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RESEARCH ARTICLE

Effect of Block Scheduling on African American Males' High School Test Performance

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Over the last several decades, the United States has seen an increase in the number of high schools implementing block schedules to enhance student learning. Yet, research on the effectiveness of block scheduling has been mixed. Furthermore, many of the existing studies have not considered factors such as sex, race/ethnicity, and socioeconomic status together. Taking these factors into account, the present study analyzed the impact of schedule type among African American male students' test performance in a large, urban district of high schools in the southeastern United States. Using a hierarchical linear modeling analysis, test scores in biology, English, and math were examined. Results indicated that schedule type had no significant effect on Black males' test scores in any of the subjects. However, White males performed significantly better in traditional schedules for biology and English. The findings suggest that schedule type may differentially effect student test scores based upon race/ethnicity.

Keywords: block scheduling, traditional scheduling, hierarchical linear modeling

Education is vital for countries and individuals because it leads to opportunities for economic prosperity and growth. In turn, higher scores in math, reading, and science are more prevalently found among industrialized nations (OECD, 2015). It is no surprise then, that the United States has invested a great deal of time and resources in educational reform, including the No Child Left Behind Act (NCLB, 2002) and Every Student Succeeds Act (ESSA, 2015), among others. While these legislative acts help ensure that all students have equal access to primary and secondary education and put general standards in place to measure academic performance, the quality of education that students receive still fluctuates due to a variety of factors. These factors could be geographical (e.g., urbanicity of a school); financial (e.g., socioeconomic status, public versus private schools); instructional (e.g., teacher experience, class size, class or school culture); or individual differences according to age, race/ethnicity, sex, language, motivation and parenting (Stewart, 2008).

Another possible difference in the quality of education received could be partially due to how each school structures its time and course schedule, particularly for secondary schools. Traditionally, high schools have been structured so that students take between six and eight courses per day, with each course lasting no more than 50 minutes. However, over the last several decades, an increasing number of American high schools have offered block scheduling as an alternative to traditional scheduling.

LITERATURE REVIEW

Block Scheduling

Block scheduling can be defined as a restructuring of the school day into longer class sessions in order to improve student performance (Huelskamp, 2014). Introduced to help academic performance, it also aims to enhance student learning, improve academic performance, reduce disciplinary problems, and accommodate the needs of gifted and at-risk students (Gruber & Onwuegbuzie, 2001). Teachers are able to devote more time to fewer students, spend less time on administrative tasks such as attendance, provide more content depth to subjects, and implement more active teaching strategies through laboratory experiments and cooperative projects that facilitate a more authentic learning experience (Banicky, 2012; Biesinger, Crippen, & Muis, 2008). Students are not interrupted by switching classes as often, which creates more time for lab work and group activities (Zepeda & Mayers, 2006). Furthermore, the use of block schedules allows students to take additional electives, earn more academic credits, or retake courses if needed (Biesinger et al., 2008).

Approximately 30-50% of high schools in the United States have been estimated to utilize some form of block scheduling (Cawelti, 1994; Dexter, Tai, & Sadler, 2006; Holley & Park, 2017; Rettig & Canady, 1996). These percentages vary by state, with the greatest proportion of block schedules implemented in North Carolina, Maine, Maryland, and the District of Columbia (Holley & Park, 2017). Estimates of block scheduling in Virginia and North Carolina have reportedly been higher than 70% (Banicky, 2012; Bonner, 2012; Zhang, 2001).

There are a number of different block scheduling designs, each of which vary in length per class period, number of courses, and number of semesters. The most common block schedule is the 4x4 semester plan, whereby each day is split into four equal 90-minute class periods for an entire semester (Lewis, Dugan, Winokur, & Cobb, 2005). The trimester schedule divides the academic year into three semesters, with students taking two courses per semester that meet for two hours every morning and an extra 45 minutes in the afternoon (Canady & Rettig, 1995). The alternate day or A/B block has students enroll in six to eight courses and attend 90-minute classes on alternating days (“A” or “B” days) for the entire school year (DiBiase & Queen, 1999). In the Copernican Plan, block periods of differing lengths are combined so that students either take one macro-class (e.g., English or algebra) longer than several others and change schedules after 30 days (Zepeda & Mayers, 2006). In another variation of the Copernican Plan, the student takes two classes for two hours each and then switches schedules after 60 days (Zepeda & Mayers, 2006). In some instances, there are also hybrid approaches that may combine both block and traditional schedules (Wronkovich, Hess, & Robinson, 1997).

While the intentions of block scheduling have sought to benefit both students and teachers, results of the research on the effectiveness of block scheduling have been mixed. When examining academic achievement by grades or grade point average (GPA), most studies provide support for block scheduling (e.g., Cobb, Abate, & Baker, 1999; Khazzaka, 1997; Knight, De Leon, & Smith, 1999; Snyder, 1992; Veal, 1999; Zepeda & Mayers, 2006). However, a few studies have found little to no differences (e.g., Georgia Department of Education, 1998, as cited in Gruber &

Onwuegbuzie, 2001; Gruber & Onwuegbuzie, 2001; Nichols, 2005). After adjusting for prior grades and academic ability, Spencer and Lowe (1994) found grades significantly improved in English, but not for math, science, or history. Lare, Jablonski, and Salvaterra (2002) found that the percentage of honor roll students increased after implementation of a block schedule, although the authors concluded that academic achievement has typically remained constant after implementation.

On the other hand, research examining block scheduling as measured by end-of-course (EOC) or standardized tests have been contradictory. Several studies have provided support for block scheduling (e.g., Knight et al., 1999; Payne & Jordan, 1996; Reames & Bradshaw, 2009; Snyder, 1992), while others have provided support for traditional schedules (e.g., Cobb et al., 1999; Gruber & Onwuegbuzie, 2001; Lawrence & McPherson, 2000; Raphael, Whalstrom, & McClean, 1986; Zelkowski, 2010). In most instances, studies have reported no differences between the two schedules (e.g., Arnold, 2002; Bonner, 2012; Dostal, 2010; Huelskamp, 2014; Lare et al., 2002; Roberts, 2016; Underwood, 2014). A number of studies have also addressed the effects of block scheduling according to specific content areas. For example, Hess, Wronkovich, and Robinson (1999) found that students in block schedules had significantly higher pre-post differences in English and biology test scores, but there were no differences for geometry or world history. Veal and Schreiber (1999) found that students on a traditional schedule scored significantly higher on math computation, but no difference was found for reading or language achievement. Similarly, Wronkovich et al. (1997) found that math test scores were significantly greater for students enrolled in a traditional schedule. Using a mixed-methods design, Williams (2011) examined high school data from a suburban school district in Florida and found higher EOC reading scores for the block schedule, but higher EOC math scores under a traditional schedule. When examining EOC test scores between two high schools in rural South Georgia, Ford (2015) found students in traditional schedules to have significantly higher Writing and Biology scores. However, no statistically significant differences emerged for ten other subject areas.

Despite the mixed evidence regarding academic achievement, block scheduling is received positively by teachers and students (e.g., Biesinger et al., 2008; Hurley, 1997; Staunton, 1997), as students have reported better grades, and interactions between students and teachers have increased (Zepeda and Mayers, 2006). Studies have reported a decrease in disciplinary referrals (e.g., Deuel, 1999; Stader, 2001), and an improved school climate (e.g., Buckman, King, & Ryan, 1995; Fletcher, 1997). Biesinger et al. (2008) conducted a pre-post mixed-methods study in a large urban school district in the southwestern United States to explore the effects of block scheduling on several student attributes within the context of math. Students in block schedules reportedly made significantly greater gains in self-efficacy and their attitude towards math remained the same over the course of the academic year, compared to students in traditional schedules, whose attitude significantly decreased over time (Biesinger et al., 2008).

In their review of 58 empirical studies, Zepeda and Mayers (2006) concluded that block scheduling appeared to improve student grade point averages (GPA) and school climate, but results were inconclusive regarding its impact on test scores and attendance. The authors noted that it is difficult to make generalizations around the effectiveness of block scheduling due to the inconsistent findings, a paucity of descriptive information regarding the samples of students and teachers, and an inability to use the appropriate statistical and methodological procedures to answer research claims (i.e., a lack of longitudinal studies to investigate change over time). Furthermore, Zepeda and Mayers (2006) also called for more research to be conducted in urban settings, as only five of the 58 studies examined block scheduling in urban settings.

A recent review of the literature on the effects of block scheduling pertaining to high school science teaching and learning was conducted by Holley and Park (2017). The authors identified 45 articles published between 1996 and 2016 and concluded that the arguments in favor of block scheduling were more focused on non-academic, discipline, and curricular outcomes. The effectiveness of the type of schedule implemented might be dependent upon teacher professional development, of which there is little data. Finally, there is little research that block scheduling benefits learning outcomes.

When examining academic achievement among schedule type, a number of studies have controlled for variables such as GPA, prior test scores, or academic ability. Yet, only a handful of studies have statistically controlled for factors such as race/ethnicity, sex, or socioeconomic status (SES) (e.g., Cobb et al., 1999; Hess et al., 1999; Huelskamp, 2014; Zhang, 2001). However, all of these factors play a critical role in student achievement.

Sex

Several studies have looked at performance differences by sex in both block and traditional schedules, with mixed results. Using an ex post facto, longitudinal research design, Lewis et al. (2005) investigated the effects of schedule type, sex and ethnicity on changes in 9th grade Levels test scores and 11th grade ACT test scores. The authors found no significant sex differences on changes in math scores. However, significant differences in sex were found for reading gain scores, with females outperforming males in all schedules (Lewis et al., 2005). Schreiber, Veal, Flinders, and Churchill (2001) compared two Sophomore classes (1997 and 1998) statewide test performance according to schedule type and sex in a predominantly Caucasian high school in Indiana implementing traditional, block, and hybrid schedules. In both cohorts, males scored significantly higher for reading vocabulary, math computation, and math concepts (Schreiber et al., 2001). On the other hand, females scored significantly higher in language mechanics, with the 1998 cohort also performing significantly better in language expression. In examining the long-term effects of high school scheduling and sex on college biology test scores, Huelskamp (2014) found no significant differences between schedule type, sex, or the interaction between the two. Using a multi-level approach for a meta-analysis of differences of sex on academic achievement, Voyer and Voyer (2014) found a small, albeit significant, positive effect for females among all courses (Cohen’s $d = .23$, $p < .05$). The greatest effect was evident in language, while the smallest effect was found among math subjects. Significant positive effects were also present in global measures, science, social sciences, and other subjects.

Race/Ethnicity

The racial “achievement gap” has been widely documented throughout the years (e.g., Coleman, 1968; Entwisle & Alexander, 1992; Evans, 2005; Lee, 2004), suggesting that African American/Black and Hispanic students’ performance in academics falls significantly behind their Caucasian/White and Asian American counterparts. Racial disparities in academic performance also appear to be greater than differences in sex (Mead, 2006, as cited in Voyer & Voyer, 2014). The racial achievement gap appears to be just as prominent today as ever before. Based upon the National Association of Educational Progress (NAEP) report from 2017, 12th grade Asian students obtained the highest reading scores (297), followed by White (295), Hispanic (276), and Black students (266) (Musu-Gilette et al., 2017, p. 48). Among 12th graders, NAEP math scores were highest among Asian students (171), followed by White (160), Hispanic (139), and Black students (130) (Musu-Gilette et al., 2017, p. 52). Similar patterns for math and reading achievement are also apparent at Grade 4 and Grade 8. Additionally, Asian students have earned more advanced placement/international baccalaureate (AP/IB) credits (4.5 credits) than Hispanic (3.2 credits), White (3.1 credits), or Black students (2.7 credits; Musu-Gilette et al., 2017, p. 65).

Socioeconomic Status

In a meta-analytic review of SES and academic achievement, both White (1982) and Sirin (2005) have found moderate correlations between family SES and student performance of 0.34 and 0.30, respectively. White (1982) noted that SES and social class have been used interchangeably and can be assessed by a wide range of different variables, from family income to parental education or occupation. This ambiguity can lead to inconsistent findings between SES and academic achievement (White, 1982). Recently, one of the more commonly used aggregated measures has been to assess school SES through the proportion of students in each school who are eligible for free or reduced lunch (FRL) (Sirin, 2005). Although the relationship between SES and academic achievement was dependent upon several variables (i.e., unit, source, range of SES variable, and type of SES), Sirin (2005) found that aggregated school-level measures, such as FRL, had effect sizes doubling in magnitude when compared to individual-level SES measures. Sirin (2005) recommended future research use hierarchical level modeling (HLM) to better understand student level academic achievement through aggregated school-level measures like FRL.

Purpose

The purpose of this study was to examine the impact of scheduling type (i.e., block versus traditional) on high school test performance in a large urban district in the southeastern United States. Based upon mixed results from the literature regarding schedule type effectiveness, combined with the lack of studies incorporating each of the main influential variables (i.e., sex, race/ethnicity, FRL), there remains a need to determine whether block schedules favor student performance above traditional schedules, and whether these differences vary according to sex, race/ethnicity, or a combination of both. Specifically, our research question was whether there was a significant difference between Black male students' test score performance according to schedule type, in each of three subject areas (English, math, and biology), after controlling for FRL?

METHODS

Procedure

Data from high schools in a large urban district in the southeastern United States was provided by the district's research and evaluation department. The data contained student scores and demographic information including sex, race/ethnicity, and the proportion of students in each school receiving FRL. Student-level SES was unavailable, but school-level FRL measures have been used as an appropriate proxy (Sirin, 2005). Participants included students who took classes and EOC exams in 9th grade math, 10th grade English, and 10th grade biology during the 2018 academic year.

Participants

All schools in the urban district that implemented a block or traditional schedule were used in the analysis. Among 34 schools within the district, the final sample consisted of 15 schools, 10 of which implemented a block schedule, and five that utilized a traditional schedule. Schools were removed from analysis if they identified as an early college or special education program, or if the school offered an alternative type of schedule. Across the three subjects, the average number of students per school was 279.09 (SD = 60.76). The average school reported a percentage of 45.54% of students receiving FRL. More than half of the students (54.50%) in block schedules received FRL, compared to 30.58% of students in traditional schedules. Due to unbalanced group sizes, only three races/ethnicities were used in the analysis. Black student scores represented the greatest percentage (46.19%), followed by White (37.62%), and Hispanic (16.19%). The percentage of female scores (52.38%) was slightly greater than the percentage of male scores (47.62%). Table 1 provides descriptive statistics for the sample, broken down by schedule type.

TABLE 1
Descriptive Statistics

Descriptor	Overall	Traditional Schedule	Block Schedule
School Level			
Number of Schools	15	5	10
School Size*			
Mean (*SD*)	279.09 (60.76)	266.20 (32.27)	285.53 (60.76)
Sex			
Male	47.62%	47.63%	47.62%
Female	52.38%	52.37%	52.38%
Race/Ethnicity			
White	37.62%	35.14%	38.78%
Black	46.19%	44.28%	47.08%
Hispanic	16.19%	20.59%	14.14%
FRL Percentage	45.54%	30.58%	54.50%

Note. * Averaged across the three subjects.

Measures

End-of-Course Biology Test. The End-of-Course (EOC) Biology Test includes five levels of achievement to categorize students. The following levels were used by the State Board of Education, who adopted college and career readiness Academic Achievement Standards and Academic Achievement Descriptors for EOC tests. Level 1 denotes limited command of knowledge and skills, with scores of 242 and below. Level 2 denotes partial command of knowledge and skills, with a score range of 243-249. Level 3 denotes sufficient command of knowledge and skills, with a score range of 250-251. Level 4 denotes solid command of knowledge and skills, with a score range of 252-260. Level 5 denotes superior command of knowledge and skills, with a cut score of 261 and higher. Tenth grade student scores were exclusively used because the EOC Biology Test is typically administered to tenth grade students. While the levels help to categorize students into levels of proficiency, the scaled scores for all three subjects were used for analysis.

End-of-Course English II Test. Similar to biology, the EOC English II Test includes five levels of achievement to classify students. The following levels were used by the State Board of Education, who adopted college and career readiness Academic Achievement Standards and Academic Achievement Descriptors for EOC tests. Level 1 denotes limited command of knowledge and skills, with scores of 140 and below. Level 2 denotes partial command of knowledge and skills, with a score range of 141-147. Level 3 denotes sufficient command of knowledge and skills, with a score range of 148-150. Level 4 denotes solid command of knowledge and skills, with a score range of 151-164. Level 5 denotes superior command of knowledge and skills, with a cut score of 165 and higher. Tenth grade student scores were exclusively used because the EOC English II Test is typically administered to tenth grade students.

End-of-Course Math I Test. Similarly, the EOC Math I Test includes five levels of achievement to categorize students. The following levels were used by the State Board of Education, who adopted college and career readiness Academic Achievement Standards and Academic Achievement Descriptors for EOC tests. Level 1 denotes limited command of knowledge and skills, with scores of 243 and below. Level 2 denotes partial command of knowledge and skills, with a score range of 244-249. Level 3 denotes sufficient command of knowledge and skills, with a score range of 250-252. Level 4 denotes solid command of knowledge and skills, with a score range of 253-263. Level 5 denotes superior command of knowledge and skills, with a cut score of 264 and higher. Ninth grade student scores were exclusively used because the EOC Math I Test is typically administered to ninth grade students.

Analyses

Using a hierarchical linear modeling (HLM) analysis, EOC scores were compared by type of school schedule. Since our data contained student (individual level) and school (group level) data, HLM was appropriate as it accommodates multiple levels of data by which students are nested within schools. HLM was used because it allows for the examination of cross-level effects. That is, we can examine how student performance changes based upon individual characteristics (i.e., sex and race/ethnicity) as well as at the school level (e.g., school schedule). One model was run for each subject area (English, math, and biology) using HLM 7 software (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011). Using math as an example, the level 1 model describes individual student performance on EOC math exams as a function of school characteristics (i.e., FRL, schedule type) and student characteristics (i.e., sex, race/ethnicity). The level 2 model partials out the influence of FRL and adds a factor of shared uniqueness among students at a given school. HLM assumes that among schools, the range of individual differences (error terms) will be similar. Main effects and interactions between sex and race/ethnicity were explored, while differences in school FRL was controlled for. Since the average FRL differed between block (54.5%) and traditional schedules (30.6%), the error terms between the schedule types would not be similar. As a result, FRL was grand-mean centered so that the error level would be consistent between schedule types. Other studies have also controlled for FRL when exploring multilevel data (e.g., Cullen, Chen, Dave, & Jensen, 2016; Ohri-Vachaspati, Turner, & Chaloupka, 2012).

Prior to running HLM, each of the three models were tested for assumptions. Chi-squared (χ^2) statistics indicated that the homogeneity of variance condition was satisfied, while Q-Q plots and scatterplots suggested that the level 1 error terms were normally distributed, and residuals were independent of each of the predictors (i.e., sex, race/ethnicity). A check of the distribution of the level 2 error terms indicated no systematic differences between block and traditional schedules. However, due to the small number of schools (10 block versus 5 traditional) in the data and an evaluation of the models suggesting that the assumptions held, fixed effects without robust standard errors were reported (Raudenbush & Bryk, 2002). Each of the cases used for the analyses had complete information so missing data was not an issue. Due to small sample sizes, several races/ethnicities were removed from analysis.

An intercept/slope-as-outcomes model (Raudenbush & Bryk, 2002) was used, whereby students' scores were predicted by school characteristics (level 2) and factors unique to the student (level 1). A full model was first run to determine significant predictors of EOC scores. The full model for each subject was as follows:

Level 1 Model:

$$Y_{ij} = \beta_{0j} + \beta_{1j} * \left(HISPANIC_{ij}\right) + \beta_{2j} * \left(FEMALE_{ij}\right) + \beta_{3j} * \left(WHITE_{ij}\right) + \beta_{4j} * \left(FEMALE * WHITE_{ij}\right) + \beta_{5j} * \left(FEMALE * HISPANIC_{ij}\right) + r_{ij}$$

Level 2 Model:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} * \left(SCH\_TYPE_j\right) + \gamma_{02} * \left(SCH\_FRL_j\right) + \mu_{0j}$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11} * \left(SCH\_TYPE_j\right) + \gamma_{12} * \left(SCH\_FRL_j\right)$$
$$\beta_{2j} = \gamma_{20} + \gamma_{21} * \left(SCH\_TYPE_j\right) + \gamma_{22} * \left(SCH\_FRL_j\right)$$
$$\beta_{3j} = \gamma_{30} + \gamma_{31} * \left(SCH\_TYPE_j\right) + \gamma_{32} * \left(SCH\_FRL_j\right)$$
$$\beta_{4j} = \gamma_{40} + \gamma_{41} * \left(SCH\_TYPE_j\right) + \gamma_{42} * \left(SCH\_FRL_j\right)$$
$$\beta_{5j} = \gamma_{50} + \gamma_{51} * \left(SCH\_TYPE_j\right) + \gamma_{52} * \left(SCH\_FRL_j\right)$$

where:

i = a student;
j = a school;
Y_{ij} = a student's score on the EOC exam;

β_{0j} = the intercept; the average score on an EOC exam for a Black male student in a block schedule, after controlling for FRL;
$\beta_{1j} - \beta_{5j}$ = slopes for each of the student predictors (i.e., Hispanic, Female, White, Female*White, and Female*Hispanic; respectively);
r_{ij} = level 1 error;
$\gamma_{00} - \gamma_{52}$ = fixed effects (only significant fixed effects in the results are documented here);
γ_{00} = the average score for a Black male student in a block schedule, after controlling for FRL;
γ_{01} = the average score difference for Black male students between block and traditional schedules, after controlling for FRL;
γ_{02} = the change of the average score for Black male students in block schedules, for every one unit increase in FRL;
γ_{10} = the average score difference between Black male and Hispanic male students in block schedules, after controlling for FRL;
γ_{20} = the average score difference between Black male and Black female students in block schedules, after controlling for FRL;
γ_{30} = the average score difference between Black male and White male students in block schedules, after controlling for FRL;
γ_{31} = the score gap difference in block and traditional schedules between Black male and White male students, after controlling for FRL;
γ_{32} = the score gap difference in block and traditional schedules between Black male and White male students, for every one unit increase in FRL;
γ_{40} = sex moderates the difference between Black and White students in block schedules,
SCH_TYPE_j = block or traditional schedule;
SCH_FRL_j = proportion of students receiving FRL in a given school (grand-mean centered); and
μ_{0j} = random effects of the schools.

Reference groups (coded as 0) were Black, male, and block schools. FRL was grand mean centered because we wanted to adjust for the proportion of students receiving free-or-reduced lunch (Enders & Tofighi, 2007). Because different schools have different levels of FRL, we partitioned out the effect of FRL by centering, thereby examining the effect of the remaining variables on the scores.

After running the full model for each subject, predictors were removed if they were non-significant and not central to the research question (i.e., γ_{01} and γ_{02}). Thus, each subject has its own unique model. The final reduced models are reported in Table 2 below.

TABLE 2
Final Reduced Models for Each Subject

Biology
Level 1 Model: $$Y_{ij} = \beta_{0j} + \beta_{1j} * (HISPANIC_{ij}) + \beta_{2j} * (FEMALE_{ij}) + \beta_{3j} * (WHITE_{ij}) + \beta_{4j} * (FEMALE * WHITE_{ij}) + r_{ij}$$

Level 2 Model:
$\beta_{0j} = \gamma_{00} + \gamma_{01} * (SCH\_TYPE_j) + \gamma_{02} * (SCH\_FRL_j) + \mu_{0j}$
$\beta_{1j} = \gamma_{10}$
$\beta_{2j} = \gamma_{20}$
$\beta_{3j} = \gamma_{30} + \gamma_{31} * (SCH\_TYPE_j) + \gamma_{32} * (SCH\_FRL_j)$
$\beta_{4j} = \gamma_{40}$

English

Level 1 Model:
$Y_{ij} = \beta_{0j} + \beta_{1j} * (HISPANIC_{ij}) + \beta_{2j} * (FEMALE_{ij}) + \beta_{3j} * (WHITE_{ij}) + r_{ij}$
Level 2 Model:
$\beta_{0j} = \gamma_{00} + \gamma_{01} * (SCH\_TYPE_j) + \gamma_{02} * (SCH\_FRL_j) + \mu_{0j}$
$\beta_{1j} = \gamma_{10}$
$\beta_{2j} = \gamma_{20}$
$\beta_{3j} = \gamma_{30} + \gamma_{31} * (SCH\_TYPE_j) + \gamma_{32} * (SCH\_FRL_j)$

Math

Level 1 Model:
$Y_{ij} = \beta_{0j} + \beta_{1j} * (HISPANIC_{ij}) + \beta_{2j} * (FEMALE_{ij}) + \beta_{3j} * (WHITE_{ij}) + \beta_{4j} * (FEMALE * WHITE_{ij}) + r_{ij}$
Level 2 Model:
$\beta_{0j} = \gamma_{00} + \gamma_{01} * (SCH\_TYPE_j) + \gamma_{02} * (SCH\_FRL_j) + \mu_{0j}$
$\beta_{1j} = \gamma_{10} + \gamma_{11} * (SCH\_FRL_j)$
$\beta_{2j} = \gamma_{20}$
$\beta_{3j} = \gamma_{30} + \gamma_{31} * (SCH\_FRL_j)$
$\beta_{4j} = \gamma_{40}$

RESULTS

Biology

Our research question sought to determine whether there was a significant difference between Black male students' test score performance in block versus traditional schedules, after controlling for FRL. The analysis revealed that there was no significant difference between Black male students' biology test scores in block ($M = 245.39$) versus traditional schedules ($M = 244.93$), after controlling for FRL ($\gamma_{01} = -0.46, p = .79$). Other findings from our analysis revealed that the average biology score for Black male students in block schools did not significantly change based upon FRL ($\gamma_{02} = -0.10, p = 0.06$). Hispanic male students scored significantly higher (+2.20 points) than Black male students in block schedules, after controlling for FRL ($\gamma_{10} = 2.20, p < 0.001$). Black female students, on average, scored significantly higher (+2.38 points) than Black male students in block schedules, after controlling for FRL ($\gamma_{20} = 2.38, p < 0.001$). White male students, on average, scored significantly higher (+6.93 points) than Black male students in block schedules, after controlling for FRL (γ_{30} = 6.93, p < 0.001). A significant difference was also found in the score gap among Black and White male students between block and traditional schedules, (γ_{31} = 4.84, p < 0.001). That is, the score gap between Black male and White male students is bigger in traditional schools by 4.84, after controlling for FRL. So, White students perform better in traditional schools compared to block schools, whereas Black students' performance did not change by schedule type. School FRL was also significant as it pertains to the score gap between Black male and White male students in block schools (γ_{32} = 0.08, p < 0.001); thus, the average biology test score for White males increases by 0.08 for every one unit increase in FRL. We also found that sex moderates the difference between Black and White students in block schools by -1.56 points, after controlling for FRL ($\gamma_{40} = -1.56$, p = 0.005). That is, test scores are higher in traditional schools for White female students. There was also a significant random effect (not shown; $\mu_0\ sd = 2.19, p < 0.001$), suggesting that there are still unexplained differences across schools that our model did not take into account. Table 3 provides the final reduced model for biology test scores, with estimated effects, standard errors, and significance values.

TABLE 3
Final Estimation of Fixed Effects for Biology Test Scores

Fixed Effect	Coefficient	Standard Error	*t*-ratio	*p*-value
For Intercept, β_0				
Intercept, γ_{00}	245.39	0.85	288.02	**<0.001**
Schedule Type, γ_{01}	-0.46	1.71	-0.27	0.79
School FRL, γ_{02}	-0.10	0.05	-2.08	0.06
For Hispanic slope, β_1				
Intercept, γ_{10}	2.20	0.41	5.31	**<0.001**
For Female slope, β_2				
Intercept, γ_{20}	2.38	0.36	6.65	**<0.001**
For White slope, β_3				
Intercept, γ_{30}	6.93	0.52	13.31	**<0.001**
Schedule Type, γ_{31}	4.84	0.78	6.18	**<0.001**
School FRL, γ_{32}	0.08	0.02	3.41	**<0.001**
For Female*White slope, β_4				
Intercept, γ_{40}	-1.56	0.55	-2.83	**0.005**

English

In assessing the research question with respect to English, the intercept/slope-as-outcomes model revealed that there was no significant difference between Black male students' English test scores in block (M = 143.05) versus traditional schedules (M = 144.27), after controlling for FRL (γ_{01} = 1.22, p = 0.22). Unlike biology, the average English score for Black male students significantly changed based upon FRL ($\gamma_{02} = -0.09$, p = 0.06), indicating that the change of the average biology score for Black male students is -0.09 for every one unit increase of FRL. Stated otherwise, for every 1% increase in a school's FRL proportion, the average Black male student's score decreases by -0.09. Similar to biology, Hispanic males, Black females, and White males scored significantly higher than Black male students, after controlling for FRL. There was also a significant difference in the score gap among Black and White male students between block and traditional schedules ($\gamma_{31} = 3.40, p < 0.001$), such that the disparity in performance is more pronounced in traditional schedules, as opposed to block schedules. School FRL was also significant, as it pertains to the score gap between Black male and White male students in block schools ($\gamma_{32} = 0.08, p < 0.001$); thus, the average English test score for White males increases by 0.08 for every one unit increase of FRL. There was also a significant random effect (not shown; $\mu_0\ sd = 1.09, p < 0.001$), suggesting that there are still unexplained differences across schools that our model did not take into account. Table 4 provides the final reduced model for English test scores, with estimated effects, standard errors, and significance values.

TABLE 4
Final Estimation of Fixed Effects for English Test Scores

Fixed Effect	Coefficient	Standard Error	*t*-ratio	*p*-value
For Intercept, β_0				
Intercept, γ_{00}	143.05	0.49	291.65	**<0.001**
Schedule Type, γ_{01}	1.22	0.95	1.28	0.22
School FRL, γ_{02}	-0.09	0.03	-3.11	**0.01**
For Hispanic slope, β_1				
Intercept, γ_{10}	1.65	0.38	4.28	**<0.001**
For Female slope, β_2				
Intercept, γ_{20}	3.95	0.26	15.27	**<0.001**
For White slope, β_3				
Intercept, γ_{30}	5.86	0.43	13.76	**<0.001**
Schedule Type, γ_{31}	3.40	0.75	4.55	**<0.001**
School FRL, γ_{32}	0.08	0.02	3.61	**<0.001**

Math

With respect to testing for differences in math, the analysis revealed that there was no significant difference between Black male students' math test scores in block (M = 242.99) versus traditional schedules (M = 245.51), after controlling for FRL ($\gamma_{01} = 2.52, p = .07$). Similar to biology and English, Hispanic males, Black females, and White males scored significantly higher than Black male students, after controlling for FRL. Unlike the previous models, which found a significant difference in the score gap among Black and White male students between block and traditional schedules, no significant difference was found for math. Therefore, the variable was removed from the final model. School FRL was also significant ($\gamma_{31} = -0.05, p < 0.001$), albeit in the opposite direction of findings from biology and English. That is, the gap in math test scores between White male and Black male students decreases by 0.05 for every one unit increase of FRL (i.e., Black male student scores approach White male student scores as FRL decreases). We also found that sex moderates the difference between Black and White students in block schools by -1.24 points, after controlling for FRL ($\gamma_{40} = -1.56, p = 0.02$). That is, test scores are higher in traditional schools for White female students. There was also a significant random effect (not shown; $\mu_0\ sd = 1.65, p < 0.001$), suggesting that there are still unexplained differences across schools that our model did not take into account. Table 5 provides the final reduced model for biology test scores, with estimated effects, standard errors, and significance values.

TABLE 5
Final Estimation of Fixed Effects for Math Test Scores

Fixed Effect	Coefficient	Standard Error	*t*-ratio	*p*-value
For Intercept, β_0				
Intercept, γ_{00}	242.99	0.65	376.49	**<0.001**
Schedule Type, γ_{01}	2.52	1.28	1.97	0.07
School FRL, γ_{02}	-0.01	0.04	-0.16	0.87
For Hispanic slope, β_1				
Intercept, γ_{10}	1.36	0.35	3.92	**<0.001**
School FRL, γ_{11}	-0.04	0.02	-1.80	0.07
For Female slope, β_2				
Intercept, γ_{20}	1.58	0.28	5.58	**<0.001**
For White slope, β_3				
Intercept, γ_{30}	3.93	0.40	9.83	**<0.001**
School FRL, γ_{31}	-0.05	0.02	-2.29	**0.02**
For Female*White slope, β_4				
Intercept, γ_{40}	-1.24	0.55	-2.26	**0.02**

Notes. γ_{31} in the biology and English models was schedule type. However, schedule type was non-significant and was removed from the final model

Figures 1-3 illustrate the average test scores by schedule type, sex, and race/ethnicity. It can be seen that Black and Hispanic male scores did not significantly vary by schedule type, while White male scores significantly differed for both English and biology, but not for math. The five- point increase from block to traditional schools in White male English scores represents a higher average level of achievement. That is, the average White male in a block school earned a sufficient command of English knowledge and skills (Level 3) compared to the average White male in a traditional school, who earned a solid command of English knowledge and skills (Level 4). Although biology scores significantly differed between schedule types, the average White male student in both block and traditional schools earned a solid command of knowledge and skills (Level 4). For Black male students, their average level of performance was at partial command of knowledge (Level 2) for all subjects in both block and traditional schedules with the exception of math in block schedules (Level 1 – limited command of knowledge).

Figure 1. Average Biology Score by Schedule Type, Gender, and Race/Ethnicity

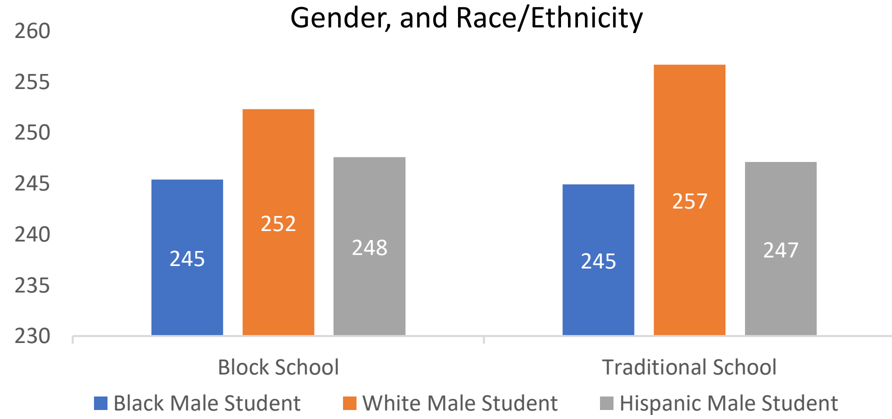


Figure 2. Average English Score by Schedule Type, Gender, and Race/Ethnicity

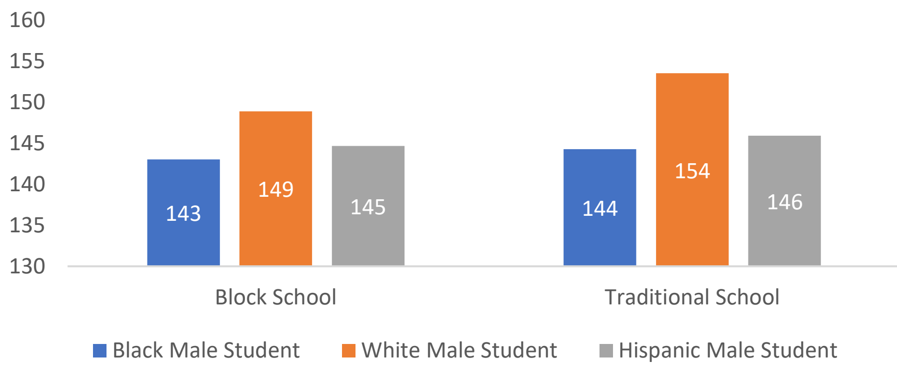
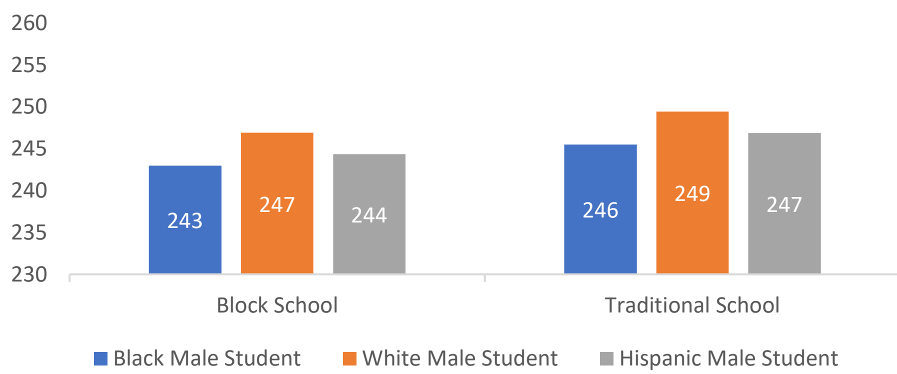


Figure 3. Average Math Score by Schedule Type, Gender, and Race/Ethnicity



DISCUSSION

Findings from our analyses revealed that schedule type (γ_{01}) was not a significant predictor of Black male students' test scores in biology, English, or math. However, the score gap between Black and White males increased between schedule type for biology and English (γ_{31} for both), such that White male students performed significantly better in traditional schools, whereas Black male students performed similarly across both schedule types. Hispanic males and Black females performed significantly better than Black male students in block schedules in each of the three subjects. These findings are discussed in more detail below.

Much of the research conducted on the impact of block scheduling on test scores has been mixed. Our findings revealed no significant differences in Black male student test scores between block and traditional schedules for biology, English, or math. This result is consistent with several studies that have found no differences (e.g., Arnold, 2002; Bonner, 2012; Dostal, 2010; Huelskamp, 2014; Lare et al., 2002; Roberts, 2016; Underwood, 2014). However, our findings also suggest that White male student test scores in biology and English were significantly greater in traditional schedules than White male student test scores in block schedules, providing support to several other studies (e.g., Cobb et al., 1999; Gruber & Onwuegbuzie, 2001; Lawrence & McPherson, 2000; Raphael, Whalstrom, & McClean, 1986; Zelkowski, 2010). Moreover, the score gap between White and Black males in biology and English indicated that White males performed significantly better in traditional schedules compared to block schedules, but Black males' performance did not change across schedules. These results indicate that schedule type may differentially effect student test scores based upon race/ethnicity. That is, the performance of White male students is greater in traditional schedules for biology and English, whereas Black male students perform similarly in all three subject areas regardless of schedule type.

Consistent with previous studies examining sex and race/ethnicity effects on academic performance (e.g., Coleman, 1968; Entwisle & Alexander, 1992; Evans, 2005; Lee, 2004; Musu-Gilette et al., 2017; Voyer & Voyer, 2014), we found that Black male students scored significantly lower than Hispanic males, White males, and Black females in block schools. This same pattern of scores is also evident in traditional schools as well. Given that these findings have remained consistent over the years, other familial or cultural factors may play a more prominent role in explaining these achievement differences.

Although no evidence was found for block schedules, it is interesting to note that Black male student scores were slightly higher for biology (+0.5 points) in block schedules, whereas English and Math scores were higher in traditional schools (+1.2 and +2.5 points, respectively). There could be some advantage to offering longer science classes in block schedules, particularly those with labs (Zepeda & Mayers, 2006). This finding could also be the result of having a more interactive class structure, which enhances student performance through laboratory work (Jones, 2009).

It is important to note that although FRL was included in our model, and was interpreted in our results, there are a couple reasons why these findings should be interpreted with caution. First, we chose to grand-mean center FRL as a way to control for differences in poverty level between schools. Thus, the purpose was not to use FRL as a predictor to explain the variation in scores, but to allow our other variables to explain the variation in scores. Also, Sirin (2005) suggested that when aggregated SES data was used to examine the SES-achievement relationship at the student level, the findings were likely to be contaminated because of ecological fallacy. Thus, extending our FRL findings from the school-level to the student-level may not be appropriate.

Limitations

This study was not without limitations. First, it was unknown how long each school had implemented a block schedule. Had this information been gathered, it could have been added into the model as another covariate. As mentioned by Schroth and Dixon (1995), block scheduling might best be studied between three and five years after implementation for the most valid results. Second, the type of block schedule that was implemented by each school was not reported. It is possible that different types of block schedules can lead to different student achievement results. Third, this was not a longitudinal study that could analyze differences over time. This would be helpful in determining whether students start at the same level and whether students learn at the same pace (e.g., linear or quadratic growth curves, or repeated measures HLM). Fourth, a mixed-methods approach using student/teacher surveys and interviews could have provided convergent evidence for our findings (e.g., is the student/teacher comfortable with the block schedule approach; has enough support been provided to both students and teachers). Fifth, due to small and unbalanced school schedules (i.e., 10 block and 5 traditional), it was chosen to report the results of fixed effects without robust standard errors, which can provide different estimates than fixed effects with robust standard errors. Although robust standard errors are preferable, robust estimates may perform best when the group-level (schools) sample consists of 100 or more units (Hox & Maas, 2001). Sixth, due to the small number of schools included in the analysis, Asian populations and other races/ethnicities were excluded. Thus, our findings are somewhat limited in generalizability. Seventh, our HLM analysis used Black male students as our reference group. Therefore, we were only able to compare these students to Black females, White males, and Hispanic males. Future research should be conducted to investigate the impact on White females, Hispanic females, and other groups that were not included in this analysis. Finally, an individual-level SES unit of measurement may have provided a better means of interpretation for average student level of performance. Using an aggregated-level measure of SES may lead to contaminated student-level findings.

Future Research

Future research may take into account other associated school-level factors such as climate and culture (e.g., MacNeil, Prater, & Busch, 2009); familial factors like parental involvement and parenting styles (e.g., Castro et al. 2015; Pinqart, 2016); teacher attributes and retention rates; and student factors such as optimism, motivation, and self-efficacy (e.g., Hoy, Tarter, & Hoy, 2006; Turner, Chandler, & Heffer, 2009). All of these factors may work in unison when attempting to explain academic achievement. Longitudinal measures would also help to decide if students begin at the same level of achievement, and whether different groups experience different learning trajectories over time. Further studies may also include mixed methods, in order to triangulate findings from school records, with the actual perceptions held by students, teachers, and parents.

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