EFFECTIVENESS OF SCIENCE AND MATHEMATICS TEACHERS ACROSS THREE LEARNING MODALITIES POST-COVID-19

Molly Weinburgh
m.weinburgh@tcu.edu
Texas Christian University

Melissa K. Demetrikopoulos
mdemetr@biophi.org
Institute for Biomedical Philosophy

Daniella Biffi
d.biffi@tcu.edu
Texas Christian University

Zhan Shi
zhan.shi@tcu.edu
Texas Christian University

John L. Pecore
jpecore@uwf.edu
University of West Florida

Dean Williams
dean.williams@tcu.edu
Texas Christian University

Andreas C. Thompson
athom177@vols.utk.edu
Institute for Biomedical Philosophy, and University of Tennessee

Abstract

Learning modalities implemented for reopening during COVID-19 impacted effectiveness of science and mathematics teachers in high-need local educational agencies (HN-LEAs). The distribution of learning modalities was very similar between Title I and SRSA/RLIS eligible HN-LEAs, with approximately half of each reopening in a hybrid fashion. From 2019 to 2022, students who initially returned to learning in-person had higher graduation rates and performance on science and mathematics tests than those who returned to remote or hybrid learning environments. However, these differences were already present in the 2018–2019 pre-pandemic baseline, suggesting reopening choices reflected yet-to-be-determined disparities between districts.

Keywords: high-need local educational agency, teacher effectiveness, learning modality, COVID-19, pandemic

Introduction

Traditional research on school district responses to past emergencies focused on episodic, localized events such as the impact of what was previously one of the most widespread and costly disasters (NOAA, 2019), Hurricane Katrina (e.g., Cannon et al., 2009; Loder-Jackson & Sims, 2008; Phillips & Herlihy, 2009). However, closing and reopening of US schools in response to COVID-19 was far from episodic or localized. An event such as this was predicted, almost 20 years ago by Laprairie and Hinson (2006), who argued that deadly flu outbreaks or bioterrorist attacks would disrupt education in the future as hurricanes had in the past, and that states and local districts should prepare for this inevitability by developing guidelines and infrastructure to move instruction virtually. Despite early warning and advances in virtual and distance education, very little infrastructure or guidelines were in place when COVID-19 hit. In 2020, K-12 schools transitioned

to virtual instruction, and during the course of COVID-19, teachers and students experienced learning modalities they had not encountered before or with which they had little experience.

Objectives of the Study

This project examines (a) which learning modalities were utilized by HN-LEAs during COVID-19, and (b) how school reopenings during COVID-19 impacted middle school and high school science and mathematics teacher effectiveness in HN-LEAs.

Related Literature

Learning modalities are defined according to the Center for Disease Control (CDC) as being In-Person (five days per week face-to-face), Remote (all instruction online/remote), or Hybrid (any one of many combinations of remote and face-to-face) (HHS, 2022). Although districts reported returning to the classroom with one of these modalities, the Institute of Education Science (2022a, b) found inconsistent implementation related to school characteristics (e.g., demographics, geographic location). The complexity of teaching is increased by this implementation as well as shifting contexts (e.g., student demographics, school environment, political climate). Shizari et al. (2022) stressed that effectiveness differentiates across disciplines as well as across cultural and organizational contexts. Effectiveness is defined as the "ability to produce the required results or capacity to produce output" (Akram & Malik, 2021, p. 140). Cantrell and Kane (2013) did not find a 'silver bullet' for detecting effectiveness but three widely used measures are structured observations of teaching, student achievement, and student perception of the teacher. Teacher effectiveness measures in this study focused on student achievement and included standardized mathematics and science scores, as well as high school graduation rates, beginning with the 2018-2019 academic year, since student standard scores or academic gains are readily available across school districts and are not subject to concerns with retrospective data collection.

Methodology

Sample Selection

The details of the sample selection and exclusion criteria are provided in (Shi et.al., 2024; Weinburgh et al., in press) using data from large public datasets (i.e., US Department of Education (USDE, n.d.), National Center for Educational Statistics (NCES, 2022), and Health and Human Services public data (HHS, 2022; DHHS, 2022). Four HN-LEAs were randomly selected per US

Census Division (n=36). In order to include a diversity of HN-LEAs, within each division, two HN-LEAs were eligible for Title I Funding (USDE, n.d.), and two were eligible for Small, Rural School Achievement (SRSA) (OESE, n.d.-a), or Rural or Low-Income School (RLIS) (OESE, n.d.-b) programs. In addition, the districts were verified to meet the economic criteria of having either at least 20% or 10,000 children participating in free or reduced lunch. The final section included 36 districts located in 20 states. Exclusion criteria included service agency listings, independent charter districts, districts without all grades K-12, and districts that did not report their learning modalities.

Determination of Learning Modality

RQ 1: What learning modalities were used by HN-LEAs beginning in Fall 2020?

In this study, HN-LEAs (hereinafter "districts") are grouped, for all years of analysis, by the learning modalities implemented Fall 2020. In-Person, Remote, and Hybrid Learning modalities were defined according to the CDC (HHS, 2022).

Time Points

The research period includes four academic years, starting from 2018-19.

- 2018-2019 academic year: pre-COVID-19 pandemic baseline when teaching and learning occurred in in-person classroom settings.
- 2019-2020 academic year: COVID-19 pandemic began and teaching and learning shifted to a virtual environment starting in March 2020 for the remainder of the academic year. While graduation rate data were available for the 2019-2020 academic year, standardized testing was suspended and thus not available.
- 2020-2021 academic year: districts reopened with a variety of learning modalities and, for all the years in this study, districts are grouped by the Fall 2020 Learning Modalities.
- 2021-2022 academic year: majority of districts return to fully in-person.

Determination of Teacher Effectiveness

RQ 2: How did the use of different learning modalities contribute to STEM teacher effectiveness in HN-LEAs?

Multiple measures were used to operationalize teacher effectiveness at the district level, from the 2018-2019 academic year (pre-pandemic) through the 2021-2022 academic year, including high school graduation rates, and four standardized test scores: high school mathematics, high school science, middle school mathematics, and middle school science. The tests given varied across

districts but were consistent within districts over time. For the middle school tests, 8th grade was chosen unless the district only administered both tests in 7th grade. Districts often reported standardized End of Course tests (e.g. Algebra I, Biology) for their high school measures of mathematics and science proficiency rather than being grade specific; but other districts choose to administer tests like the ACT to all of their students at a particular grade for their reported measures. Once districts were identified for inclusion in the study, the data sets used for teacher effectiveness were retrieved from public-facing school or district level webpages or from the relevant state department of education websites. In cases where data could not be located, districts were contacted to either provide the data, or to clarify why it was not available. Data were not publicly reported by some districts that served a small number of students in order to protect student privacy in compliance with the Family Educational Rights and Privacy Act.

Data were not imputed, and a complete case analysis was used, whereby, for any specific measure, districts were excluded from analysis and data visualizations if data were missing for that measure in any year. Imputing the data was not appropriate for at least two reasons: (a) data were collected over a time period whereby it was anticipated that the data would change across time points, and (b) data are missing differently from different groups and so do not appear to be "missing completely at random" or even "missing at random" (van Buuren, 2018).

Results and Discussion

Learning Modality

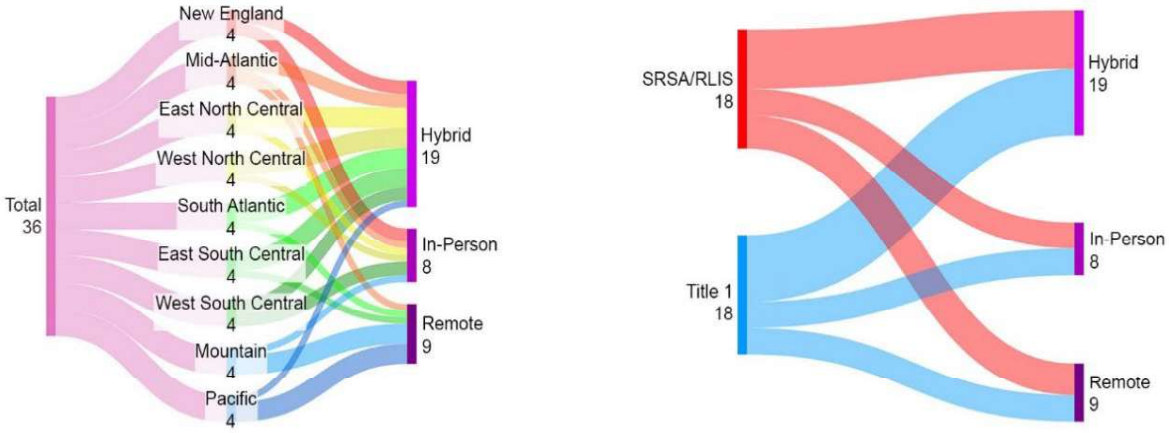
Approximately half of the representative HN-LEAs (53%) reopened with a hybrid learning modality, and approximately a quarter reopened with remote (25%) and in-person (22%) modalities (Figure 1a). For eight of the nine Census Divisions, only two of the three learning modalities were utilized within their districts, and for the remaining Division, Mid-Atlantic, all three of the learning modalities were utilized. Hybrid instruction was used as a learning modality option in eight of the nine Census Divisions; in-person instruction was used in six; and remote instruction was used in five. When the Divisions are grouped by Census Regions, it was noted that none of the districts included in the study from within the Midwest Region (i.e., East North Central and West North Central Census Divisions) used remote instruction.

There was no distinction between learning modalities used by the HN-LEAs participating in the different federal programs. Distribution across learning modalities was similar between Title I and combined SRSA/RLIS districts with 56% of Title 1 and 50% of SRSA/RLIS districts reopening

with a hybrid learning modality; 22% of Title 1 and 28% of SRSA/RLIS districts reopening remotely; and 22% of both Title 1 and SRSA/RLIS districts reopening in-person (Figure 1b).

Figure 1 a and b

a. *Learning Modalities Used by Four Randomly Selected HN-LEAs in Each of Nine Census Divisions* and b. *Learning Modalities Used by Eligibility for Federal Program Type*



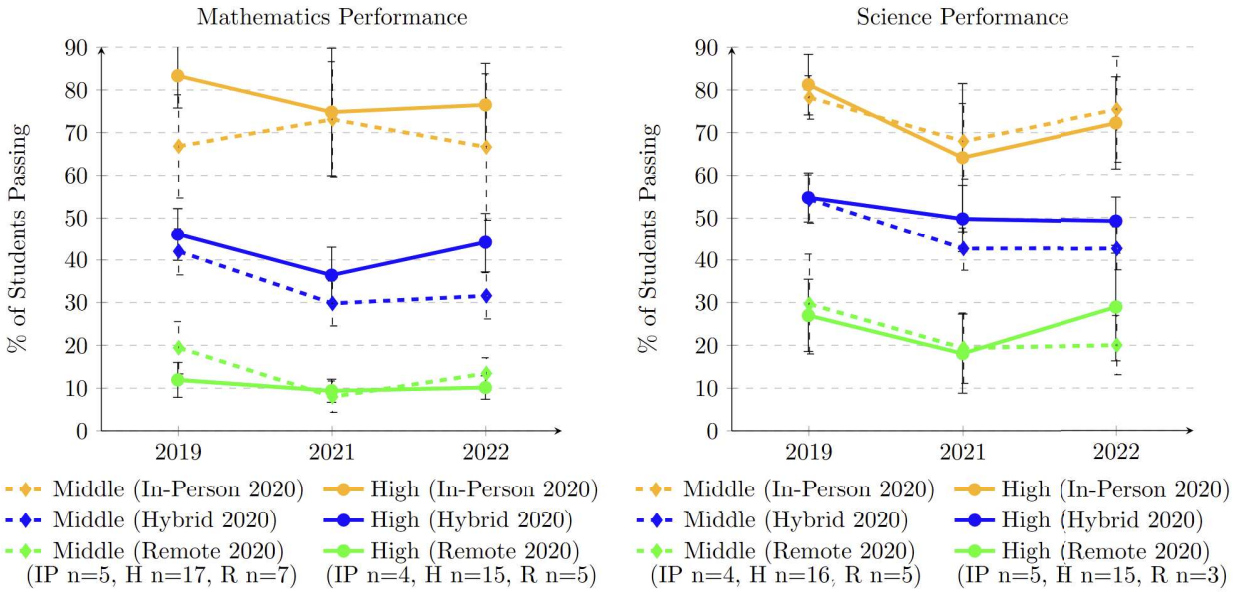
Note: a. Census Regions are color-coded: Red – Northeast; Yellow – Midwest; Green – South; Blue – West. b. Within each Census Division, two HN-LEAs were Small, Rural School Achievement (SRSA) or Rural or Low-Income School (RLIS) and two were Title I.

STEM Teacher Effectiveness

From 2019 to 2022, students who initially returned from the COVID-19 shutdown to in-person instruction performed better than those who returned to remote or hybrid instruction as show in Figure 2a Mathematics, Figure 2b Science, and Figure 3 graduation rates. These findings were consistent across all time points, including the pre-COVID-19 baseline year.

Figure 2a and 2b

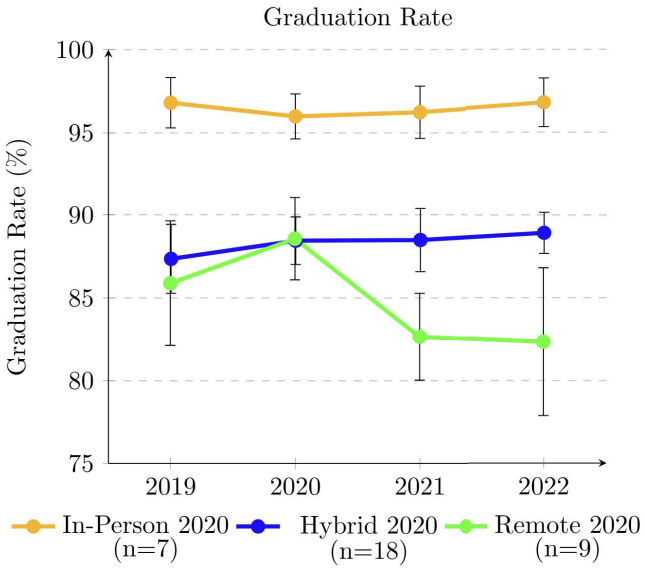
Mathematics (a) and Science (b) Performance for Middle and High School



Note: a. Students who initially returned from the COVID-19 shutdown in-person (IP) had higher standardized mathematics performance levels than students who returned remotely (R) or in a hybrid (H) manner across time points, including the 2018-2019 academic year prior to the pandemic (ANOVA: middle school $n = 29$, $p < 0.05$). b. Students who initially returned to in-person instruction after the COVID-19 shutdown also tended to have higher standardized science performance levels than students who returned remotely or in a hybrid manner across time points including the 2018-2019 academic year prior to the pandemic.

Figure 3

Graduation Rate



Note: Students who initially returned from the COVID-19 shutdown in-person had higher high school graduation rates than remote or hybrid students across time points, including the 2018-2019 academic year prior to the pandemic, $p < 0.02$ (Tukey HSD), $n = 34$. Despite baseline differences, data suggest a possible negative impact on graduation rates for remote instruction.

Implications

This study found that high-need districts across the country made choices at comparable differential proportions about the learning modality they would use to reopen their schools following the COVID-19 shutdown. Since these proportions were similar across the total sample and within both the Title I sample and the combined SRSA/RLIS sample, and the sample was drawn using a random sampling technique, it is reasonable to infer that these patterns are representative of the broader high-need districts' learning environment, and possibly generalizable to similar educational contexts at the national level. Further, findings across the Title I and combined SRSA/RLIS samples suggest rural and urban schools made choices in similar proportions and that these decisions were made at the local level.

More importantly, this study included the 2018-2019 academic year as pre-COVID-19 baseline data that was unimpacted by COVID-19. Inclusion of this time point is critically important for the interpretation of teacher effectiveness data during the pandemic. If the baseline data had not been included, we might have incorrectly concluded that there was a differential impact of teacher

effectiveness based on the way in which HN-LEAs returned to instruction in the Fall of 2020. Rather, inclusion of this timepoint demonstrates that the districts that chose to open in-person were substantially more successful at meeting educational standards at all time points compared to the districts that chose to open remotely or in a hybrid fashion. The districts that made the choice to open in-person that Fall were already largely meeting the educational needs of their students as demonstrated by more than 80% of their high school students passing their mathematics and science standardized tests prior to the pandemic. This is in stark contrast to the high-need-districts that made the choice to open remotely and failed to meet the educational needs of their students as demonstrated by less than 30% of their high school students passing their science standardized tests prior to the pandemic and even fewer (less than 15%) passing their mathematics tests. This suggests that the choice to open in-person was part of a larger successful approach taken by these high-need districts to support their teachers' effectiveness and students' achievement. Future research should aim to identify how districts that elected to reopen in-person differ by identifying the factors that distinguish these districts from those that elected to reopen to remote or hybrid instruction. Furthermore, interpretation of research concerning learning modalities during COVID-19 should be conducted with caution, particularly if baseline pre-COVID-19 measures are not included for comparison.

Acknowledgements

Supported by NSF Award ID: 2243392. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

Akram, M., & Malik, M. I. (2021). Development and validation of head teachers' effectiveness questionnaire. *Journal of Educational Science & Research, 8*(2), 138–161.

Cannon, S. R., Davis, C. R., & Fuller, S. C. (2009). Preparing for the next natural disaster: Understanding how hurricanes affect educators and schooling. *AASA Journal of Scholarship and Practice, 17*(2), 6–11

Cantrell, S., & Kane, T. J. (2013). Ensuring fair and reliable measures of effective teaching: Culminating findings from the MET project's three-year study. *MET Project Research Paper*, 183.

Department of Health and Human Services ArcGIS Online. (2022, June 15). *Districts by learning modality*. https://public-data-hub-dhhs.hub.arcgis.com/apps/c387b4ff3ec346289680c361f1c2a253/explore

HHS Protect Public Data Hub. (2022, February 2). *School Learning Modalities*. https://public-data-hub-dhhs.hub.arcgis.com/pages/school-learning-modalities

Institute of Education Sciences. (2022a) *National Assessment of Educational Progress. Learning Mode, Masking, and Social Distancing Dashboard.* https://ies.ed.gov/schoolsurvey/2022NAEPEnrollment_Policies/

Institute of Education Sciences. (2022b) *Impact of the Coronavirus (COVID-19) Pandemic on Public and Private Elementary and Secondary Education in the United States: First Look*. https://nces.ed.gov/pubs2022/2022019.pdf

Laprairie, K. N. & Hinson, J. M. (2006). When disaster strikes, move your school online. *Journal of Educational Technology Systems, 35*(2) 209–214. https://doi.org/10.2190/D154-XK20-7264-5013

Loder-Jackson, T. L. & Sims, M. J. (2008). On indignation, hope, and a call to action assessing hurricane Katrina's impact on urban education in the immediate aftermath of hurricane Katrina. *Urban Education, 43*(4), 419–420.

National Center for Educational Statistics (2022). *Section 201 of the Higher Education Act of 1965 (20 U.S.C. 1021)*. https://nces.ed.gov/ccd/districtsearch/

NOAA (2019). 2018's billion dollar disasters in context. https://www.climate.gov/news-features/blogs/beyond-data/2018s-billion-dollar-disasters-context

Office of Elementary and Secondary Education (OESE). (n.d.-a). *SRSA Eligibility*. https://oese.ed.gov/offices/office-of-formula-grants/rural-insular-native-achievement-programs/rural-education-achievement-program/small-rural-school-achievement-program/eligibility/

Office of Elementary and Secondary Education (OESE). (n.d.-b). RLIS Eligibility. https://oese.ed.gov/offices/office-of-formula-grants/rural-insular-native-achievement-programs/rural-education-achievement-program/rural-and-low-income-school-program/eligibility/

Phillips, T. M. & Herlihy, B. (2009). Motivational factors underlying college students' decisions to resume their educational pursuits in the aftermath of Hurricane Katrina. *Journal of College Counseling, 12*, 101–112.

Shi, Z., Weinburgh, M.H., Demetrikopoulos, M. K., Pecore, J. J., Williams, D., & Biffii, D. (2024). Pros and cons of national and state databases: Learning modality return to school for STEM teachers during COVID-19 era. In B. Cory, & A. Ray (Eds.). *Proceedings of the 123rd annual convention of the School Science and Mathematics Association* (Vol. 11). Knoxville, TN: SSMA.

Shizari, P. T., Ghaemi, F., Pourdana, N., & Tavassoli, K. (2022). Developing and validating EFL Teacher Effectiveness Questionnaire: Investigating the impact of modular instruction. *Journal of Language and Translation, 12*(3), 87–100.

U.S. Department of Education (USDE). (n.d.). *Estimated ESEA Title I LEA Allocations—FY 2020*. https://www2.ed.gov/about/overview/budget/titlei/fy20/index.html

van Buuren, S. (2018) *Flexible Imputation of Missing Data* (2nd ed.). Chapman & Hall/CRC Press.

Weinburgh, M., Biffi, D., Demetrikopoulos, M.K., Williams, D., Shi, Z., Pecore, J.P., & Thompson, A.C. (in press) Exploring COVID-19 impacts on STEM teachers: Challenges of the lack of clear definitions and standardized reports. In M. Bloom & S. Quebec Fuentes (Eds). *Collaboration to advance science & mathematics education*. Valladolid, Mexico: ICRSME.