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

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Abstract

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: telepresence, distance learning, digital learning, educational access, advanced course-taking

Access to advanced high school courses to promote college readiness and increase learning opportunities has been gradually expanding and has more recently been propelled by concerted efforts to foster participation 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."[2] While over time participation in AP courses has increased at a rapid rate among racially and socioeconomically diverse students, disparities in access persist (Malkus, 2016; Kolluri, 2018). Kolluri, for example, points out that students in a low-income school may have only basic computer literacy courses, whereas a wealthier school may offer a full slate of advanced and AP computer science courses.

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 that are not able to offer more advanced course options because of financial and personnel constraints. Also known as distance education courses, they are defined by the Institute of Education Sciences 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." In a national survey conducted during the 2009-2010 school year, Queen & Lewis (2011) found that 55 percent of public school districts reported having students enrolled in distance education courses (largely at the high school level). Most school districts (79 percent)

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

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 percent were for Advanced Placement (AP). The primary mode of instructional delivery for the distance education courses (for 63 percent) was via the Internet using asynchronous instruction.

Newer telepresence learning systems alternatively utilize high-end videoconferencing to emulate traditional classroom experiences and facilitate two-way, synchronous communication. To date, there has been very limited research on the use and effectiveness of these telepresence learning systems in K-12 education. Most studies that examine their use and effectiveness for expanding educational opportunities have focused on higher education and medical education (Means et al., 2009; Gray et al., 2014; Bauer et al., 2015). 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 et al. (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. Apparently 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.[3]

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: 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 and their learning and engagement outcomes?

Methods

Program Description

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

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 more typical teleconferencing technologies. MPS describes its telepresence 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 wide screen interactive monitors that facilitate instructor-student interactions similar to what is feasible in face-to-face interactions in traditional high school classrooms. MPS is using the telepresence technology to expand the number of AP and other advanced and elective courses it offers in participating high schools in the district, as well as the number of students who can take these courses.

Data Sources

In this case study, we examine how MPS rolled out telepresence courses in the district during the 2015-16 through 2017-18 school years. MPS 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 2015-16) to 175 students across a dozen courses in 2016-17, and to over 17 different courses serving more than 400 high school students across 10 schools. Our analysis of the associations between telepresence course-taking and student outcomes drew on data from 571 students who engaged in telepresence courses, of whom 180 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.

[Insert Table 1]

Empirical Strategy

We drew on student-level data provided by the district to explore the relationship between student participation in telepresence courses (in-class or remotely) and educational outcomes, such as the number of AP courses in which a student enrolled, school absences, and standardized test scores. 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, due to the longitudinal nature of the outcome variable, these models did not employ student fixed effects and instead controlled for pre-treatment student, classroom, and school covariates.

We also observed three telepresence courses in the district that 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. We accordingly identified themes from teachers who were asked about their experiences with telepresence teaching in the *Telepresence Staff Survey* administered electronically in March 2017 (n=11), March 2018 (n=14) and November 2018 (n=18), and from

499 students who took at least one telepresence course and responded to the November 2018 *Telepresence Student Experience Survey*. Survey response rates varied from 87 to 100 percent.

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 in the far northern part of the state, where MPS provided an American Sign Language course and Northland Pines provided AP computer science in exchange. 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 in the classroom. To facilitate social presence, they make Google Hangouts available for students to communicate, arrange field trips for students to get to know each other, have learning opportunities where they are all physically present, and 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 is 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 after-school professional development session. 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 one year of experience teaching via telepresence, and the telepresence unit in the school that was the "home base" for these courses was known to be operating relatively smoothly.

In AP Spanish, students connected from two remote classrooms with students in the classroom with the lead instructor (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 went to the course material online. They 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 white board 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 then 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 calculus exam and discussed strategies for efficiently solving the problems. The instructor would check students' "comfort level" verbally across the three classrooms as he worked out problems. The 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 Spanish AP 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 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 two 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 the teacher and students remotely or in the room. The few technical difficulties in the audio did not disrupt the lessons, and 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. Teachers were asked to rate the same six items (see

Figure 1) on a Likert scale (strongly agree, agree, disagree, strongly disagree) for each round of surveys. 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 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.

[Insert Figure 1]

Telepresence staff were also given the option to provide "additional feedback or comments on the telepresence program" at the end of the survey, and five (Spring 2017), seven (Spring 2018) and eight (Fall 2018) respondents provided comments in response. 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, such as:

> *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, but given the substantial need in the district for more telepresence-trained teachers, the district might consider other incentives and support as suggested in the feedback for teachers to make the considerable investment required to become effective teachers in telepresence courses.

Telepresence Student Experiences

In reporting on their experiences with telepresence courses, 499 MPS students responded to Likert scale questions (strongly agree, agree, disagree, strongly disagree), if applicable, 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.

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. About 88 percent of students provided a response to the open-ended questions.

The analysis of the Likert scale questions—comparing responses of students who experienced the class remotely vs. on-site—showed generally favorable experiences with the telepresence classes. Over 90 percent of the students agreed or strongly agreed that course requirements were clearly communicated, and about 95 percent 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 (ρ=0.981). In addition, about 93 percent of students agreed or strongly agreed that the teacher encouraged them to participate in class, but here there were some differences (statistically significant at the 10 percent level, ρ=0.070), between remote and onsite students, 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 percent 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.*

As alluded to in the above excerpt, students also appreciated experiencing a new way of learning. 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 many commonalities in the responses. Students remarked that it is 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 a variety of technical difficulties they experienced, 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.

Other 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 ways that MPS could give students an opportunity to try out telepresence

before committing to taking a course via this technology or to learn more about the value of AP courses facilitated through telepresence.

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 courses 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 (mean = 0.849-0.928 AP courses) than students attending schools that did not offer telepresence courses (mean = 0.333-0.512 AP courses). 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 years when they did not participate in telepresence. Specifically, we examine the number of AP courses that a given student enrolled in during the years he/she took a telepresence course to the number of AP courses that he/she enrolled in during the years that the student did *not* 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 (Mean=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 prior year attendance, credits earned/attempted, GPA, and race/ethnicity as well as 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.

[Insert Table 2]

[Insert Table 3]

[Insert Table 4]

Student Learning and Engagement

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 course to the same students' test scores and attendance in the years they did *not* enroll in a telepresence course. Participating students did not achieve significantly different standardized test scores when enrolled in a telepresence course, either in-person or remotely. However, the percent of days absent from school is reduced by approximately two percent 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 course compared to the scores of students who never enrolled in a telepresence course after

controlling for 8th grade student, classroom, 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 course (in-person 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 were able to enroll in more AP courses through telepresence course-taking. Students were also absent less frequently while enrolled in telepresence courses and scored higher on the ACT test than similar students who never took a telepresence course. The program features implemented in MPS—including robust professional development, best-practice sharing among instructors, and networking and relationship building between teachers and students across classrooms and outside the school day—appeared to contribute to positive overall experiences for students and teachers in telepresence courses. Both 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. Although some technical and logistical difficulties reduced the quality of the learning experience at times, the staff experiences survey suggested that the reliability of the technology was improving over time.

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). Sustained positive feedback, rapidly expanding advanced course offerings, and climbing student enrollment in telepresence courses suggests 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.[4]

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

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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 Eligible (FRL)	0.743	0.720**	0.682***
	(0.437)	(0.449)	(0.467)
Special Education Eligible (SPED)	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

Asterisks indicate significantly different from students not enrolled in a telepresence course, * p<.01, ** p<.05, *** p<.001

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

	# of AP Courses	Reading Score (Std.)	Math Score (Std.)	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 & Grade Fixed Effects	Yes	Yes	Yes	Yes	
8th Grade Student, Classroom, and School Covariates					Yes
Number of observations	56,700	19538	19953	57282	3602
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 & Grade Fixed Effects	Yes	Yes	Yes	Yes	
8th Grade Student, Classroom, and School Covariates					Yes
Number of observations	56,700	19538	19953	57282	3602

* .10, ** .05, *** .001 significance level

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 (Std.)	Math Score (Std.)	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 & Grade Fixed Effects	Yes	Yes	Yes	Yes
Current Year Student Covariates	Yes	Yes	Yes	Yes
Prior Year Achievement Covariates	Yes	Yes	Yes	Yes

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 (Std.)	Math Score (Std.)	Percent Absent
Student Race: Black	1.033***	-0.025	-0.016	-0.007
	(0.128)	(0.068)	(0.087)	(0.007)
Observations	35327	11901	12168	35323
Student Ethnicity: Hispanic	0.885***	0.089	-0.025	0.004
	(0.258)	(0.128)	(0.165)	(0.010)
Observations	11826	4516	4493	11826
English Language Learners	0.253	0.123	-0.366	0.027
	(0.402)	(0.159)	(0.405)	(0.018)
Observations	7309	2902	2952	7309
Free/Reduced-Price Lunch	1.087***	-0.047	-0.079	-0.000
	(0.129)	(0.067)	(0.105)	(0.007)
Observations	42863	15173	15447	42861
Received Special Education Services	0.513*	-0.036	-0.016	0.009
	(0.205)	(0.098)	(0.204)	(0.020)
Number of observations	13446	4137	4137	13443
Remote Telepresence Participants Only				
	Number of AP Courses	Reading Score (Std.)	Math Score (Std.)	Percent Absent
Student Race: Black	0.978***	0.093	0.056	-0.016
	(0.235)	(0.091)	(0.113)	(0.010)
Observations	35327	11901	12168	35323
Student Ethnicity: Hispanic	1.659**			-0.026*
	(0.520)	*N/A*	*N/A*	(0.011)
Observations	11826			11826
English Language Learners	1.502			0.001
	(0.941)	*N/A*	*N/A*	(0.016)
Observations	7309			7309
Free/Reduced-Price Lunch	1.162***	0.057	-0.033	-0.010
	(0.224)	(0.097)	(0.100)	(0.010)
Observations	42863	15173	15447	42861
Received Special Education Services	0.790	0.075	0.199	-0.009
	(0.523)	(0.110)	(0.133)	(0.034)
Number of observations	13446	4137	4137	13443

N/A indicates there were insufficient students in the subgroup to conduct the analysis.

Figure 1.Telepresence Staff Experiences