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The Potential of Telepresence for Increasing Advanced Course Access in High Schools

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The adoption of telepresence technology in K–12 schools potentially expands students' access to course offerings and new ways of learning, but little is known about its implementation and promise for improving student outcomes. We employ a mixed-methods analysis to examine the experiences of students and teachers in telepresence courses in a large, urban school district as well as student learning outcomes and access to advanced placement courses. Findings from fixed effects models indicate improved access to advanced courses and higher ACT scores among students enrolled in telepresence courses. In surveys, students and teachers reported generally favorable perceptions about the enhanced opportunities for advanced course-taking and collaboration across schools afforded by the telepresence technology.

Keywords: achievement; case studies; computers and learning; econometric analysis; educational policy; high schools; instructional technologies; learning environments; mixed methods; observational research

Access to advanced high school courses promotes college readiness and increases learning opportunities (Attewell & Domina, 2008; Kolluri, 2018). A concerted effort has been made in recent years to foster participation in these courses among historically underserved student populations (Kolluri, 2018). The College Board created the Advanced Placement (AP) Opportunity Program to ensure that any student who is prepared for the rigor of AP courses—"regardless of their location, background, or socioeconomic status"—has the "right to fulfill that potential."[1] While over time participation in AP courses has increased at a rapid rate among racially and socioeconomically diverse students, disparities in access persist (Kolluri, 2018; Malkus, 2016). Between 1990 and 2013, the percentage of students identifying as Black participating in AP courses increased 430%, but even after adjusting for access to AP courses, the percentage of students identifying as Black receiving AP course credit is considerably lower than all other racial groups (Malkus, 2016).

In this research, we consider the potential for telepresence technology to expand access to AP and other high school courses (e.g., foreign language studies) for students in low-income schools. These schools were previously not able to offer more advanced course options because of financial and personnel constraints. For instance, administrators reported that fewer than the minimum number of students required to offer an AP course demonstrated interest. Also known as distance education courses, telepresence courses are defined by the Institute of Education Sciences (IES) as "courses offered to elementary and secondary school students regularly enrolled in the district that meet all of the following criteria: (1) are credit granting; (2) are technology delivered; and (3) have the instructor in a different location than the students and/or have course content developed in, or delivered from, a different location than that of the students." Although courses that students complete from home also meet the definition for distance education courses provided by IES, we focus in this study on a model delivered in a student's school where the teacher facilitates instruction from an alternative school setting in the district for at least some classes (and some students in those classes) during the school year. For this paper, we refer to students attending the same school as the teacher facilitating instruction as being *on-site* at the *host school* and students attending any other school as being *remote* participants.

In a national survey conducted during the 2009–2010 school year, Queen and Lewis (2011) found that 55% of public school districts reported having students enrolled in distance education

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courses (largely at the high school level). Most school districts (79%) with distance education-enrolled students reported total enrollments of less than 100 students, and three-quarters of the districts reported that the courses were developed by entities other than their districts (e.g., postsecondary institutions, independent vendors). Furthermore, the most common uses of distance education courses were for credit recovery, whereas only about 29% were for AP courses. The primary mode of instructional delivery for the distance education courses (for 63%) was via the Internet using asynchronous instruction. Although this survey did not disaggregate prevalence of access or establish effects for students from low-income backgrounds, other research has identified continuing gaps in student access to technology at home by race and income despite improvements in access to technological devices in schools through investments by the federal e-Rate program (Warschauer & Matuchniak, 2010). In fact, equity concerns persist not only regarding the quality of digital devices and Internet access and connectivity (e.g., access to broadband) for low-income students, but of even greater concern may be in *how* the integration of educational technology (both in school and out of school) interacts with the systemic social, economic, and racial patterns of inequality in education that have historically limited the quality of educational opportunities for low-income, minoritized students.

Newer telepresence learning systems alternatively utilize high-end videoconferencing to emulate traditional classroom experiences and facilitate two-way, synchronous communication (Bower et al., 2012). To date, there has been very limited research on the use and effectiveness of these telepresence learning systems in K–12 education, with no studies examining use specifically in schools serving students from predominately low-income backgrounds. Most studies that examine their use and effectiveness for expanding educational opportunities have focused on higher education and medical education (Bauer, Durakbasa, Bas, Guclu, & Kopacek, 2015; Bower, 2011; Gray et al., 2014; Means, Toyama, Murphy, Bakia, & Jones, 2009). These educational environments are distinct, however, in that the learners are adults, and educational approaches in which the instructor and students are separated by both time and space are already more common practice (e.g., flipped classrooms). Other research on distance learning, such as meta-analyses by Bernard et al. (2009) and Cavanaugh, Gillan, Kromrey, Hess, and Blomeyer (2004), do not include sufficient observations with higher end telepresence systems to distinguish their performance or effectiveness from other more common forms of asynchronous, online distance education. Schaffhauser (2011) suggests that the high costs of the sophisticated videoconferencing equipment have been the primary reason that telepresence has lagged in K–12 education. Recognizing this barrier, Cisco Systems recently partnered with public school districts, particularly those in low-resource contexts, to subsidize and explore the use of telepresence for creating expanded learning opportunities at the K–12 level.[2]

The introduction of new media for learning such as telepresence systems is redefining our understanding of "presence," suggests Picciano (2002), particularly the relationship between telepresence (spatial) and social presence and how active learning is enabled in environments where at least some fraction of the interactions among students and instructors are facilitated digitally. "Presence" includes the "social and communicative interactions" between students and teachers—for example, the ability to share information and opinions, ask questions, challenge information that is conveyed by others, and reflect (Picciano, 2002, p. 21). These types of interactions, which are likely to be particularly important for success in AP and other advanced high school courses, must be adapted to new learning environments where a Web-based or digital presence changes how students and teachers navigate these interactions (Tammelin, 1998). Indeed, it is still an open question as to whether the two-way interactions facilitated in telepresence learning allow students participating remotely to obtain the same level and quality of instruction as they would in a traditional, face-to-face classroom setting.

In this investigation, we draw on qualitative and quantitative data to address the following two research questions: (1) What are the experiences of high school teachers and students who are offering or accessing advanced courses through the telepresence program? (2) To what extent does participation in a telepresence course change students' access to AP courses, standardized test scores, and school absences? We examine these associations separately for students attending telepresence courses in a host school (on-site) versus remotely due to the different contexts of the intervention in each type of setting.

Methods

Program Description and Study Design

Milwaukee Public Schools (MPS) is a large, urban school district in Wisconsin that began a collaboration with Cisco through its "Connected Education" program in 2015. Cisco donated five telepresence system units to MPS that provide enhanced video and sound quality compared to typical teleconferencing technologies. MPS, which had no prior existing platform for telepresence, describes its model as "an interactive learning experience that is two-way or synchronous" (Means et al., 2009), where a live teacher interacts with the remote students using the video conferencing equipment. The equipment provided by Cisco includes site-to-site specialized cameras and widescreen interactive monitors that facilitate instructor-student interactions similar to what is feasible in face-to-face interactions in traditional high school classrooms. In the first year of implementation, MPS contracted with a third-party consultant that worked on-site with MPS technology staff to support the integration and use of the telepresence units. MPS is using the telepresence technology to expand the number of AP and other advanced and elective courses it offers in the district, as well as the number of students who can take these courses, and has made additional investments in technology (e.g., cameras) to support this expansion.

In acknowledgment of the IES definition of distance learning that states that the instructor (or course content development) is located in a different location from the student, we examine separately students who enrolled in a telepresence course in the host school, where the student received instruction in the same location as the instructor on most days, versus students who participated remotely and received instruction in a different location as the instructor on most days. It is important to provide information on both groups of students, as students enrolled in the host

schools also had their educational experience shaped by participation in a telepresence course because (a) the instructor had access to and used technological tools designed to facilitate electronic and audiovisual communications and (b) the instructor delivered some lessons every semester from the remote school to meet and interact with those students face-to-face.

In this case study, we employ a pragmatic research paradigm (as described by Anderson & Shattuck, 2012; Anderson & Zawacki-Richter, 2019) to examine how MPS rolled out telepresence courses in the district during the 2015–2016 through 2017–2018 school years. Pragmatic research typically takes place like ours in a natural setting within the context of a research-practice partnership and applies mixed methods to address practical (or pragmatic) questions about an intervention. As we describe below, our research draws on quasi-experimental empirical analyses, observations of telepresence classes, and the analysis of survey data to generate insights for the expanded use of telepresence in public schools. The MPS telepresence intervention is distinct from several of the national distance education trends described above in that it is not relying on an external provider but rather certified district-employed teachers to deliver the courses. The MPS telepresence program expanded from two classes of AP Statistics (in 2015–2016) to 175 students across a dozen courses in 2016–2017 and to over 17 different courses serving more than 400 high school students across 10 schools in the 2017–2018 school year.

Our analysis of the associations between telepresence course-taking and student outcomes drew on district-provided data from 571 students who engaged in telepresence courses. One hundred and eighty of these students participated remotely. Most telepresence students participated in two telepresence courses ($N = 288$), with very few students participating in more than two telepresence courses ($N = 56$). As shown in Table 1, students enrolled in telepresence courses were less likely to receive special education courses, qualify for free or reduced-price lunch (FRL), and be identified as an English Language Learner (ELL) and more likely to be identified as White and female than the general student population.

Empirical Strategy

We drew on student-level data provided by the district to explore the relationship between student participation in telepresence courses (on-site or remotely) and educational outcomes, such as the number of AP courses in which a student enrolled, school absences, and standardized test scores. We standardized test scores to equate scores from year to year, as the school district transitioned from administering MAP to STAR assessments over the study period. Both assessments are nationally normed standardized assessments. Although data were available on student enrollment in AP courses and attendance in each grade, the district only administered standardized assessments in certain grades.[3] Thus, the analytic sample size reflects these differences in the availability of outcome data by grade.

We employed student fixed effects models in estimating these relationships. An advantage of the student fixed effect approach is that it controls for all student characteristics that do not change from one year to another (i.e., that are fixed) and potentially associated with the outcomes of interest. We also examined associations with ACT scores. However, because most students only took the ACT once, these models did not employ student fixed effects and instead controlled for pretreatment student and school covariates. We established a .05 threshold for significance for all statistical tests but also indicated in the tables where coefficients met a .10 and .01 threshold to show where estimates were approaching significance or would be identified as significant if held to a higher standard. All models used standard errors robust to heteroscedasticity.[4]

We also observed three telepresence courses in the district using a research-based observation instrument designed to evaluate the implementation of digital instructional tools (Heinrich, Darling-Aduana, Good, & Cheng, 2019). Observers rated each lesson on a 5-point Likert-type scale in each of the following areas: physical environment, access to technology and digital tools, curricular content and structure, instructional model and tasks, interactions, digital citizenship, student engagement, instructor engagement, and assessment/feedback. In addition, each observer recorded a narrative description of the lesson that included additional information regarding each of the components listed above. These observations enabled us to describe interactions among students and teachers in the courses and provide context for interpreting results.

In addition, the district developed surveys to collect feedback from participating teachers and students. Teachers were asked to rate the same six items on a Likert-type scale (*strongly agree, agree, disagree, strongly disagree*) for each round of surveys. The items included questions related to professional development, the reliability of equipment, peer collaboration, coaching, and technical assistance. Telepresence staff was also given the option to provide "additional feedback or comments on the telepresence program" at the end of the survey, and we identified themes about their experiences with telepresence teaching. Three teachers taught telepresence classes in the first year (2015–2016), and more teachers were added to staff classes in each of the subsequent 2 years, with no teachers dropping from the telepresence teaching roster. Thus, we have responses from some of the same teachers from year to year in the *Telepresence Staff Survey*, which was administered electronically in March 2017 ($n = 11$), March 2018 ($n = 14$), and November 2018 ($n = 18$). Survey response rates varied from 87% to 100%.

We also analyzed data from a student survey administered in November 2018 by the district that asked participating students to reflect on their experiences with telepresence courses (*Telepresence Student Experience Survey*). A total of 499 students responded to Likert-type scale questions (*strongly agree, agree, disagree, strongly disagree*) and rated the following aspects of their experience:

- course requirements clearly communicated,
- teacher creates a learning environment that allows for questions,
- instructor encourages me to participate in class,
- telepresence technology facilitates my interactions with remote classmates, and
- technology provides multiple opportunities for student input throughout the course.

Table 1
MPS and Telepresence Sample Characteristics

	All Students	All Telepresence	Remote Only
Female	0.494	0.540**	0.571**
	(0.500)	(0.499)	(0.496)
Black	0.617	0.556**	0.535**
	(0.486)	(0.497)	(0.500)
Asian	0.073	0.116***	0.076
	(0.260)	(0.321)	(0.267)
White	0.103	0.133**	0.206***
	(0.304)	(0.339)	(0.406)
Hispanic	0.199	0.188	0.171
	(0.399)	(0.391)	(0.377)
Other race	0.007	0.007	0.012
	(0.086)	(0.086)	(0.108)
English Language Learner (ELL)	0.125	0.101*	0.094*
	(0.331)	(0.302)	(0.293)
Free/reduced-price lunch (FRL) eligible	0.743	0.720**	0.682***
	(0.437)	(0.449)	(0.467)
Special education (SPED) eligible	0.223	0.085***	0.053***
	(0.416)	(0.279)	(0.225)
9th grade	0.108	0.013***	0.012***
	(0.311)	(0.113)	(0.108)
10th grade	0.323	0.114***	0.165**
	(0.468)	(0.318)	(0.372)
11th grade	0.306	0.331***	0.347***
	(0.461)	(0.471)	(0.477)
12th grade	0.263	0.541***	0.476***
	(0.440)	(0.499)	(0.501)
Number of credits earned in prior year	5.534	6.400***	6.636***
	(2.060)	(1.326)	(1.204)
Number of credits attempted in prior year	6.943	7.077**	7.028
	(1.148)	(0.776)	(0.831)
Prior year percent absent	0.152	0.085***	0.067***
	(0.173)	(0.096)	(0.077)
Prior year GPA	1.933	2.569***	2.855***
	(1.041)	(0.885)	(0.805)
Number of student-year observations	56,710	398	181

*$p < .01$. **$p < .05$. ***$p < .001$.

The survey also allowed students to respond to open-ended questions about the telepresence activities, the benefits and challenges of taking a course through telepresence, and their recommendations for promoting and improving telepresence courses. Eighty-eight percent of students responded to the open-ended questions. When comparing differences between groups, we ran two-tailed *t* tests, using a .05 significance level.

Findings

Telepresence Implementation

Most telepresence courses offered in MPS are made available to students in the district from one MPS school to another. MPS did initiate a telepresence partnership with one rural Wisconsin district, where MPS provided an American Sign Language course and Northland Pines provided AP computer science. However, the expansion of rural/urban telepresence partnerships across the state has been limited by different school-year and bell schedules. Making these partnerships work requires considerable flexibility between the partners. In addition, the MPS model for implementing telepresence recognizes the importance of social presence for the success of telepresence learning in advanced courses. MPS staff leading this initiative want students to feel as though they are in one classroom, regardless of whether they are accessing the instructional resources and their peers remotely or on-site.

To cultivate social presence, MPS telepresence teachers and support staff developed various strategies that they employ at the start of the semester and throughout the class. Initially, they create seating charts and have students wear name tags, and they motivate students to get to know each other by giving them quiz credit for being able to place their peers on the seating chart. In the first 3 days of the class, each student is required to speak in front of the

camera, and students also contribute three photos to a Google slide deck that includes interesting facts about the students that help them to get to know each other. Throughout the class, the teachers make Google Hangouts available for students to communicate, arrange field trips for students to get to know each other, and have learning opportunities where they are all physically present. They also draw on para-professionals at the remote learning sites to ensure that there are consistent and regular communications with the course instructor. Some courses also offer Saturday study sessions where students from all participating schools work together in-person. The explicit aim of these components of the telepresence courses are to build relationships and a sense of community within the student cohorts and with their teachers.

The MPS teachers who are involved in telepresence volunteered for training that was provided by Cisco via telepresence. MPS subsequently developed its own teacher-led telepresence training, where every other month teachers and facilitators are invited to attend an afterschool professional development session. Telepresence teachers are encouraged to "look for" the following to monitor presence in their classrooms: interactions across all sites between instructors and students and among students, teacher use of technological tools to facilitate those interactions, and whole and small group instruction. In addition, because promoting social connections among the teachers is as important as those they cultivate among their students, the telepresence teachers and facilitators hold social gatherings twice a semester at a local restaurant that provides the opportunity to engage in a more casual setting. They also have an email group where posts with photos from different projects and classrooms are shared to provide information and updates on the different activities going on in the telepresence program as well as notice of upcoming events like parent-teacher conferences and exam schedules. Teachers get paid for their time in professional development, but the program developers intend for this network, support system, and the sense of community that is created to encourage teachers to make the considerable investment required to become an effective teacher in telepresence courses.

Class Observations

We observed three telepresence classes in MPS, two AP courses and one elective course: AP Spanish, AP Calculus, and Japanese. Three different teachers instructed each course, and students participated from two or three different high schools in each of the courses. These three courses were selected because the teachers had more than 1 year of experience teaching via telepresence, and the telepresence unit in the host school for these courses was known to be operating relatively smoothly. Class sizes across all MPS telepresence courses ranged from 8 to 30 students, which is in line with district norms for AP courses (the College Board recommends a maximum of 25 students). The class sizes we report below are *observed* class sizes on a given day and do not reflect any absences.

In AP Spanish, students connected from two remote classrooms with students in the host school (a total of 20 students among the three classrooms). The lesson was conducted primarily in Spanish, and after some minor technical difficulties with the microphone audio, the discussion of an article in Spanish got underway. The teacher set out discussion questions and encouraged engagement from students in all three classrooms. She had students read aloud in Spanish from an article. Each student took a part and then called to another student to read; they knew each other's names and reached out across the three classrooms. The video shifted focus automatically to the student reading; the students had to be following along to know where to pick up the line when selected to read by another student. After a half hour, the students all took out their computers and accessed the course materials online. Students wrote answers to questions posed by the teacher, and the teacher used Google Classroom to view responses. The students were required to comment on the responses of at least two other students, which the class then discussed with the teacher via Google Classroom.

The AP Calculus class brought together 15 students from three classrooms, and the lead teacher used a whiteboard to teach concepts and work out problems in whole-class instruction. As he was differentiating a question on the whiteboard, he asked the students for their input and to consider whether a given function was continuous or differentiable. The teacher moved around the room, asking questions and sharing input from a given student with the others, using it as a "teaching moment" for all. The students were then asked to solve problems and indicate the correct (multiple choice question) response. The instructor posted a new problem and solved it with student input (with students simultaneously working out the problems on their own). The instructor then showed questions from an actual AP exam and discussed strategies for efficiently solving the problems. As one strategy to maintain "presence" in the classroom, the instructor would check students' "comfort level" verbally across the three classrooms as he worked out problems, while support teachers (facilitators) also took the "temp of the room" during the lesson. As the class session wound down, the teacher gave instructions for the students to work through practice problems and look at instructional support materials homework. There was minimal static in the audio, and a technical support staff person was troubleshooting the problem during the class. Differing bell schedules across the schools also created a small transition issue, where students from one school were still in the AP Spanish classroom so that students attending AP Calculus from that school had to enter the telepresence session late.

The Japanese elective course included 16 students from two classrooms. The teacher and the students all spoke Japanese during the class session. The teacher and students had created fictional families that they described in Japanese to each other. The teacher then used the screen to test the students' knowledge of Japanese characters; the students called out in unison the character pronunciations. The teacher shifted to showing Japanese words and called on students to identify their meaning. Some students were quieter, and some raised their hands and were more engaged. The teacher then told students to get a whiteboard. She displayed a sentence and asked the students to write it and read it out loud in Japanese. They discussed grammar and punctuation. The students were just 2 months into their first Japanese course. The acoustics were sometimes problematic in that a cough, laugh, or movement seemed to be magnified in the sound level.

Overall, we saw little difference in teacher and student "presence" in the classrooms, regardless of whether we were observing

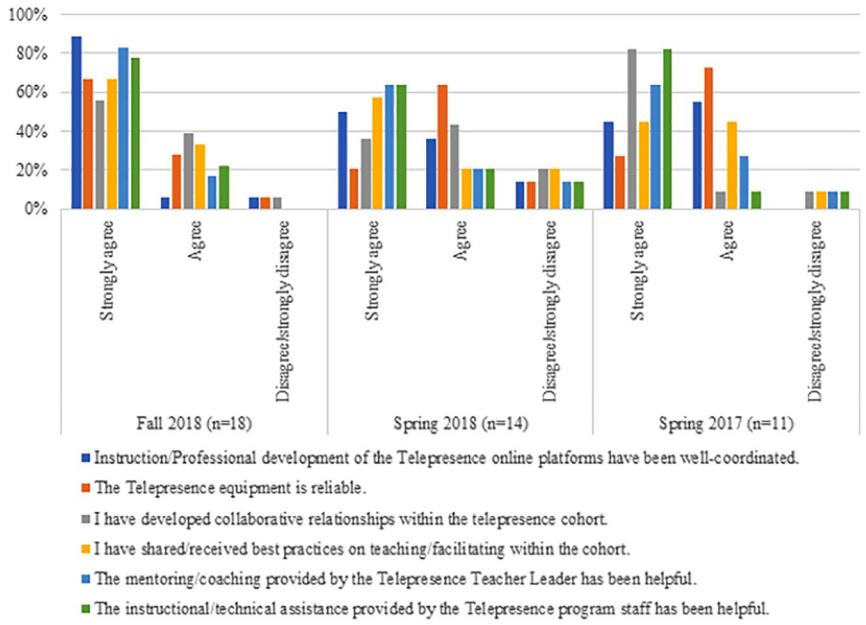

FIGURE 1. *Telepresence staff experiences.*

the teacher and students remotely or on-site. The few technical difficulties in the audio did not disrupt the lessons. Students seemed to know each other and called on each other by name across the classrooms engaged in the telepresence sessions.

Telepresence Staff Experiences

As indicated above, MPS teachers involved in telepresence instruction were surveyed by the district at three separate time points. The staff responses shown in Figure 1 indicate high levels of agreement (strongly agree/agree) over time to the statements that describe the telepresence program as well-coordinated, the equipment as reliable, the mentoring/coaching and instructional/technical assistance as helpful, and the relationships as collaborative, with high levels of sharing of best practices. The responses to each question over time also suggest perceptions of continuous improvement in the coordination of the instruction and professional development for the use of telepresence. In the most recent staff survey, there is much greater confidence in the reliability of the equipment. Agreement is also strongest in the most recent survey that the mentoring/coaching and sharing of best practices were helpful and working well.

Five (Spring 2017), seven (Spring 2018), and eight (Fall 2018) respondents also provided open-ended comments. While self-selected, the comments were uniformly positive with consistent themes over time. The following comments are emblematic of feedback offered across the three survey waves:

> *This has been a remarkable experience for me. I have learned practices that have changed my teaching. Working with our Telepresence coach has been really rewarding—developing those relationships with the other Telepresence teachers has been very helpful as well. Teaching a wonderful group of students on the other side of the screen presents challenges but is truly rewarding.*
>
> *This is a phenomenal program for opening doors within the schools in our district and for being more able to match classes and teachers with students' needs and interests. I hope to see this program continue to grow.*

Teachers also embedded suggestions for improving the program in their feedback:

> *Supporting a future stipend for telepresence teachers would be appreciated in acknowledging the extra work that goes into being a part of this program. It is meaningful to have connections with students across the district, but also logistically complicated.*
>
> *As we continue, I would love to also meet more frequently as an experienced cohort, as our needs develop differently than those working their way through the developing side of Telepresence.*

MPS teachers get paid for their time in professional development to acquire the skills required for teaching in the telepresence program. However, given the substantial need in the district for more telepresence-trained teachers, the district might consider offering other incentives and support (as suggested by teachers in the surveys) to encourage the considerable investment required to become effective teachers in telepresence courses.

Telepresence Student Experiences

The analysis of the Likert-type scale questions on the student survey—comparing responses of students who experienced the class remotely versus on-site—showed generally favorable experiences. Over 90% of the students agreed or strongly agreed that course requirements were clearly communicated, and about 95% of students agreed or strongly agreed that the teacher created a learning environment that allowed for questions, with no statistically significant differences between remote and on-site student responses ($\rho = 0.981$). In addition, about 93% of students agreed or strongly agreed that the teacher encouraged

them to participate in class. But here there were some differences between remote and onsite students ($\rho = 0.070$), where remote students were more likely to disagree that they were encouraged to participate in class. Approximately three-fourths of the students agreed that the telepresence technology facilitated their interactions with remote classmates, although remote students were slightly more likely than on-site students to disagree with this statement. Lastly, about 86% of the students agreed or strongly agreed that the telepresence technology provided multiple opportunities for student input throughout the course.

Among student responses to the open-ended questions, the most common responses suggested that students appreciated the opportunity to take advanced courses that otherwise would not have been offered at their school and liked getting to know and interact with students from other schools. For instance, one student explained that participating in a telepresence course allowed them "to meet other students and make connections with other schools to form more of a community within our school district." Specifically, students enjoyed hearing opinions, ideas, and perspectives of students from other schools and parts of the community that were different from their own, as highlighted by a student in the following excerpt.

> *One benefit is that we get to engage with another school, with students completely different from us. Like when playing Kahoot! or Quizlet Live. Our discussions are very informative, and because we're so different, we learn more and better ways to learn new things. Another benefit would be that we learn how to do things on our own. Our teacher switches schools every once in a while, and that gives both schools the opportunity to get the feel without the teacher in the other room.*

Students also appreciated experiencing a new way of learning. Beyond recreating the traditional classroom environment, students identified increased access and use of audiovisual tools as a valued benefit of telepresence classrooms (Themelis, 2014). For instance, the use of technology made the following student feel more comfortable engaging in instructional activities:

> *You get to meet people from a school you don't even go to. Also, if you're a shy person, this helps you lose that shyness by interacting with other people, because it's like a video chat. Kids feel more comfortable with modern technology.*

Students also remarked on other benefits facilitated by the technology and the MPS model for facilitating "presence," such as the ability to access classes from their phones and the opportunity to collaborate via video chat. One student explained:

> *One of my favorite assignments was when we made presentations, but in order to communicate with our partner from a different school, we used Google Hangouts, and that was fun and cool to use because it was like Facetime.*

As highlighted in the above excerpt and similar student comments, participation in telepresence courses increased access to advanced course content and facilitated enhanced engagement for many students.

Although they were a minority of the responses, some students did not see any benefits of telepresence courses. When asked to describe challenges to taking a telepresence course, there were commonalities in the responses. Students remarked that it was more difficult to get one-to-one assistance from the teacher, and some felt challenged by the pacing of the instruction. Students also commented on technical difficulties, including poor connections, noise levels, and problems accessing networks outside of school. They also described logistical challenges associated with different bell schedules or other issues (e.g., pep rallies, fire drills) that caused them to miss part of the instruction.

Student comments reflected a range of opinions about their overall experiences. Some students indicated a clear preference for the traditional classroom setting and did not believe telepresence should be continued or expanded, while others were very happy with the classes or, as in this quote, saw telepresence having a major role in the future of high school education:

> *Increased use of telepresence will have the kinks increasingly worked out and the experience increasingly improved. I think that this could be a great thing for MPS and could one day lead to an interconnected school system. Ideally, it could even represent the future of education. The worst thing that MPS could do to telepresence would be to abandon it.*

Given that telepresence classes may not be desirable or suitable for everyone, some of the students suggested that MPS should allow students to try out telepresence before committing to taking a course via this technology.

Increasing Access to AP Courses

Nearly three quarters of telepresence courses were classified as AP courses. This is the best proxy for advanced coursework available in the data. In our analysis, we estimated the number of AP courses in which a student enrolled (in a given school), comparing students in schools where no students participated in a telepresence course with students in schools where one or more students participated in a telepresence course. Students attending schools that offered telepresence enrolled in more AP courses than students attending schools that did not offer telepresence courses. Depending on the year, students attending schools offering telepresence enrolled in 0.849 to 0.928 AP courses on average, compared to 0.333 to 0.512 AP courses completed per student in schools in years that telepresence courses were not offered. In addition, while the number of AP courses in which students enrolled decreased over time in both school types, student enrollment in AP courses decreased to a lesser extent in schools where students had the option to participate in telepresence courses.

Table 2 reports the results from a student fixed effects analysis that compares students with themselves in alternative years.[5] The main treatment estimates are thus driven by differences in outcomes between the years when students did and did not participate in telepresence. Specifically, we examine the number of AP courses that a given student enrolled in during the years he or she took a telepresence course to the number of AP courses that he or she enrolled in during the years that the student did *not*

Table 2
Associations Between Participation in Telepresence Courses and AP Enrollment, Test Scores, and Absences

	Number of AP Courses	Reading Score (*SD*)	Math Score (*SD*)	Percent Absent	ACT Comp Score (1–36)
Participated in telepresence course(s)	1.347***	–0.006	–0.043	–0.002	1.897***
	(0.107)	(0.055)	(0.074)	(0.005)	(0.237)
Constant	0.654***	0.107*	0.227	–0.040	23.066***
	(0.001)	(0.047)	(0.213)	(0.032)	(0.990)
Student and grade fixed effects	Yes	Yes	Yes	Yes	
Eighth grade student and school covariates					Yes
Number of observations	56,700	19,538	19,953	57,282	3,602
Participated remotely in telepresence	1.508***	0.064	0.001	–0.015*	2.890***
	(0.195)	(0.079)	(0.107)	(0.007)	(0.489)
Constant	0.663***	0.107*	0.227	–0.040	23.112***
	(0.001)	(0.047)	(0.213)	(0.032)	(1.009)
Student and grade fixed effects	Yes	Yes	Yes	Yes	
Eighth grade student and school covariates					Yes
Number of observations	56,700	19,538	19,953	57,282	3,602

Note. Eighth-grade student covariates include whether the student failed a course in eighth grade, race/ethnicity, gender, FRL status, special education classification, and ELL distinction. School covariates include school enrollment count, school type (i.e., neighborhood, alternative, charter), the proportion of students in the school identified as ELL, FRL, and proportion of students enrolled in special education, advanced coursework, work-study, service learning, and career/technical education. We also controlled for the geographic region of the school as indicated by the school board member district and a fixed effect for the school year.
*$p < .10$. ***$p < .001$.

Table 3
Sensitivity Test Examining Associations Between Telepresence Participation and Student Outcomes Controlling for Student Covariates and Prior Year Performance

	Number of AP Courses	Reading Score (*SD*)	Math Score (*SD*)	Percent Absent
Participated in telepresence course(s)	1.161***	0.094	–0.025	–0.001
	(0.117)	(0.073)	(0.100)	(0.005)
Adjusted *R*-squared	0.063	0.087	0.065	0.163
Number of observations	37,875	10,349	10,560	37,870
Participated remotely in telepresence	1.422***	0.272**	0.057	–0.009
	(0.221)	(0.101)	(0.165)	(0.008)
Adjusted *R*-squared	0.055	0.088	0.065	0.163
Number of observations	37,875	10,349	10,560	37,870
Student and grade fixed effects	Yes	Yes	Yes	Yes
Current year student covariates	Yes	Yes	Yes	Yes
Prior year achievement covariates	Yes	Yes	Yes	Yes

Note. Student covariates in the above models include prior year attendance, credits earned/attempted, and GPA as well as any changes in ELL, special education, and FRL status.
**$p < .05$. ***$p < .001$.

enroll in a telepresence course. This analysis indicates that participation in one or more telepresence courses in a given year translated into enrollment in 1.347 (SE = 0.107) more AP courses. Remote participation in a telepresence course translated into even higher AP course enrollment (M =1.508, SE = 0.195). Given that most students participated in one or two telepresence courses, it appears likely that many, if not most, AP telepresence courses represented an AP course in which the student would otherwise not have been able to enroll. We observed qualitatively similar results in sensitivity tests that controlled for student covariates including a student's prior year attendance, credits earned/attempted, and GPA as well as any changes in ELL, special education, and FRL status, as reported in Table 3. By student subgroup, we observed comparable gains among students identified as Black or Hispanic and with FRL status but not among students receiving ELL and special education services, as shown in Table 4.

Student Test Scores and Attendance

In Table 2, we also present the results from a student fixed effects analysis that compares student test scores and attendance in the years in which a given student enrolled in one or more telepresence courses to the same students' test scores and attendance in the

Table 4
Associations Between Participation in Telepresence Courses and Test Scores and Absences by Student Subgroup

All Telepresence Participants				
	Number of AP Courses	Reading Score (*SD*)	Math Score (*SD*)	Percent Absent
Student race: Black	1.033***	–0.025	–0.016	–0.007
	(0.128)	(0.068)	(0.087)	(0.007)
Observations	35,327	11,901	12,168	35,323
Student ethnicity: Hispanic	0.885***	0.089	–0.025	0.004
	(0.258)	(0.128)	(0.165)	(0.010)
Observations	11,826	4,516	4,493	11,826
English language learners	0.253	0.123	–0.366	0.027
	(0.402)	(0.159)	(0.405)	(0.018)
Observations	7,309	2,902	2,952	7,309
Free/reduced-price lunch	1.087***	–0.047	–0.079	–0.000
	(0.129)	(0.067)	(0.105)	(0.007)
Observations	42,863	15,173	15,447	42,861
Received special education services	0.513*	–0.036	–0.016	0.009
	(0.205)	(0.098)	(0.204)	(0.020)
Number of observations	13,446	4,137	4,137	13,443

Remote Telepresence Participants Only				
	Number of AP Courses	Reading Score (*SD*)	Math Score (*SD*)	Percent Absent
Student race: Black	0.978***	0.093	0.056	–0.016
	(0.235)	(0.091)	(0.113)	(0.010)
Observations	35,327	11,901	12,168	35,323
Student ethnicity: Hispanic	1.659**	N/A	N/A	–0.026*
	(0.520)			(0.011)
Observations	11,826			11,826
English language learners	1.502	N/A	N/A	0.001
	(0.941)			(0.016)
Observations	7,309			7,309
Free/reduced-price lunch	1.162***	0.057	–0.033	–0.010
	(0.224)	(0.097)	(0.100)	(0.010)
Observations	42,863	15,173	15,447	42,861
Received special education services	0.790	0.075	0.199	–0.009
	(0.523)	(0.110)	(0.133)	(0.034)
Number of observations	13,446	4,137	4,137	13,443

Note. The above models control for student and grade fixed effects for the subgroup indicated. N/A indicates there were insufficient students in the subgroup to conduct the analysis. Specifically, students identified as Hispanic and English language learners were typically not tested when enrolled in telepresence remotely.
*$p < .10$, **$p < .05$, ***$p < .001$.

years they did *not* enroll in a telepresence course. Participating students did not have significantly different standardized test scores when enrolled in a telepresence course, either in person or remotely. However, the percentage of days absent from school was lower by approximately 2% among students participating in telepresence courses remotely (versus when not participating). Results were not sensitive to the inclusion of student covariates apart from a positive association with reading test scores that emerged among students enrolled remotely (see Table 3). Estimates were also generally consistent across subgroups (see Table 4), although we did observe lower attendance among the relatively small number of students identified as Hispanic who participated remotely.

We next examined the ACT scores of students enrolled in one or more telepresence courses compared to the scores of students who never enrolled in a telepresence course after controlling for eighth-grade student and school covariates. To be included in this analysis, students must have taken the ACT, which is generally administered to all 11th-grade students. Table 2 shows that students who participated in one or more telepresence courses (on-site or remotely) and took the ACT

scored approximately two points higher on this test. Students who participated remotely scored approximately three points higher on the ACT.

Conclusion

Our mixed-methods analysis of a telepresence program in a large, low-income urban school district suggests that telepresence may be a promising and viable technology for increasing student opportunities to take advanced courses in high school. The empirical analysis confirmed that students enrolled in telepresence courses also enrolled in more AP courses. Students were absent less frequently while enrolled in telepresence courses and scored higher on the ACT than similar students who never took a telepresence course. The estimated associations are substantial in size—the observed two-point increase in ACT scores would move a student previously projected to score at the 50th national percentile to above the 60th percentile (ACT, 2019).

The program features implemented in MPS—including relatively small class sizes, robust professional development, best practices sharing among instructors, and networking and relationship building between teachers and students across classrooms and outside the school day to cultivate presence—appeared to contribute to positive overall experiences for students and teachers in telepresence courses (Filges, Sonne-Schmidt, & Nielsen, 2018; Van Driel & Berry, 2012). Without these features, such positive results would likely not have been possible. Teachers and students appreciated the opportunity to interact with students from other schools and to experience a new way of teaching or learning with this technology. Opportunities to interact with classmates attending other schools through videoconferencing and in-person field trips appeared to support the development of community and sense of belonging that are precursors to engagement and learning despite the geographic distance (Themelis & Bougia, 2016). Although some technical and logistical difficulties reduced the quality of the learning experience at times, the staff experiences surveys suggested that the reliability of the technology improved over time, with research suggesting that overcoming these initial barriers around operational technology use are precursors to successful instructional use (Bower, 2011).

While both students taking the telepresence courses remotely and those on site were largely positive and enthusiastic about their experiences, some students were challenged by the pace of instruction and felt that they would have benefitted from more one-to-one support from teachers. Students also mentioned problems accessing networks to do their work outside of school, which is a broader challenge for equity in access to educational technology with low-income student populations (Heinrich et al., 2019; Warschauer & Matuchniak, 2010). Sustained positive feedback, rapidly expanding advanced course offerings, and climbing student enrollment in telepresence courses suggest that MPS was largely navigating these hurdles well, although we acknowledge the limitations of generalizing these findings from a single case study to other districts. The Cisco Connected Education website includes information on how other school districts can acquire and use telepresence technology to support increased learning opportunities for students.[6] More broadly, we encourage districts looking to expand AP course offerings while struggling with low enrollments in certain schools to consider whether this type of technology-facilitated resource sharing might allow more students to access rigorous courses with the potential to earn college credit. While many tools might be used depending on district resources and contexts, educators and researchers should continue identifying where new technologies can play a role in providing more students access to high-quality educational experiences in low-resource school settings.

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[1]See https://apcentral.collegeboard.org/about-ap/start-grow-ap/access-initiatives/ap-opportunity-program.

[2]See https://www.cisco.com/c/en/us/solutions/industries/education/case-studies.html#~tab-one.

[3]Across the district, around half of all 9th and 10th graders took a standardized assessment, compared to only one third of 11th graders and fewer than 5% of 12th graders. All students were required to take the ACT under Wisconsin law.

[4]We were not able to cluster by school as over 15% of students changed high schools at least once during the 3-year study period. However, we did estimate the models employing student fixed effects clustering the standard errors by students' first high school attended as a sensitivity test. Results were qualitatively similar in terms of magnitude, directionality, and significance.

[5]Results are qualitatively similar in direction, magnitude, and significance when we control for year fixed effects. We chose not to report these as our preferred estimates due to concerns over using two-way fixed effects (see Imai & Kim, 2019). Additionally, an examination of pretreatment trends among students comparing future participants to students who never participated in the 2015–2016 and 2016–2017 school years identified no significant differences for most models. Exceptions included the model predicting the number of AP courses when examining students who participated in any form of telepresence and the model predicting reading test scores when examining students who ever participated remotely. As such, we recommend caution in interpreting these coefficients considering some differences in pretreatment trends.

[6]See https://www.cisco.com/c/en/us/solutions/industries/education.html#~stickynav=4.

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