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Blended Learning in Middle School Math: The Question of Effectiveness

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Blended learning models can help teachers leverage the power of technology to customize student learning and differentiate instruction for students at varying achievement levels. Research on the effectiveness of blended learning in K-12 education has largely relied on case studies, and findings suggest differences in achievement outcomes based on content areas and grade levels. This paper reports findings from a quantitative comparative study conducted to investigate the effects of blended learning, specifically using the station rotation model, on the math achievement of 413 6th grade students. Scores on the State of Texas Assessments of Academic Readiness (STAAR), as well as the Measure of Academic Progress (MAP) were used. Student groups were selected based on teacher responses on a survey in which they were asked to identify what portion of their class was spent on blended learning practices and on face-to-face teaching. A t-test was conducted to determine the differences in the scores of students taught in traditional fully face-to-face classrooms and those taught in blended learning classrooms. Findings showed that students instructed through blended learning scored higher on the MAP assessment ($M = 11.12$, $SD = 7.88$) than students in a fully face-to-face environment ($M = 8.84$, $SD = 7.40$), $t(411) = 3.02$, $p < .01$. On the other hand, students instructed in a face-to-face setting scored higher on STAAR ($M = 29.96$, $SD = 11.84$) than those in blended learning settings ($M = 26.75$, $SD = 11.06$), $t(411) = -2.85$, $p < .01$. Blended learning was more effective in facilitating growth in math learning as compared to meeting grade level criteria. These findings indicate that schools can benefit from implementing blended learning particularly for students who are behind academically and need additional academic growth in one school year.

INTRODUCTION

Education professionals want to create learning experiences that will ensure knowledge acquisition for all students. In today's diverse classrooms, teachers are constantly challenged to differentiate instruction to meet the learning needs of all students, especially those who require accelerated growth in the core content areas of math and reading. Mathematical ability is key to being prepared for the 21st century workplace and has led to increased rigor in math standards. However, student performance in math continues to lag, as evidenced by NCES reports (National Center for Education Statistics, 2018). Successful completion of Algebra has long been considered the gateway to higher level math and science courses as well as postsecondary success (U.S. Department of Education, 1997). Middle school students need a strong mathematical foundation in order to succeed on the pathway to successful completion of algebra as well as other math courses in middle and high school. Educators can leverage recent advances in technology to differentiate math instruction for students at varying achievement levels and blended learning is one way in which a teacher can incorporate technology to customize student learning.

Blended learning is defined as "any formal education program in which a student learns at least in part through online learning, with some element of student control over time, place, path, and/or pace" (Horn & Staker, 2014, p.34). Blended learning offers schools the option of using the typical school day in different ways, combining instruction via online learning content with traditional teacher-facilitated best practices, thus giving students more learning opportunities which can lead to learning growth. Typically, a blended learning classroom involves a portion of the class led by the teacher and part of the class time where students are instructed in content via online digital curricula. Blended learning is at times referred to as personalized learning, depending on the degree of adaptation and personalization of content, delivery, and demonstration of learning, based on individual student needs and preferences. In either case, it refers to ways in which instruction can be tailored by utilizing technology to meet the individual needs of students (Flores, 2018). In education, content has typically been presented in a linear manner where the same information is presented to every student at the same time. In the online environment, however, digital content is becoming increasingly adaptive. This makes it possible for content to be adjusted in real time based on a student's activity and responses to frequent formative assessments. The student interacts with only the content that he or she needs for the mastery of a given topic. This is where the power of technology can be leveraged for differentiation.

The goal of any effective blended learning program is to differentiate instruction to meet the learning needs of all students (Horn, 2014). Students differ in content knowledge and have different learning targets and they learn best when instruction is aligned to their learning needs and goals (Tomlinson, 2001). Teachers in many blended learning classrooms use proprietary packaged standards-based online learning content (Brodersen & Melluzzo, 2017). These programs provide instruction aligned with data from frequent student assessments by adapting the sequence and pacing of topics based on student need, skill level and background knowledge. This flexibility of pacing and content gives teachers the potential to differentiate learning opportunities for all students (Kazakoff, Macaruso, & Hook, 2018). Data generated from online content can also help the teacher effectively differentiate face-to-face instructional time with the students. However, blended learning is not a one-size-fits-all solution. There are multiple models that need constant adapting based on school paradigms and student needs. Existing evidence suggests that blended learning can lead to some positive outcomes but impact on student learning may depend on the content area and type of blended learning implemented (Pane, Steiner, Baird, Hamilton, & Pane, 2017). Therefore, additional research needs to be conducted in multiple settings, grades, content, and diverse student groups.

Purpose of the Study

The purpose of this study was to investigate whether blended learning increased 6th grade student achievement in math, when compared to traditional face-to-face learning. This study focused on teachers implementing the station rotation model of blended learning where students rotate through stations including an online learning station, where they access adaptive digital content with individualized learning pathways based on each student's learning needs. Other stations typically included small group instruction with the teacher, independent work, and some form of collaborative or project-based learning. In the traditional face-to-face learning, teachers mostly relied on whole class instruction and guided practice, followed by independent practice. In these classes, no adaptive digital content was used. One achievement measure and one growth measure were used to study effectiveness. The independent variables of this study were the instructional method: blended learning versus fully face-to-face. Once student groups were determined, two dependent measures were collected for each student participant: the 6th grade State of Texas Assessments of Academic Readiness (STAAR) math scores and the growth shown on the 6th grade Measure of Academic Progress (MAP) math assessment.

LITERATURE REVIEW

Over the years, educators have implemented a variety of instructional practices that can increase student learning and can keep their students engaged. In recent years, blended learning practices have become increasingly adapted in classrooms, particularly in core content areas to help close the achievement gap. Education reforms at the national and state levels have sought to address disparities in student achievement, specifically in the area of math. In addition to an increase in more rigorous standards, there is also pressure to increase math achievement, given its relevance for becoming productive in the 21st century workforce. According to the National Center for Education Statistics (2018) the national math scores for 4th and 8th graders improved in 2017 from 1990; however, there was no measureable growth from 2015. National comparisons of student achievement indicate that between 4th and 8th grades students in general, and particularly minority and high poverty students, fall behind desired levels of learning and the academic achievement gap rapidly increases (Balfanz & Byrnes, 2006). A strong foundation in math during middle school is essential for students to be prepared for the high demands of a high school math curriculum. It is even more challenging for students in high-poverty urban schools as they enter middle school with significant gaps in math achievement (Rockoff & Lockwood, 2010). While there is emphasis on higher levels of achievement, the resources and strategies needed to make it happen especially in high poverty middle schools are often insufficient in supporting instructional practices that meet the varying learning needs of students.

This is where the promise of blended learning becomes critical and worth investigating. Greer, Rowland, and Smith (2014) define blended learning as, "… a traditional face-to-face class where students complete a portion of their coursework on the computer and another part engaged with their face-to-face teacher or their classmates" (p. 79). Math teachers can use blended learning as the means to scaffold instruction and provide targeted learning opportunities through small group and individualized instruction informed by real-time student data.

It is unknown what differences exist, if any, in achievement scores between middle school students who are in blended learning math classrooms versus those students who are in fully face-to-face, teacher-led math classrooms. Although many teachers use technology in their classrooms, it may often be used as a teacher-directed instructional tool. Blended learning, on the other hand, puts the technology in the hands of the students where they can learn at their own pace. Teachers embracing this method are beginning to see positive results on student learning (Means, Toyama, Murphy, & Baki, 2013).

There are several published studies on blended learning, however, K-12 focused blended or personalized learning research accounts for only a fraction of published peer-reviewed research on this topic. The majority of blended learning studies are based on research in post-secondary settings, in online universities, and adult technical education programs (Brodersen & Melluzzo, 2017; Pulham & Mohammed, 2018). Some are conducted as case studies based on grant funding from non-governmental organizations (NGOs) or not-for-profit foundations and are disseminated as briefs and reports. Recently, studies have been conducted by the companies that develop online learning content to establish the effectiveness of blended learning when their specific program is used. Most of these studies have shed light on the promise of blended learning; however, rigorous comparative research has been far from conclusive. There have been some studies that sought to compare instructional approaches and have found increased student achievement in blended learning classrooms (Bottge, et al., 2014; Veres, 2013). On the other hand, Hein (2014) found that direct instruction was more effective and led to higher scores than when taught through a blended approach where the teacher combined face-to-face instruction with a combination of digital tools. Clark (2015) concluded that there were no significant differences in achievement between students taught in traditional classroom and those taught by teachers using the flipped classroom approach.

Blended learning effectiveness is also being looked at for special needs students. According to Rivera (2017), blended learning can provide teachers with flexibility and options to integrate supplemental online activities to support reading and math skills with their special needs students. A blended-learning classroom can be more inclusive because students at different levels with different learning needs can be in the same classroom while working on different content areas and target activities, thus allowing for opportunities to expand special education inclusion efforts (Fisher, 2015). Rigorous research is needed to test blended learning practices with special student populations.

In 2015, the Christensen Institute published 12 case studies on how traditional school districts improved student learning outcomes such as test scores and graduation rates after implementing blended learning (Mackey, 2015). In addition, digital content providers often make a case for the effectiveness of their products when implemented under certain conditions. Although these are success stories, what is left out is information from school districts that are implementing blended learning but have not seen growths in these traditional achievement indicators. For this reason, more empirical studies are needed to authenticate whether or not blended learning works, under what conditions, and for which students. Additional systematic studies are needed in this area as online digital content gets more and more sophisticated and schools invest more dollars in technology.

The current study sheds light on effective ways to educate middle school students in math and extends findings from previous studies regarding impact of blended learning on student achievement. It examines the effectiveness of blended learning relative to fully face-to-face learning by analyzing 6th grade students' scores on two tests: STAAR math assessment and growth scores on the MAP assessment.

RESEARCH QUESTIONS

Although many factors are involved in assessing the effectiveness of instructional practices, the following research questions were used to guide this study regarding instructional methods and student achievement:

R1: What differences exist, if any, in scores on the sixth-grade STAAR math assessment between students who were in blended learning classrooms and those in fully face-to-face math classrooms?

R2: What differences exist, if any, in growth measure scores on the sixth-grade MAP assessment between students who were in blended learning classrooms and those in fully face-to-face math classrooms?

METHOD

Research Design

For this study, a quantitative comparative research design was selected as a way to compare two variables by using student achievement data (Fraenkel, Wallen, & Hyun, 2015). The independent variable was the type of classroom instruction, i.e., blended or face-to-face only. Dependent variables were student achievement scores on the end-of-year state assessment, STAAR, and growth shown on the MAP math assessment for sixth grade. This non-experimental design used a comparative approach in order to investigate the differences in achievement of two independent pre-existing groups.

Population and Sample Selection

Two student groups were selected from a population of 812 sixth-grade students enrolled in a Texas charter school district. One group consisted of students who were in classrooms where the teacher primarily used face-to-face instruction in which the pace and path of instruction were the same for all students. A typical lesson included the teacher introducing the concept to the whole class and modeling sample problems, followed by students

doing independent or group work solving problems. Technology may have been used in these classrooms, but it was primarily used by the teacher as an instructional tool. The lesson typically ended with a quiz using paper and pencil. The second group was comprised of students who were in math classrooms where blended learning took place almost every day, mostly using the station-rotation model. Within this model, students rotated in small groups between teacher-led instructional activities, project-based activities or independent tasks, and at least 10 minutes of learning from online digital content that was self-paced and adaptive based on real-time data from periodic assessments embedded in the digital content. All assessments were completed online as part of the learning content software. The school district where the study took place has a number of middle schools with one sixth-grade math teacher per school. The district office periodically collected information from the school principals on which math teachers at their schools used blended learning practices and the degree to which they implemented various components of effective blended learning. This data included the level of online learning content integration, use of data to form small groups, competency-based progression opportunities for students, and the degree to which students monitor their own learning and set goals for learning tasks and activities. The researcher received this information for all sixth-grade math teachers in the district.

Next, a survey was sent to teachers in which they rated themselves on their instructional practices. The survey asked the teachers to identify what portion of their class was spent on the two instructional practices: blended learning and/or fully face-to-face. Teachers were asked to indicate the number of days in a given week they implemented each component and what percent of the class time was devoted to it. This two-pronged approach of using principal input and teacher self-rating allowed for the identification of classrooms where blended learning was implemented with consistency and fidelity so as to make the necessary comparisons. For this study, students of four sixth-grade math teachers were selected based on the district information and teacher survey. Students of two teachers that reported fully face-to-face instruction made up one group of the sample (N=205). The other group consisted of students of two teachers that reported the highest and most consistent frequency and time in blended classroom instruction (N=208).

In order to avoid false-negative results or type II errors, it was essential to include the necessary sample size (Hedges & Rhoads, 2009; Kraemer & Blasey, 2016). Therefore, a power analysis was calculated to determine adequate sample size using a power of .80 and a medium effect size of .25. It was determined that the study would require a sample of 102 students with

a minimum group size of 51 (Bryant, 2017). In the Butzler (2014) study, it was shown that the combined sample population of 70 students was not sufficient to provide valid results. With Briggs (2014), however, his sample population of 137 students was sufficient, although no significant difference was found between the blended and controlled groups. For this reason, as well as the findings of the power analysis, the current study consisted of a minimum of 200 students per group with a total of no less than 400 participants. Of the 413 total students in the sample, the blended learning group consisted of 208 students and the fully face-to-face instruction group consisted of 205 students.

Instrumentation and Sources of Data

Studies examining the impact of blended learning practices tend to use data from one or more of the following sources: state norm-referenced assessments, district level tests, graduation rates, and the MAP growth measures (Hein, 2014; Mackey, 2015; Pane et al., 2017). The public/charter school district in which this study took place used data from the Texas state assessment and MAP growth measures when making decisions regarding student achievement and accountability. Therefore, both these measures were used in this study as the dependent variables.

The STAAR assessment is used annually in Texas to determine if students meet the adequate yearly progress (AYP) criteria. The internal consistency of this assessment across content and grade levels is between .81 and .93, indicating a good measure of reliability (Texas Education Agency, 2016). External validity was established for STAAR by finding correlations with other measures such as the students' subsequent performance in high school courses, previous State assessment, ACT, and SAT, all reporting significantly high external validity.

The MAP growth measure provides data on annual academic growth and is calculated by the Northwest Evaluation Association (NWEA). Construct validity of MAP assessment has been established through studies that validate achievement and growth measures (Wang, McCall, Jiao, & Harris, 2013). The internal consistency reliability measure of MAP assessment is reported at above .80 for all grade levels and content areas except for 2nd grade, which was not the focus of this study.

RESULTS

Data Analysis

In order to assess the significance of the difference in the mean scores of the two groups, an independent *t*-test was performed to compare the scores of those taught through blended learning and those taught with face-to-face instruction. In addition, Cohen's *d* effect size was calculated to determine the standardized difference between the means of the two groups. Prior to performing the t-test the following assumptions had to be met: (i) independent variable consists of at least two independent groups; (ii) dependent variable is measured on a continuous scale; (iii) adequate sample size; (iv) no significant outliers on the dependent variable(s); (v) normal distribution of the dependent variable; (vi) homogeneity of variance; (vii) independence of observation (Bryant, 2017).

The achievement scores were consistent with continuous scale criteria, and the groups were independent of each other as one group included students taught through blended learning and the other through a fully face-to-face model. At no time was a student included in both the blended learning and the face-to-face groups. Regarding sample size, the a priori analysis projected a total sample size needed of 128. The initial data involved 422 students; however, nine students did not test in all assessments and were therefore removed from the sample. There were no students with missing results.

Regarding the normal distribution, the Shapiro-Wilk test was used on the data of each group. Although the normality test was satisfied with the MAP face-to-face group ($p = 167$), the test of normality was violated with the STAAR blended learning ($p = .000$), STAAR face-to-face ($p = .000$) and MAP blended learning ($p = .000$). While only one of the Shapiro-Wilk tests satisfied the test for normality, the skewness of both the STAAR and MAP data was normally distributed with the blended and face-to-face groups. As the kurtosis of the blended students on STAAR and the face-to-face students on MAP fell in a normally distributed range, the kurtosis of the face-to-face students on STAAR revealed a slightly negative distribution with a result of -1.296. Also, outside of the normal distribution was the kurtosis of the blended students on the MAP assessment at 2.087. Even with these slight shifts the skewness and kurtosis of the groups revealed a normal distribution. Finally, the Levene's test for homogeneity revealed that the homogeneity of each group was satisfied as the null hypothesis for both the STAAR and the MAP data was rejected.

Findings

Table 1
Group Statistics for STAAR Assessment

	Number of Classes	*N*	Mean	Std. Deviation	Std. Error Mean
Blended Learning	2	208	26.75	11.06	0.77
Face-to-Face	2	205	29.96	11.84	0.83

As seen in Table 1, for the STAAR assessment there were 208 students instructed through blended learning with a mean score of 26.75 and a standard deviation of 11.06. In addition, data from 205 students instructed in fully face-to-face classrooms was used, with a mean score of 29.96 and a standard deviation of 11.84.

An independent two sample *t*-test was used based on the significance level of .05. Table 2 shows the data from the *t*-test which resulted in a statistically significant difference between the scores of those students taught through a blended approach (M = 26.75, SD = 11.06) and those taught through a fully face-to-face method (M = 29.96, SD = 11.84), $t(411) = -2.85$, $p = .005$; $d = -0.28$.

Table 2
Independent Samples *t*-test and Effect Size Results for STAAR Comparison

Equality of Variances			t-test for Equality of Means							Effect Size
	F	Sig.	*t*	*Df*	Sig. (2-tailed)	Mean Diff.	St. Error Diff.	Lower	Upper	*d*
Equal variance assumed	2.43	0.12	-2.85	411	0.005	-3.21	1.13	-5.43	-0.99	-0.28

For the MAP assessment, the researchers used the growth measure scores of the students in the blended learning classrooms and those taught without blended learning. This score is the difference between the MAP assessment taken at the beginning of the sixth grade and the MAP assessment taken at the end of the year. As seen in Table 3, MAP assessment data was obtained from 208 students in the blended learning group from two classes with a mean growth score of 11.12 and a standard deviation of 7.88. There were 205 students taught through a face-to-face approach in which the mean of the raw scores for these students was 11.12 with a standard deviation of 7.40.

Table 3
Group Statistics for MAP Assessment

	Number of Classes	*N*	Mean	Std. Deviation	Std. Error Mean
Blended Learning	2	208	11.12	7.88	0.55
Face-to-Face	2	205	8.84	7.40	0.52

Table 4
Independent Samples t-test and Effect Size Results for MAP Growth Measure Comparison

Equality of Variances			*t*-test for Equality of Means							Effect Size
	F	Sig.	*t*	*Df*	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper	*d*
Equal variance assumed	0.06	0.80	3.02	411	0.003	2.28	0.75	0.78	3.75	0.30

An independent two sample test was used based on the significance level of .05. As with the first research question, this test also resulted in a significant difference between the scores of those taught through blended learning (M = 11.12, SD = 7.88) and those taught through face-to-face instruction (M = 8.84, SD = 7.40), $t(411) = 3.02$, $p = .003$; $d = 0.30$. These results are shown in Tables 3 and 4.

The findings of this study show that students in blended learning classrooms scored higher on the growth measures of the MAP assessment. However, students in the face-to-face group performed better on the STAAR assessment as compared to the blended lerning group. The results for both measures were statistically significant. In addition, the Cohen's *d* indicated a moderate effect size for both types of classroom practices. With a Cohen *d* of 0.30 for MAP assessment, approximately 62% of the blended learning group is expected to be above the mean of the face-to-face instruction group. Likewise, with a d of -0.28 for the STAAR assessment, approximately 60% of the face-to-face instruction group is expected to score above the mean of the blended learning group. For both assessments, the means of the two groups differ by approximately 0.3 standard deviations, which is considered to be a moderate size difference between the means.

DISCUSSION AND IMPLICATIONS

Discussion of Results

The findings of this study are consistent with case studies from individual school districts in New York, Illinois, and South Carolina that reported students in blended learning classrooms outperformed their face-to-face classroom peers on the MAP measures of growth (Mackey, 2015). On the other hand, the same report also presented data that showed blended learning students outscored face-to-face students on state and district norm reference tests. However, the present study's conclusions are not consistent with the Mackey report. For the current study, the results of the STAAR assessment indicated higher achievement for those students instructed in a fully face-to-face, non-blended teaching and learning environment.

In spite of the high correlation between the STAAR and MAP math scores which range from 0.76 to 0.82 (NWEA, 2016), the findings of this study did not reflect consistency in results. One possible explanation for the difference in achievement on the two tests is the nature of the assessments. STAAR is a criterion-referenced test that measures student performance based on curriculum standards for a content area and grade level. In contrast, MAP is a norm-referenced measure of student growth over time. Students who are behind academically may not be able to meet grade level criterion targets if they make average growth and therefore, above average growth is necessary for them to catch up (Cronin, 2016). The reasonable growth target for students who are not performing at grade level is usually one and one-half years in one school year. Therefore, it can take multiple years for a student to catch up and meet the grade level criterion in a given content area. In this study, even though fewer students in the blended learning group met the criterion on STAAR than in the face-to-face group, more students showed increased growth on the MAP assessment, which is also considered a significant achievement for students who are academically behind their grade level cohort. As this study reported findings from one school-year data, more research with data over multiple years needs to be conducted to test this hypothesis.

Another possible explanation for the differences in the two assessments may have to do with the testing modality. The STAAR test was a paper and pencil test whereas students took the MAP assessment on the computer. Students in blended learning environments were familiar with doing assessments online and this transfer of modality could also account for at least some of the success they experienced with the MAP assessment. Further studies are needed to investigate this effect

Implications

The current study indicates that schools could benefit from implementing the station-rotation blended learning practices within math classes, particularly for students who are behind academically and need additional learning growth in one school year. Within blended learning, students become direct consumers of content and can advance through learning at their own pace based on their academic level, where the online digital content is able to adapt to student learning needs. This in turn allows the teacher to create differentiated learning opportunities for all students. Blended learning is one of the most scalable way of differentiating instruction. School leaders should support their teachers in adopting blended learning practices in their classrooms, with a focus and emphasis on differentiation. Care should be exercised in selecting the digital content which is standards based and adaptive. Teacher professional development should focus on using student data from the adaptive digital content in order to design targeted learning opportunities for students.

Just as the literature review included findings that supported both fully face-to-face as well as blended learning practices, findings of this study also showed support for both approaches but for different goals. The current study highlighted that research on effective teaching and learning models should not only center on which method allows maximum number of students to meet grade level criteria, but should also focus on learning growth, which can ultimately result in success on criterion referenced state assessments. For schools that use MAP data consistently to assess student learning, blended learning practices should be strongly considered, especially in middle school math classrooms. Teachers can use online learning content in math that is aligned to specific learning standards to help remediate learning and allow students to advance through concepts based on mastery rather than on teaching time.

Limitations and Delimitations

For this study, students were chosen based on assigned class enrollment and were not randomly assigned to the two instructional approaches. Random assignment would be ideal; however, most classroom based educational research is limited by intact groups due to legal and ethical considerations. Pre-existing groups of participants were used based on instructional practices of the teachers. Secondly, the scale used on the teacher survey to determine the degree to which blended learning was implemented in their math classrooms was comprised of Likert type items. There can be limitations with such scales where responses can be subjective. In the future, adding open-ended items could provide additional data regarding classroom

practices. In addition, the target population involved students in an urban public/charter school, with a majority (91%) of the students qualified for free or reduced lunch based on reported family income. The findings of this study cannot be generalized to populations that do not fit this demographic. In addition, as data from classes of only four teachers was selected, the study did not document teacher demographic information to avoid presenting identifying factors that may compromise confidentiality. Hence the study could not control for teacher differences. Similarly, since classroom observation was not part of the research method, the study did not document or compare the learning activities that occurred in the fully face-to-face and blended classrooms. Another limitation is that the study did not focus on additional outcome measures such as student agency and engagement that were likely impacted but were not included as the dependent variables. Finally, this study focused on students in sixth-grade math classrooms in the study district. No other grades were investigated.

Recommendations for Future Research

Future mixed-methods studies are recommended that combine repeated classroom observations with teacher surveys as a way to determine groups in an effort to ensure fidelity of practice within the groups. Teacher characteristics could pose a threat to the validity of the study and therefore, where possible, radom selection should be made from blended learning and face-to-face groups so as to minimize bias. This should be done where the total number of students that can be included in the study is large enough so that statistical power is not reduced. Focus of future multi-year studies should consider learning growth in addition to whether or not students meet the grade level content criteria. Overall, blended learning is still evolving, and strong empirical studies need to be conducted in order to help schools determine best practices.

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