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The ‘Homework Gap’ and Academic Achievement in High School Science: An Ecological Perspective for Policymakers and Practitioners

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Abstract

Information and communication technologies (ICTs) are increasingly required within K-12 educational settings, yet the impact of youth's access to and use of digital resources outside of the classroom on academic achievement is only beginning to be explored in the literature. This study used data from the Fragile Families & Child Wellbeing Study to assess the relationship between grades in high school science and digital equity across the learner's ecological environment. Digital inequities experienced by school-aged youth are referred to as the homework gap. The COVID-19 pandemic placed new urgency on resolving the homework gap as millions of students shifted to full-time online or learning at home during the pandemic. Study findings show that ICT access and use across ecological domains is a significant predictor of urban youths' academic achievement in science.

Keywords

academic achievement, digital equity, broadband, homework gap, urban communities

Cover Page Footnote

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Introduction

Digital equity initiatives in American elementary to secondary education systems, referred hereafter as K-12, are widely valued but not implemented systemically as evidenced by the patchwork of approaches and programs for school-aged youth across the United States. Digital equity refers to the “condition in which all individuals and communities have the information technology capacity needed for full participation in our society, democracy, and economy” (National Digital Inclusion Alliance, 2020) through *access to* digital literacy, digital devices, and broadband to support one’s well-being. The COVID-19 pandemic forced millions of youth into emergency online learning environments for the first time as administrators navigated concerns about the sustainability of these virtual settings. Quantitative (i.e., academic performance) and qualitative feedback from students, educators, and parents around the world (Huck, C. & Zhang, J., 2021; Lorenza, & Carter, 2021) confirmed that not all students were thriving academically in these do-it-yourself virtual classrooms. Three out of five K-12 students began the 2020-2021 school year in a fully or partially online learning environment (Burbio, 2020) while many school-aged youths lacked robust access to broadband and/or internet-enabled devices for schooling. Fifteen percent of U.S. households with K-12 students do not have home broadband access (Auxier and Anderson, 2020) and only 37 percent of school districts were found to support access to digital devices or broadband during the time of COVID-19 online instruction (Burbio, 2020). The coronavirus pandemic illuminated digital inequities in K-12 education (Hasan & Bao, 2020; Sayer & Braun, 2020; Bansak & Starr, 2021) that digital inclusion and education advocates urged federal policymakers to address comprehensively in the five years before the pandemic (McLaughlin, C., 2016; SHLB Coalition, 2021).

K-12 students' inability to access or use information and communication technologies (ICT) at home for learning is a digital inequity that is widely referred to as the *homework gap*. In 2015 approximately 5 million American school-aged children experienced the homework gap (Anonymous) which stifles the academic possibilities and future earning potential of young learners who are not equipped with the information technology required to learn outside of the classroom (National Education Association, 2016; North Carolina Department of Information Technology, 2021). Moreover, most K-12 teachers reported not knowing definitively if their students have access to a computer and the internet at home (National Center for Education Statistics, 2018) despite systemwide efforts to increase technology-supported instruction.

Affordable and reliable broadband in the home, a personal computer, and the knowledge to use digital resources (i.e., digital literacy) are the three *back-to-school* tools needed by digitally prepared students in modern U.S. society. Yet, research has shown that information and communication technologies (ICT) are not equitability distributed to all learners. Students in households characterized by lower levels of income and parental education have historically been less likely to have basic digital resources to support learning at home. Inequalities in the access to and use of ICT also often fall along racial, ethnic, and geographic lines in America (Council of Economic Advisors, 2015; Reisdorf et al., 2019; Warf, 2013). As a result, students must complete their school assignments through unreliable means such as borrowing a family member's device, using unsecured public Wi-Fi networks or completing homework on a smartphone. See a California elected official's tweet during the height of the pandemic's first wave in the U.S. in Figure 1 (Alejo, 2020) which captured children working outside next to a Taco Bell restaurant to obtain free Wi-Fi access, for instance.

https://digitalcommons.georgiasouthern.edu/nyar/vol6/iss1/1
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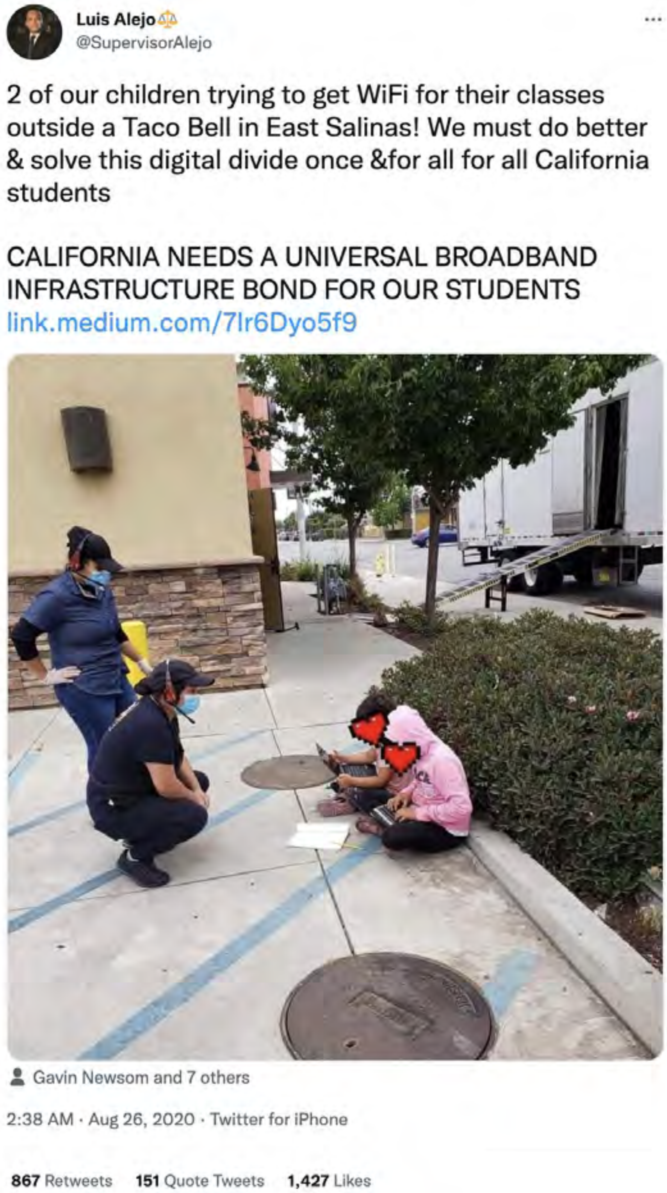
Figure 1.
A picture of two children using the restaurant’s free Wi-Fi connection on the sidewalk near a Taco Bell, Tweeted by Monterey County Board of Supervisor Luis Alejo.



While public awareness of the homework gap peaked early in the pandemic, research has only begun to explore the effectiveness of associated interventions in supporting student learning outcomes. Initial interventions to close the homework gap were driven by public-private partnerships to provide primarily low- to no-cost home broadband, and in some cases digital devices, to households with K-12 students (The 1million Project Foundation, 2021; Meyer, L., 2016). Researchers (Hampton et al., 2021; Smith, Walker & McKenna, 2021) have shown significant indirect relationships between the homework gap, school-related behaviors, and academic performance, however, these studies were limited to academically advanced students or learners in a rural environment whereas 70% of the 50 million K-12 students in public school live in urban and suburban communities (Riser-Kositsky, M, 2021). Evidence also suggests that homework gap initiatives that lack one or more of the three components of digital equity are unlikely to be effective at promoting long-term adoption of technology among new users (Reisdorf et al., 2019). Lastly, current literature often reports on data collected at one time point in the technology user's experience to predict correlates of access and adoption which are believed to occur over time. This study sought to address these limitations by exploring the homework gap's relationship to academic performance in high school science from an ecological systems perspective which provides a nuanced lens through which youth experience technology across their social and physical environments. Additional insight pertaining to digital inequities related to the future earnings of youth and the ecological systems perspective are provided in the following section to frame the narrative of digital equity as a marathon instead of a sprint.

Background

Homework Gap Implications for Youths' Economic Opportunity

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The homework gap is not only tied to learning outcomes for K-12 students but also their future success in higher education, and their future earning potential in the labor market. Reynolds (1982) described the transition from school to work as a crucial pathway to future economic opportunities for learners. Moreover, the unemployment rate for persons age 25 and over with less than a high school diploma (6.5%) is nearly double that of workers who earned an Associate's degree and nearly triple that of workers with a Master's degree (U.S. Bureau of Labor Statistics, 2017). Related research has shown that closing the homework gap may aid K-12 institutions in preparing learners for academic success after high school. A U.S. Department of Education meta-analysis found stronger learning outcomes associated with students who participated in online instruction in adult learning environments (2010). The proliferation of internet-enabled technology along with the nationwide response to learning during the coronavirus pandemic have positioned ICTs at the center of future success in K-12 education.

Access to ICT at home has been found to have a positive relationship to the academic success of school-aged children, especially for learning outcomes in reading and math (Judge, 2005; Judge et al., 2006; Lee, Brescia, & Kissinger, 2009; Schlee, Mullis, & Shriner, 2009; Vigdor et al., 2014). Additionally, Fairlie et al. found that a majority of high schoolers with home computer access, 94 percent, graduated by the age of 19 (2010). Home internet access has also been associated with higher academic success (Kingston, 2013). Jackson et al. (2006) found that home internet access and higher frequency of use were related to better state-level testing scores and higher student grade point averages. While home internet access has many positive correlates to learning, too much internet use has been shown to have negative effects on youth. Students who were described as intense internet users; those using at home, school, friends’ houses, and other places, were less likely to receive A or B grades and were more likely to receive a D (Austin & Totaro, 2001).

Bronfenbrenner's Ecological Theory

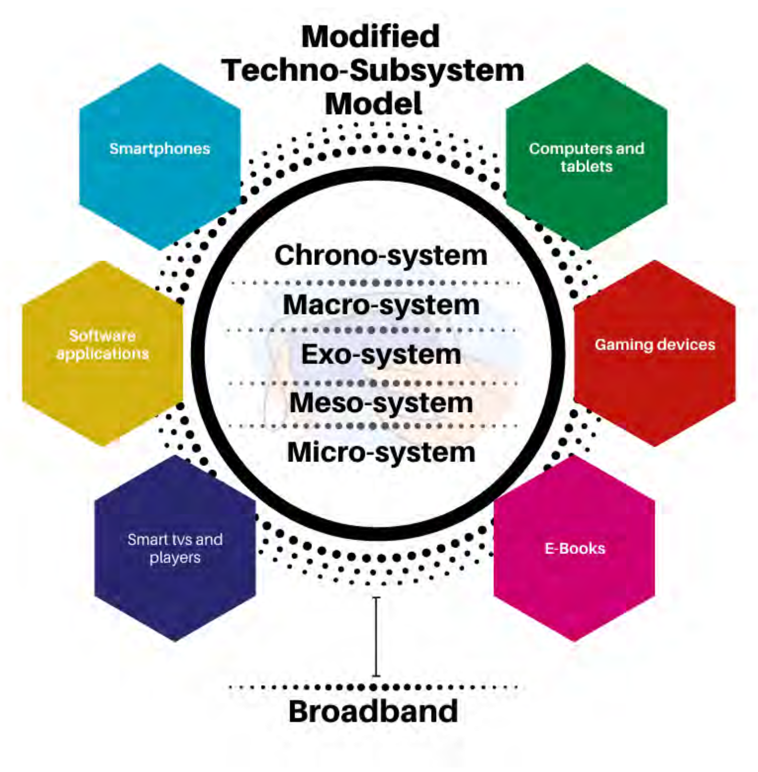
These findings show that ICT skills and access influence children's learning outcomes in K-12 education. However, digital literacy is a spectrum where skills compound with time and technological change, and across a variety of settings in the youth's environment (i.e., school, home, work). The current literature has yet to describe the relationship between long-term exposure to ICTs and learning, nor does it assess learning outcomes for students whose access to ICTs varies across cultures and subsystems in the environment as espoused in Bronfenbrenner's ecological theory (1996). Bronfenbrenner put forth that a child's development is influenced by an interconnected structure of five subsystems throughout the child's environment. The microsystem represents proximal relationships between the child and their immediate environment including family, friends, neighbors, and teachers at school. The mesosystem reflects the relationship and interaction between groups in the child's microenvironment. The latter three subsystems embody a distal physical presence in the life of the child. For example, the exosystem refers to the agencies and actors in the environment whose actions may shape the child's experience such as employers or local ordinances that define acceptable forms of community activity. The next system, the macrosystem, is closely related in that this system refers to the culture and values held by members of society that shape the exosystem. The last subsystem is temporal in nature. The chronosystem includes changes that occur over one's life course that shape behavior and perspective. The absence of any assurance that all K-12 students are digitally prepared in the more proximal microenvironment (i.e., family and home) assumes that unidirectional distal environments offer students a digital *back-to-school* checklist for academic success. Research abroad shows that the opposite is true when examining K-12 youth’s internet usage and the role of parental influence. (Herrick, 2014; Xie et al., 2021; Zhu & Chen, 2021). Possessing a better understanding of these ecological relationships will inform educators, school social workers, and digital equity practitioners whose efforts to holistically support K-12 learning outcomes are rooted in a digital equity framework that will prepare students for the digital savvy workplaces of tomorrow. School social workers are a group of professionals who provide specialized support to K-12 students that experience challenges to academic success are trained to assess needs using Bronfenbrenner’s ecological theory (Kelly et al., 2015) yet the terms broadband and internet are used interchangeably in this article to refer to the minimum internet speeds as currently defined by the Federal Communications Commission (FCC) as 25 megabits per second download and 3 megabits per second upload (2021).

Theoretical Underpinning

ICTs offer K-12 students a greater choice in the location, timing, and type of learning interaction. Young learners are now able to cultivate a personal strategy for success in the classroom. Students with internet-enabled devices can access cloud-based homework assignments on their smart devices at home or in a local library, for instance. The techno-subsystem, a modified representation of Bronfenbrenner's ecological systems model was introduced by Genevieve Marie Johnson and Korbla Puplampu (2008) and places childhood digital resources at the center of the microenvironment. This proximal positioning recognizes the essential nature of ICTs to modern daily living. As the child interacts with digital resources in the environment, the authors contend that their model is a holistic approach to capture how rapidly evolving ICTs impact child development through interaction with living and non-living entities. Paiva et al. (2017) recently used the techno-subsystem model in a qualitative study and found it useful to understand the fluctuating roles of children and parents in completing homework to improve literacy.

Despite the recognition of evolving technology in the techno-subsystem's model, this article includes a slightly modified application of the techno-system model that accounts for the present pervasiveness of internet-enabled and portable ICTs which allow learners to creatively use technology for education in ways not addressed at the macrosystem level (i.e., standard K-12 educational practices). This modification considered software, devices, and broadband across every subsystem in the environment (See Figure 2).

Figure 2.
Modified techno-subsystem model. The Techno-Subsystem: a new dimension of the Bronfenbrenner's model of the ecological systems theory. Source: G.M. Johnson & K.P. Puplampu.



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The shift in the model application was intended to capture the current use of devices such as smartphones and gaming devices for learning, as well as for the portability of devices that allow learners to complete homework in any public space with accessible internet. These ICT uses were not common at the time of the authors' original model conception (Johnson & Puplampu, 2008). This distinction lends itself to an ecological environment where proximal and distal interactions are not defined by where the child is positioned in the environment but rather by the digital landscape that exists in that space and time, which influences their development. For instance, could elementary school-aged children who learn about ICTs such as virtual reality and gaming in a structured community-based setting be better prepared to immerse themselves in high school academics than teenagers who recently attained home broadband access but possess no literacy training? Societal value systems are espoused through community practice and policy implementation at the local level (i.e., the chrono-, macro- and exo-systems) which influences how these youngsters are exposed to the varied uses of ICTs. The logit models used in this study compared ICT *access* to ICT *use* variables across the ecological environment to better understand predictive factors for earning an A average in high school science. Equitable access was tangibly defined as having reliable access to both broadband and a computer in the home. The affordability of ICTs as a measure of household utilities has not been captured in any wave of the Fragile Families study.

Material and Methods

In this study, a secondary analysis of data pertaining to a sample of children born in large U.S. cities was conducted to answer the research question. The sample of children was from the Fragile Families & Child Wellbeing Study, a panel study of 5,000 children born in 20 large U.S.

cities. Baseline interviews were conducted between 1998-2000. The stratified multistage sampling design aimed to recruit unwed parents in urban hospitals at the time of their child's birth. Researchers sought to include a significant number of low-income parents, and parents from Black or Hispanic backgrounds. The study currently includes six waves. Beginning at the focal child's birth, interviews were conducted with the mother and father, or primary caregiver when the child was approximately aged one, three, five, nine, and fifteen. The interviews were expanded beyond the parents or primary caregivers to include the child, teacher, and interviewer observations at various waves. The number of observations in the regression models is limited primarily by the three out of five teacher surveys that were completed when the focal child was aged nine. Additional information regarding the study design and measures at each wave can be found in Reichman et al. (2001)

This article reports on data collected from primary caregivers, teachers, and the focal study child at two time periods – when the child was approximately aged nine and again at fifteen years of age. The study interviews were conducted when the focal child was aged 9 between 2007-2009 while the interviews at approximately 15 years of age occurred between 2013-2015. Both periods are notable for shifts in the design and availability of ICTs for personal use in America. Slightly more than half of U.S. households had broadband at home in 2008 compared to two-thirds of households in 2014 (Pew Research Center, 2021).

Cases were listwise deleted from the sample if the focal child was not in the study wave at age 15, home-schooled or not enrolled in school, did not respond to the academic performance measures, or responded that they did not receive a grade. These actions resulted in a sample of approximately 3,065 youth and subsequent analyses of deleted cases detected no bias. The focal dependent variable is the youth's self-reported grades in science at approximately age 15. Key

ICT predictors are grouped by the setting. Bivariate and robust ordered logit analyses were performed to reveal the relationship between academic performance in science and ICTs in the ecological environment using a modified version of Johnson's and Puplampu's (2008) techno-subsystem model. Three ordered logit models were crafted to determine the best predictive model for the probability of worse grades in science based on ICT access, ICT use, and the combined predictors. Analyses were conducted using Stata 16.1 to answer the following research questions:

R1. How are student grades in high school science associated with their access to and use of technology across the ecological environment?

R2. Does technology access or use better reduce the probability of earning a grade other than an A in high school science?

R3. Concerning the chronosystem, how are technology access and use in elementary school associated with student grades in high school science?

Findings

The youth reflected in the study represent a diverse group of learners who are an average age of 15 years old. Most youths live in predominately single-parent households headed by their biological mother. Three out of five youth live in households earning less than 200 percent of the federal poverty level annually, or less than $43,440 for a family of three in 2020 (U.S. Department of Health and Human Services). What's more, roughly thirteen percent of all households in the study live in deep poverty where families only earn up to 49 percent of the federal poverty guidelines for income, joining 3.3 million other American families in 2015 according to data from the American Community Survey (U.S. Census Bureau, 2021).

Discretionary income and career advancement opportunities are likely limited to the service sector or part-time roles for workers in these households (U.S. Bureau of Labor Statistics, 2021). The overrepresentation of low-income families in this study has not been adjusted to highlight ICT access and use among this population of low-income residents in urban communities who often rank among the most digitally divided.

Further background data is provided to contextualize the study findings within the distal environments of the meso- and exo-systems. Fifty-one percent of the youth's assigned gender at birth was male. They also largely self-rated their health as good to excellent, and one in five youth had been diagnosed by a doctor with ADD/ADHD, Autism, or another learning impairment. Half of the adolescents in the study were African American and another quarter reported Hispanic ethnicity. Twenty-eight percent of youth were found to have worked for pay in the 4 weeks before the survey interview. Additional youth and family background univariate statistics are reported in Table 1.

Table 1

Youth and Family Background or Socioeconomic Conditions

	Mean or %	N
Age	15.58 (0.75)	3063
Female[a]	48.84%	3065
Learning disability[b]	19.76%	3062
Health status		
Poor/Fair	7.16%	3059
Good	20.30%	
Very good/Excellent	72.74%	
Grade level		
7th grade or less	0.95%	3057
8th grade	10.34%	
9th grade	46.32%	

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10th grade	31.44%	
11th grade	8.80%	
12th grade	2.16%	
Primary caregiver		
Mother	88.38%	3065
Father	6.98%	
Other relative or adult	4.63%	
Household income[c]	62,444 (65,764)	3061
Household income logged	10.58 (1.11)	3048
Poverty category		
0-49%	13.34%	3058
50-99%	16.48%	
100-199%	27.89%	
200-299%	14.68%	
300%	27.60%	
Race		
Black	49.16%	2915
Hispanic	25.25%	
Multi-racial, non-Hisp	5.25%	
Other, non-Hispanic	2.68%	
White	17.67%	
Household size	4.72(1.84)	3062
Youth employed	28.38%	3065

Note. Standard deviations shown in parentheses.

a Gender is male or female as assigned at birth in the hospital.

b Learning disability diagnosis also includes diagnoses of ADHD/ADD or Autism.

c Median household income is $44,500.

Grades and Homework

Sixty-seven percent of youth in the sample earned a B or better in science. Of the remaining one-third of students, most earned a C grade in science. Eight percent of youth in the study sample earned a D or less in high school science. At age fifteen, the youth spent nearly two hours per weekday on homework and just over an hour on the weekends. Additional school characteristics reported in Table 2 show that youth earned significantly better grades in science the more time they spent on homework, and that previous academic challenges or parental involvement in homework was associated with grades in science. These results are similar to previous findings reported in the literature.

5.2 School ICT Access and Use

The micro- and chrono-systems were analyzed for ICT access and use in the school and the home at two time periods; when the child was aged 9 and at 15 years old. This section describes the micro-system setting of school. Ninety percent of youth attended a public K-12 institution and reported their most recent grade level as the ninth or tenth grade. The teacher's use of computer-based internet access at age 15 and the number of computers available in the classroom at age 9 were found to not be significantly associated with academic achievement. However, the availability of a computer lab at school at age 9 was significantly related to grades in science. It is unknown if the computer lab's existence is associated with ICT use or other indirect factors in the environment.

Table 2

Youth’s Academic Achievement in Science by Homework and School Use of ICTs at Ages 9 and 15

Grade		A	B	C	D or <	Overall		
		Mean or %	Mean or %	Mean or %	Mean or %	Mean or %	N	*p*
School type	Public	28.09%	38.34%	25.01%	8.56%	91.06%	3065	.219
	Private or religious	31.02%	42.34%	22.26%	4.38%	8.94%		
Youth ever failed a grade		18.47%	35.84%	32.87%	12.82%	47.43%	3059	.000
Trouble completing homework	Often	24.62%	33.59%	29.20%	12.60%	17.15%	3055	.000
	Sometimes	23.53%	39.07%	27.60%	9.80%	45.07%		
	Never	35.70%	40.81%	19.32%	4.16%	37.77%		
Weekday hours spent doing homework		1.98(1.27)	1.83(1.17)	1.79(1.28)	1.42(0.98)	1.83(1.22)	3041	.000
Weekend hours spend doing homework		1.38(1.28)	1.22(1.15)	1.11(1.18)	0.85(0.93)	1.21(1.19)	3046	.000
Computer lab at school⁺		30.67%	38.28%	23.24%	7.81%	86.25%	1811	.061
Number of computers in class⁺		3.18(2.16)	3.36(2.58)	3.23(2.53)	3.13(2.19)	3.25(2.42)	1808	.402
Teacher use of computers for the internet⁺	Daily	33.85%	33.33%	22.40%	10.42%	11.27%	1703	.760
	1-4 times a week	30.02%	39.08%	23.57%	7.32%	47.33%		
	1-3 times a month	29.77%	38.53%	23.82%	7.88%	33.53%		
	Never	27.61%	35.82%	26.87%	9.70%	7.87%		
Weekday time on the computer for school work⁺	None	28.31%	38.08%	24.65%	8.95%	63.24%	2720	.284
	30 minutes or less	28.08%	42.31%	24.10%	5.50%	19.38%		
	31-59 minutes	27.67%	37.86%	25.24%	9.22%	7.57%		
	1-2 hours	25.73%	36.84%	29.82%	7.60%	6.29%		
	More than 2 hours	28.12%	31.25%	28.12%	12.50%	3.53%		
Primary caregiver helped with homework in the past month	Often	25.12%	40.09%	26.05%	8.74%	20.95%	3059	.019
	Sometimes	26.62%	39.23%	25.74%	8.41%	44.33%		
	Never	32.58%	37.10%	22.79%	7.53%	34.72%		

Note. Standard deviations shown in parentheses. p = chi-squared or F statistic.
a Variables measured when youth was aged 9 are denoted by the symbol +.

Home ICT Access and Use

Approximately 22 percent of youth did not have access to a home computer and the internet. Together these resources are critical to accessing information on the internet using a physical setup that is common to the workplace or higher education settings. A significant association was found between computer-based internet access at home and grades in science. This figure is supplemented by the 90 percent of youth who reported mobile-based internet access at home and the roughly 60 percent of youth with tablet-based internet access at home. However, tablet- and mobile-based internet access were not significantly associated with academic achievement in science as shown in Table 3.

Table 3

Youth’s Academic Performance in Science by Home Access and Use of ICTs at Ages 9 and 15

Grade	A	B	C	D or <	Overall		
	Mean or %	Mean or %	Mean or %	Mean or %	Mean or %	N	*p*
Home internet access	28.79%	39.07%	24.13%	8.01%	88.87%	3064	.067
Home computer and regular home internet	30.67%	39.31%	22.84%	7.17%	69.18%	3063	.000
Tablet-based internet access	30.43%	38.63%	23.25%	7.69%	58.37%	2719	.145
Mobile-based internet access	26.66%	39.47%	24.23%	7.64%	90.37%	2722	.195
Internet use on computer+	32.10%	38.36%	21.85%	7.69%	60.18%	2205	.001
Hours per weekday on the internet	0.98(1.62)	0.94(1.45)	0.97(1.52)	1.02(1.68)	.97(1.53)	3044	.417
Hours per weekday playing ICT games	1.77(2.18)	1.86(2.19)	1.98(2.27)	2.46(2.94)	1.92(2.28)	3048	.015
Hours per weekday watching tv/movies	2.33(2.03)	2.60(2.07)	2.83(2.25)	2.85(2.26)	2.60(2.13	3043	.000
Minutes of screen-time before bed	56.75(40.54)	58.47(41.47)	58.75(42.40)	56.24(44.12)	57.87(41.65)	3019	.494
Hours per day using computer+	0.73(0.89)	0.80(0.87)	0.82(0.84)	0.97(1.06)	0.80(0.89)	2250	.026
Hours of electronic communication with friends per weekday	3.90(3.81)	4.08(3.80)	4.33(3.82)	4.99(4.15)	4.17(3.85)	3026	.001
Emails/IMs friends on computer+	35.76%	36.97%	20.91%	6.36%	14.97%	2205	.032
Frequency primary caregiver played video or computer games with child in the past month+							
Everyday	23.14%	36.78%	28.51%	11.57%	8.35%	2898	.260
Several times a week	27.93%	37.43%	26.63%	8.01%	18.53%		
Once a week	27.22%	42.06%	23.71%	7.01%	16.74%		
One to two times	26.93%	41.34%	24.01%	7.72%	16.53%		
Not at all	30.22%	37.23%	24.16%	8.40%	39.86%		

Note. Standard deviations shown in parentheses. p = chi-squared or F statistic.

a Variables measured when youth was aged 9 are denoted by the symbol +

A subsequent question arose as to if exposure to a broader number and type of devices was associated with better grades in science. A one-way ANOVA was conducted using access to a home computer, school computer lab, tablet, and mobile device as a continuous variable to determine if grades were different for youth based on the number of devices available to them across the ecological environment. A statistically significant difference in grades was discovered (F,(2,1606) = 7.56, p = .000). A Tukey post-hoc test showed that device access was statistically significantly lower for youth who earned a C compared to youth who earned an A (-.235 ± .055, p = .000), youth who earned a C compared to youth who earned a B (-.150 ± .052, p = .020), and for youth who earned a D or lower compared to youth who earned an A (-.243. ± .080, p = .013). The effect size was small given a partial eta squared estimate of .014. A significant relationship for grades in science and ICT access and use was also found for prior computer-based home internet access at age 9, and for youth who reported *fewer* hours of gaming, watching video media, or communicating with friends throughout the school week. For instance, youth who earned an A in science averaged roughly an hour and 45 minutes gaming on weekdays compared to youth who earned a D in science and gamed two and a half hours on average. Yet, it is important to note that early exposure to ICTs at age 9 was significantly associated with future academic success. Remarkably, youth who spent more time on a computer at age 9 subsequently earned poorer grades in high school science.

Logit Models

Independently, the predictors noted above were associated with significantly higher grades or lower grades in science. Three robust nested ordered logit model results are captured in Table 4 to determine the collective influence of these predictors on youths' grades. These models include either ICT access predictors, ICT use predictors, or both sets of predictors.

HOMEWORK GAP AND ACADEMIC ACHIEVEMENT

Table 4

Logit Models of Youth’s Academic Achievement in Science and ICT Access & Use

	Model 1: Access (N=1499)		Model 2: Use (N=1187)		Model 3: Access & Use (N=1089)	
Science Grade (Ref: A)	**OR**	**SE**	**OR**	**SE**	**OR**	**SE**
School computer lab (Yes/No)⁺	.789*	.111			.647**	.119
Number of computers in class⁺	.994	.019			1.01	.020
Home internet and computer (Yes/No)	.744**	.093			.603***	.102
Home tablet (Yes/No)	.912	.091			.891	.108
Home mobile (Yes/No)	.934	.153			.875	.183
Emails/instant message friends on computer⁺			.906	.145	.916	.153
Frequency primary caregiver played video/computer games with child⁺ (Ref: Everyday)						
Several times a week			1.28	.214	1.39*	.254
Once a week			.893	.142	.972	.165
One to two times			1.09	.177	1.14	.192
Not at all			1.10	.283	1.44	.385
Internet use on computer (Yes/No)⁺			.693***	.084	.671***	.087
Weekday hours using computer⁺			1.19**	.090	1.18**	.093
Weekday time on the computer for school work⁺ (Ref: None)						
30 minutes or less			1.06	.147	1.02	.150
31-59 minutes			.958	.207	.932	.210
1-2 hours			1.37	.329	1.57*	.394
More than 2 hours			1.33	.442	1.40	.501

Note. Both models control for the youth’s school type, grade level, weekday and weekend hours spent on homework, trouble with homework, caregiver help with homework, learning disability, age, gender, race, health status, employment status, and household income. These results are omitted from the table but contributed significantly to .

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$

a The symbol + denotes variables measured when the youth was aged 9.

	Model 1: Access (N=1499)		Model 2: Use (N=1187)		Model 3: Access & Use (N=1089)	
Science Grade (Ref: A)	**OR**	**SE**	**OR**	**SE**	**OR**	**SE**
Teacher use of computers for the internet+(Ref: Daily)						
1-4 times a week			.957	.199	1.06	.229
1-3 times a month			.985	.215	1.08	.245
Never			1.03	.296	.923	.284
Weekday hours on the internet			1.02	.043	1.02	.044
Weekday hours watching TV/videos/movies			1.09***	.032	1.08***	.334
Weekday hours playing games on computer/TV/device			.993	.029	.997	.030
Minutes looking at device screen two hours before bed			1.00*	.001	1.00*	.002
Weekday hours of electronic communication with friends			.999	.016	.989	.018
Log pseudolikelihood	-1802.1		-1386.1		-1249.02	
Wald χ^2 / Pseudo R^2	182.71****	.048	215.53****	.069	218.68****	.079

Note. All three models control for the youth's school type, grade level, weekday and weekend hours spent on homework, trouble with homework, caregiver help with homework, learning disability, age, gender, race, health status, employment status, and household income. These results are omitted from the table.

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$

a The symbol + denotes variables measured when child was aged 9.

After controlling for youth differences in school type, homework practices, and background characteristics, all models found statistically significant differences in grades based on select ICTs and associated use. The declining log pseudolikelihood from -1802.1 to -1249.02 showed that the third model, ICT access and use, was the best-fitted model. Next, statistically significant predictors from the third model are discussed beginning with several ICT experiences at age 9 that were found to be predictive of academic achievement. Model three shows that the odds of earning a B grade or less (compared to an A grade) are 35 percent lower for youth who had access to a school computer lab at age 9. At home, youth who used a computer for the internet at age 9 had 33 percent lower odds of earning a B or less in science. Yet, for every additional hour of weekday computer use at home at age 9, the youth had 18 percent higher odds of earning a B or less in science. This figure is in line with the categorical predictor of weekday time spent on a computer at home for school work which revealed that youth who spent 1-2 hours had 57 percent higher odds of earning a B or less than youth who spent no time on the computer, however, this predictor was only significant at the weaker probability of 0.10. With similar probability, the odds of earning a B or less was 39 percent higher for youth whose primary caregiver played video games with the child several times a week compared to caregivers who did not play at all.

At age 15, several ICT access and use variables were also found to be statistically significant predictors of grades in science. Youth at age 15 who had regular home internet and a computer had 40 percent lower odds of earning a B or less in science than youth who did not have these resources. It is important to note that access to other device types, tablet or mobile, was not significantly associated with grades in models 2 or 3. For every additional weekday hour that youth spent watching television or movies, they had 8 percent higher odds of earning a B grade or less. A subsequent examination of model 3 as a generalized ordered logit model using partial proportional odds through Stata's gologit2 command produced an estimate that was insignificant indicating that the model did not violate the proportional odds assumption of logit modeling. Among control variables, age, gender, learning disability, race, weekend hours on homework, trouble with homework, and receiving help from a primary caregiver with homework were all significant predictors of grades in the final model.

Discussion

The results of this study suggest that internet access and use are *both* significant predictors of academic performance in K-12 science, even when controlling for school and household factors. The techno-subsystem model also proved useful as an investigative framework as critical factors for academic success were found at proximal (i.e., micro) and distal systems (i.e., exo and chrono). Further studies are needed to model homework gap predictors representatively for learners in the 19 cities sampled in this study.

Also, early exposure to ICTs during elementary school impacts future learning outcomes for youth, particularly for youth of racial/ethnic minority backgrounds and those living in families earning low incomes. We also find that ICTs at school are just as important to grades in science as ICTs at home. The youth performed better in science when they possessed computer-based internet access, not handheld devices that often limit users' ability to navigate the full breadth of information available online. A need for monitored and structured use of ICTs emerged as a possible area for intervention based on predictors that showed more time using ICTs was not necessarily beneficial to academic outcomes, nor would limiting time spent using ICTs for communication with friends as those factors were not significant predictors.

This study adds to previous findings in the literature by showing the combined significance of parental involvement for academic achievement (Jeynes, 2007) by shedding a broader light on the environments in which youth interact with ICTs. The relationship between academic achievement and screen time or family gaming hours is worth exploring in future studies, particularly as the American Psychiatric Association weighs the formal inclusion of the Internet Gaming Disorder diagnosis as a disorder in subsequent Diagnostic and Statistical Manual of Mental Disorders (2021).

Conclusions

Alleviating homework gaps for learners is a necessary consideration for any equity initiative that aims to improve academic outcomes in K-12 education. This is particularly true given the growth of online learning during the COVID-19 pandemic. Similarly, the passage of the Infrastructure Investment and Jobs Act (U.S. Congress, 2021) will soon provide fiscal support for states to equitability and strategically implement ICT investments in urban communities in need of pathways to opportunity (Perry, 2020). Digital equity investments have the potential to influence youth across their lifespan as students, adult learners, and future American workers; and the evidence shows that ICT influences are present for elementary school-age children. Educators and school social workers who implement models for academic success that bridge the classroom to home and community may find this information helpful for engagement with families or community partners in 2022 and beyond. Policy approaches to close the homework gap need to consider multi-pronged approaches that include ICT access and use across the lifespan which is known to contribute to one's position on the digital literacy spectrum. A techno-subsystem approach to digital equity for K-12 education would begin with assessing the digital literacy of students, caregivers, teachers, peers, and other actors in the environment that influence well-being such as school social workers. This article is a preliminary offering of evidence to support ecological digital inequities mapping for homework gap interventions that target the technology behaviors most likely to be associated with poorer academic outcomes.

Limitations

This article provides a preliminary analysis of an ongoing panel study of unmarried parents and their children who were born at the turn of the century and will have reached the age of 22 in the forthcoming seventh wave of data (Fragile Families and Child Wellbeing Study, 2021). The study is limited by its provisional analytic approach. Future studies will analyze academic achievement and the homework gap using hazard models and other techniques. Additional ecological and geographic variables will be added to show representative findings for some of America's largest urban communities. Second, the Fragile Families and Child Wellbeing Study was designed to primarily understand family relationships is limited in its exploration of ICT-related variables, particularly for analysis of chronosystem and macrosystem level predictors. For instance, there is no data between the ages 9 and 15 when youth would have transitioned through pivotal developmental years at the middle school level which would add richness to our ecological model. Macroeconomic data will also be explored in future studies as an indirect value for ICTs at the exo system level.

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