 0.001[b]
	Residual	48989.886	214	228.925		
	Total	57554.884	215			

b. Dependent Variable: Score

Table 4. Linear regression coefficients table.

Model		Unstandardized B	Standard Error	Standardized Coefficients Beta	t	Significance Level
1	(Constant)	49.824	2.727	-	18.267	< 0.001
	Teacher	7.636	1.248	0.386	6.117	< 0.001

4. Conclusion

According to the plots and linear regression result above, students' math scores did depend on teachers' teaching approaches. Now can conclude that students from all ethnicities obviously achieved higher average scores when taught by Smith and Wesson, Wesson's teaching method yielded the highest average score overall, students who learnt using standards-based method got lower scores compared to students learnt using traditional method in average and students may thought it's hard to understand Ruger's lesson during the class.

For the traditional method and the standards-based method, each method has its own merits. However, the suggestion for this diverse socioeconomically junior high school is that the traditional method is better than the standards-based method and these teachers should use the same teaching approach in the future, although Smith's standards-based method also yields higher average math scores.

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