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Educational Research Quarterly; Dec 2011; 35, 2; ProQuest Central
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Cohort versus Non-Cohort High School Students' Math Performance: Achievement Test Scores and Coursework

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The purpose of this study is to compare multiple measures of mathematics achievement for 1,378 cohort students who attended the same high school in a district from 9th to 12th grade with non-cohort students in each grade level. Results show that mobility had an impact on math achievement. After accounting for gender, ethnicity, and SES, adjusted mean scores on three large-scale achievement tests and adjusted average math grades were significantly higher for the cohort than the non-cohort. In terms of course-taking, larger percentages of cohort versus non-cohort students took advanced math courses in 11th and 12th grades. However, after controlling for gender, ethnicity, and SES, the impact of mobility on the type of math course taken was negligible. The study also examined math coursework over the four years of high school for cohort students. Differences were found across demographic subgroups with regard to the type of courses taken and cumulative math grade point average. Significant gaps were found between the two SES groups for both Black and White students in terms of the percentages of students taking advanced math courses.

Introduction and Literature Review

This paper examines the mathematics performance of high school students in a large, urban school district. A cohort of students who attended the district schools from 9th grade in 2002 to 12th grade in 2006 is compared with the non-cohort students at each grade level in terms of multiple mathematics indicators. Scores on three large-scale assessments and data from three math coursework variables were examined. The research stems from a partnership between a school district, a university, and a community organization that was formed to

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produce annual school progress reports (e.g., A+ Schools, 2007) and supplementary analysis to address specific areas of interest to educators, parents, and administrators (e.g., Parke, 2009). The analysis described here was undertaken because of the low math scores in high school and the increasing student mobility in and out of the district. Unfortunately, these are growing concerns that face many schools in urban areas across the country.

Coursework and Math Achievement

In recent years, research in mathematics education and educational measurement has begun to incorporate coursework indicators into studies on academic achievement. Several reports published by ACT investigate relationships between high school math coursework and future success in college. "Not only is taking the *right number* of courses important, but taking the *right kind* of courses is critical to student readiness for college-level work" (ACT, 2004, p. v). In the math education community, Ma & Wilkins (2007) found that "regular" math courses had the smallest impact on growth in math achievement, whereas "advanced" math courses had the largest impact. In research that disaggregates results, differences were found in the types of courses taken across genders and across ethnicities (e.g., Lee, Croninger, & Smith, 1997; Maple & Stage, 1991; Smith, 1996).

In addition to the content of mathematics courses, the sequence also impacts achievement. Several studies investigated the impact of taking algebra in 9th grade or earlier (Ma, 2000; Riegle-Crumb, 2006; Smith, 1996). The benefits of early access to algebra include higher achievement levels and an increase in the amount of math courses taken later in high school (Smith, 1996), but these benefits are not equal for all demographic subgroups. For example, Riegle-Crumb (2006) found that African American and Latino males did not necessarily have increased achievement. With regard to

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advanced math courses taken in the later grades of high school, Ma (2000) showed that the coursework significantly affected math achievement, even when accounting for SES and prior math achievement.

Mobility

Research also documents the positive influence that stability has on student achievement. A cohort of students who remain in one school system during their elementary, middle, or high school years tend to score higher on academic assessments than their counterparts who leave and may or may not return (Hinz, Kapp, & Snapp, 2003; Kerbow, 1996). Temple and Reynolds' (1999) investigation of school mobility on mathematics achievement showed that mobile students performed approximately one year behind their nonmobile peers. The amount of variance accounted for by mobility was 50%. The remaining difference was explained by differences in achievement before changing schools. Another consideration is the amount of times a student moves. Temple and Reynolds (1999) found the effects of moving once to be relatively small, but with each move, students' mathematics achievement decreased by an additional amount. The detrimental effects of mobility are numerous. High mobility can lead to a disruption in learning experiences because of curricular inconsistencies and incorrect placement. Mobility is also related to dropping out of school, behavior problems, and low attendance rates (Rumberger, 2002; Malmgren & Gagnon, 2005). Lack of attendance means fewer hours of instructional time, and in turn, can negatively impact academic achievement (Roby, 2004). These relationships are complex, however, because students who do not receive a stable education are likely to have similar demographic characteristics. For instance, family income has been found to correlate with mobility from one school system to another (Heinlin & Shinn, 2000; Temple &

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Reynolds, 1999). Furthermore, mobile students are more likely to be male, have parents who did not complete high school, and qualify for free school lunches (Temple & Reynolds, 1999).

Purpose and Research Questions

The purpose of this study was to examine the impact of student mobility on math performance in a district's high schools. Students who attended the same high school in the district all four years (the cohort) were compared to those who did not (the non-cohort) in terms of multiple measures of mathematics performance, including scores on large-scale assessments and mathematics coursework variables such as quantity and type of math course taken and the grades received. The research questions are as follows:

1. After controlling for gender, ethnicity, and socioeconomic status (SES) as measured by eligibility for free/reduced lunch, how do cohort students compare to non-cohort students in terms of achievement on three large-scale assessments (TerraNova (TN) in 9th grade, New Standards Exam (NS) in 10th grade, and Pennsylvania System of School Assessment (PSSA) in 11th grade)?
2. After controlling for gender, ethnicity, and SES, how do cohort students compare to non-cohort students on three math coursework indicators (number of courses taken, type of course taken, and grades received)?

The third research question was investigated because the district was interested in knowing more about cumulative math grades and advanced course-taking for students who stayed in the district throughout their high school years. This type of longitudinal analysis could not be performed for non-

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cohort students due to their mobility in and out of the district.

3. What are the cumulative cohort results for the mathematics coursework indicators over four years of school? Do results differ across demographic subgroups (ethnicity, gender, and SES?

Methodology

The school district is located in a large urban area in the Northeast. Approximately 57% of students in the district were African American, 38% were Caucasian, and 6% were Asian, Hispanic, or American Indian. Many students were eligible for free/reduced lunch (64%).

The cohort students in our study were defined as those students who stayed in the same district high school from 9th grade (2002-03) to 12th grade (2005-06). This resulted in a total of 1378 students. The non-cohort students were defined as those students who attended a district high school for one or more grades, but did not attend the entire four years. Thus, the number of non-cohort students varied for each grade. In grades 9, 10, 11, and 12 during the years of the study, there were 1655, 977, 491, and 496 non-cohort students, respectively. Demographically, there were some differences between the cohort and non-cohort student groups when compared at each grade level. The cohort had slightly higher percentages of female students, White students, and students not eligible for free/reduced lunch compared to the non-cohort. Therefore, these student characteristics were accounted for when estimating the effects of mobility on the math indicators.

The district's Real Time Information system was used to obtain the data. It is a web-based interface designed to provide efficient and accurate access to the school's server.

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The system allows for tracking students as they progress through grade levels and includes a wealth of demographic, performance, and contextual data. A particular strength of this paper is that, unlike most other studies that incorporate high school grades and large-scale assessments, the math coursework indicators were not self-report data. Actual grades received by students and the number and type of math courses they took were analyzed.

Multiple indicators of mathematics performance were examined. Scaled scores from the TN in 9th grade (2002-03), the NS in 10th grade (2003-04), and the PSSA in 11th grade (2004-05) were used as indicators of student achievement on standardized assessments. To further describe math performance, several mathematics coursework variables were incorporated: 1) the number of math courses taken each year and across four years for the cohort (Course Total), 2) the type of math course (general math, core courses, and advanced courses) (Course Type), 3) letter grades in math courses for each year, and 4) cumulative math grade point average (GPA Math).

Investigating the assessment data and math grades in the first two research questions involved analyses of covariance and effect sizes to determine the statistical and practical significance in the differences in achievement scores and grades between the cohort and non-cohort groups after accounting for gender, ethnicity, and SES. This allowed for obtaining the net effect of mobility after removing the influences of student personal characteristics. For math grades, letter grades were converted to numerical values, then adjusted average grades for cohort and non-cohort students were compared within each school year. Descriptive results for the math course variable in the second research question show the percentages of cohort and non-cohort students taking each math course by grade level. To further investigate the impact of mobility on math course taking,

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binary logistic regression was conducted to determine if mobility significantly predicted whether students took an advanced math course after removing the influence of gender, ethnicity, and SES.

Finally, for the more in-depth examination of the cohort in the third research question, cumulative math grade point averages were calculated and compared across demographic groups using a factorial analysis of variance in which gender, ethnicity, and SES were independent variables. A dichotomous variable was created to indicate whether students took core courses only or core plus advanced courses over the four high school years. The district required three core math courses (algebra 1, geometry, and algebra 2) prior to graduating. Students had the option of taking a variety of advanced courses, such as elementary functions, calculus, and statistics.

Results and Interpretation

Achievement on Assessments

Results showed that the mean scaled scores for each assessment were statistically significant different between the two student groups after accounting for gender, ethnicity, and SES. As shown in Table 1, the adjusted means on each assessment were higher for the cohort than the non-cohort. The biggest disparity in achievement between the two groups occurred in 9th grade. Effect sizes (η^2) were moderately large for the TN in 9th grade (.097) and smaller for the PSSA in 11th grade (.022).

Math Coursework Indicators

For the number of math courses taken, results were statistically similar for the cohort and non-cohort. The large majority of students in both groups (over 90%) took one math course per year during 9th, 10th, and 11th grades. However, in 12th grade only 55% of all students (both cohort

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and non-cohort) took one math course. The remainder of students either did not take any math course in 12th grade (about 20%) or they took more than one math course (about 25%).

Table 1. Adjusted means and standard errors of mathematics assessment scores.

	9th grade TerraNova	10th grade New Standards	11th grade PSSA
Cohort n=1378	711.1 (1.3)	142.8 (0.3)	1303.7 (6.6)
Non-Cohort *	679.8 (1.5)	137.9 (.5)	1213.4 (12.9)
F	233.17	80.18	38.36
P	<.001	<.001	<.001
η^2	.097	.044	.022

Values in parentheses represent standard errors.
*Number of non-cohort students varies across 9th, 10th, 11th, and 12th grades (n=1655, 977, 491, and 496, respectively.)

With respect to the type of math course taken, Table 2 shows the observed percentage of students enrolled in each course. In 9th grade, the majority of cohort and non-cohort students (60% and 64%, respectively) took Algebra 1, the first of three core courses in the district. In 10th grade, 56% of cohort students and 44% of non-cohort students took Geometry, the second of the required courses. In 11th grade, half of the cohort students (52%) but only one-third of the non-cohort students (33%) took Algebra II, the final required course. Higher percentages of cohort compared to non-cohort students took advanced math courses in 11th and 12th grades. The most common advanced courses were

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elementary functions (similar to trigonometry), pre-calculus, and calculus. One additional noteworthy result occurred in 12th grade general math. Notice the high percentages for both student groups. When further looking into the types of courses classified as general math, data showed that many of these cohort and non-cohort students were enrolled in a standards-based math course intended for seniors who were not proficient on the state assessment.

Table 2. Percent of students taking each type of math course across grade levels.

		9th Grade	10th Grade	11th Grade	12th Grade
General Math	cohort*	8%	8%	8%	49%
	non-cohort*	18%	22%	29%	63%
Algebra 1	cohort	60%	6%	2%	2%
	non-cohort	64%	20%	6%	3%
Geometry	cohort	24%	56%	9%	4%
	non-cohort	15%	44%	29%	11%
Algebra 2	cohort	3%	24%	52%	8%
	non-cohort	1%	13%	33%	14%
Unified Math	cohort	5%	4%	0%	<1%%
	non-cohort	1%	1%	1%	0%
Advanced Math	cohort	0%	3%	30%	33%
	non-cohort	0%	1%	12%	15%

*Number of cohort students is 1378. Number of non-cohort students varies across 9th, 10th, 11th, and 12th grades (n=1655, 977, 491, and 496, respectively.)

Next, to determine if mobility had a significant impact on whether or not students take a particular math course, binary logistic regression analyses were conducted. Although results showed that after adding the effects of gender, ethnicity, and SES into the model, mobility was still a

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statistically significant factor in the regression as supported by chi-square results ($p<.001$), mobility did not have a meaningful or practical impact on determining students' course-taking. As an example, for the regression conducted on advanced math course taking in 11th grade, the model that included only the three demographic variables correctly classified 71.7% of the cases according to whether or not advanced math was taken in 11th grade. All three demographics were significant in the model. After adding mobility (cohort versus non-cohort) to the model, the percent of cases correctly classified did not improve (72.0%). Nearly identical results occurred when analyzing advanced math course taking in 12th grade. The model with demographics correctly classified 72.2% of the cases. After adding mobility, correct classification was 73.0%.

Finally, with respect to course grades, significant differences in adjusted mean math grades between cohort and non-cohort students occurred at each grade level after controlling for gender, ethnicity, and SES. As shown in Table 3, the effect size was quite large in 9th grade (.256). The adjusted mean cohort math grade was between a "B" and a "C" (2.42), whereas the adjusted mean non-cohort math grade was a "D" (1.11). Effect sizes decreased over the successive high school years. In 12th grade, the effect was small (.012) but still significant. Mean math grades were between a "B" and "C" for the cohort and non-cohort groups (2.57 and 2.32, respectively).

A likely reason for the largest achievement differences occurring in the early grade levels is that the non-cohort group loses students each successive year. Some students with academic problems drop out or leave the district. Results from a previous study in this district also showed that many non-cohort students had low attendance and incurred disciplinary infractions (Parke, 2006). Therefore, a large portion of the extremely low performing students may be out

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of the school system by 11th and 12th grades. Research in other districts has shown that mobility, nonattendance, and behavioral problems are strongly related to academic achievement (e.g., Hinz, Kapp, & Snapp, 2003; Temple & Reynolds, 1999). Students that move frequently, are in and out of alternative education centers, and do not attend school regularly have low achievement.

Table 3. Adjusted means and standard errors for math grades at each grade level and student group.

	9th Grade	10th Grade	11th Grade	12th Grade
Cohort n=1378	2.42 (.03)	2.29 (.03)	2.28 (.03)	2.57 (.03)
Non-Cohort*	1.11 (.03)	1.43 (.03)	1.70 (.05)	2.32 (.04)
F	1011.80	355.02	92.97	20.414
p	<.001	<.001	<.001	<.001
η^2	.256	.127	..049	..012

Values in parentheses represent standard errors.
*Number of non-cohort students varies across 9th, 10th, 11th, and 12th grades (n=1655, 977, 491, and 496, respectively.)

Demographic Differences in the Cohort Cumulative Results

With respect to the number of math courses taken by the cohort students throughout the high school years, there were no significant differences between genders, ethnicities, or SES subgroups. However, significant differences did

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occur for the type of course and the cumulative GPA. They are described below.

Overall, a higher proportion of White students (57%) than Black students (30%) took advanced courses ($p < .001$, $r = .272$). For SES, a higher proportion of regular lunch students (60%) than free/reduced lunch students (27%) took advanced courses ($p < .001$, $r = .331$). Further disaggregation of results within ethnicities by SES are shown in the top half of Table 4. For both the Black and White subgroups, the percentage of free/reduced lunch students taking advanced courses was lower than for regular lunch students ($p < .001$). Interestingly, the SES gap in percentage of students taking advanced math courses was greater for White students than Black students. For the White subgroup, the gap between regular lunch versus free/reduced lunch was 32 percentage points. For the Black subgroup, the gap was 21 percentage points.

The bottom half of Table 4 shows the disaggregation within ethnicity by gender. Higher percentages of Black females (34%) took advanced courses than Black males (24%) ($p = .005$, $r = .104$). Within the White student subgroup, percentages did not differ for males (54%) and females (60%) ($p = .124$, $r = .055$). This is consistent with recent national research which has shown that the gender gap in taking advanced math courses is narrowing in some demographic subgroups (Bae, Choy, Geddes, Sable, & Snyder, 2000; Freeman, 2004). Although, similar to Riegle-Crumb's research (2006), it appears that Black males are at a particular disadvantage when it comes to taking advanced courses.

To examine the cohort's cumulative math GPA, a factorial ANOVA was conducted with ethnicity, SES, and gender as the independent variables. Model assumptions were evaluated using significance tests and visual inspection of distribution shapes. Distributions were approximately normal and variances were homogeneous.

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Table 4. Percentage of students who took advanced math courses within ethnicities by SES and gender.

Ethnicity by SES			
Black Free/Red Lunch n=412	Black Regular Lunch n=197	White Free/Red Lunch n=174	White Regular Lunch n=556
27%	48%	36%	67%

Ethnicity by Gender			
Black Males n=242	Black Females n=367	White Males n=346	White Females n=384
29%	38%	56%	62%

Results in Table 5 show significant main effects for ethnicity, SES, and gender. White students had a higher math GPA than Black students. Regular lunch students had a higher math GPA than free/reduced lunch students. Females had a higher math GPA than males. Effect sizes were small to moderate. The only significant interaction was between ethnicity and SES ($F(1, 1498) = 7.41$, $p=.007$, $\eta^2 = .005$). However, the total amount of variance in math GPA accounted for by the demographic variables was only 16%.

Visual examination of the significant interaction is shown in Figure 1. For Black students, there was no difference in mean math GPA between the two SES groups (2.05 versus 2.08), both means were low. For White students, however, the regular lunch SES group had a higher mean math GPA (2.73) than the free/reduced lunch SES group (2.47). This is consistent with previous research in the district

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which showed larger SES gaps in math achievement on standardized assessments for the White subgroup compared to the Black subgroup (Parke & Kachmar, 2008).

Table 5. Descriptive statistics and ANOVA results for main effects on GPA math.

	Ethnicity		SES		Gender	
	Black n=608	White n=730	Free/Red n=586	Regular n=752	Male n=588	Female n=750
Mean	2.11	2.68	2.22	2.58	2.33	2.50
SD	.71	.77	.76	.79	.78	.80
F	129.73		7.66		24.11	
P	<.001		.006		<.001	
η^2	.089		.006		.018	

Final Remarks and Further Research

Results from this study showed that mobility did have a detrimental effect on students' mathematics performance after accounting for gender, ethnicity, and SES. Cohort students had higher achievement than non-cohort students when measured by standardized mathematics assessments. Cohort students also had higher adjusted mean grades in mathematics courses than non-cohort students. With regard to course-taking, however, mobility did not appear to impact the type of math course taken in high school after adjusting for student personal characteristics. For instance, although observed percentages of cohort students taking advanced math in 11th and 12th grades was higher than non-cohort students, the inclusion of the mobility variable in the regression model did not improve upon the percent of students correctly classified by a model containing only the student variables.

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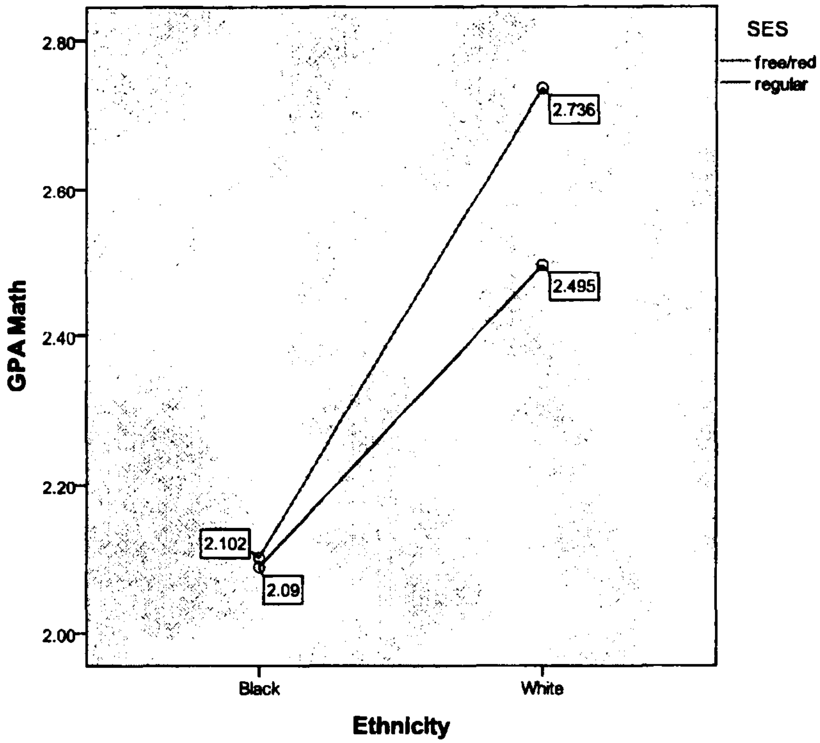

Figure 1. The significant interaction between ethnicity and SES for mean GPA math.

Examination of the cohort's cumulative math indicators indicated that there were differences among demographic subgroups. These results are consistent with other research (e.g., Lee, Croninger, & Smith, 1997; Ma & Wilkins, 2007; Maple & Stage, 1991; Smith, 1996) indicating a disadvantage for Black students and low SES students. However, when disaggregating ethnicity data in our study we found interesting results. SES gaps occurred in both the Black and White student subgroups. In fact, the gap in advanced course-taking between regular and free-reduced

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lunch groups was larger within the White subgroup than the Black subgroup. These results show the importance of unpacking data within ethnicities by gender or SES so that schools can be provided with useful information to guide their improvement efforts.

There are several paths to follow in continuing research on mathematics performance in high schools. Data can be disaggregated by the particular high school students attended during their four years in the district. Hierarchical analyses would then allow for examining relationships among school contextual factors, demographics, mathematics performance, SAT scores, and other data on college-bound seniors. A second area for further investigation is to conduct a more in-depth analysis of math courses. Analyses might include the particular version of the course students took (e.g., basic, regular, or honors), the number of times they took the same course, the availability of advanced courses in each school, and the curriculum taught. Furthermore, similar to studies by Riegle-Crumb (2006), Smith (1996), and Wilkins and Ma (2002), an examination of the effects of taking algebra prior to 9^{th} grade on high school achievement in the later years can provide schools with data-driven information that would assist them in counseling students on the mathematics courses to take.

Secondly, student mobility could be examined across schools as several other researchers have done (e.g., Alexander, Entwisle, and Dauber, 1996; Rumberger and Larson, 1998). There are ten high schools in this district. Rates of mobility differ greatly across schools. Some schools are much better at keeping their students than other schools. It would be worthwhile to investigate the impact of changing schools on student achievement. Dworkin and Lorence (2008) recently conducted a study of mathematics achievement at the elementary level which found that the impact of changing schools varied according to the type of

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school to which students moved in comparison to their original school (lower-, similar-, or higher-performing).

Lastly, studies that investigate when and why non-cohort students leave are beneficial to districts trying to decrease mobility in high school. Many districts maintain information on entries, withdrawals, and reentries from the district and from each high school. However, determining the reasons for leaving can be complicated. Coding systems are typically created to document why a student withdrew from a school. Students may leave the school system because the family moved outside the district limits or they may transfer to a charter, religious, private, or cyber school within the district limits. Other scenarios are more complex. For example, students may be placed into and out of alternative education centers several times throughout high school for disciplinary reasons, or they may repeat a grade level for one or more school years, drop out, come back to the district, enter the next grade level, transfer to a different school in the district, then drop out again for the final time. Even when districts maintain a comprehensive longitudinal database, it is a time-intensive process to keep track of all student movement. These issues speak to the problems associated with obtaining accurate dropout and graduation rates.

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