



Exploring the Relationship between 8th Grade Non-School Factors and NAEP Technology Scores

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Abstract: This study presented a secondary analysis of the National Assessment of Educational Progress (NAEP) dataset, specifically focused on the 2018 eighth-grade NAEP Technology and Engineering assessment's Information and Communication Technology (ICT) category. The purpose was to examine the impact of non-school factors, problem-solving, and digital communication use on student technology scores. This study used a quantitative descriptive research design to analyze secondary data extracted from the 2018 NAEP data set. The findings indicate that students who reported spending time outside of school exploring something to see how it works or to solve a problem consistently scored significantly higher than those who did so less often. These findings may indicate an overall positive correlation between time spent working on or with digital technology outside of school for creative and problem-solving purposes and ICT literacy.

Keywords: NAEP, national data, technology, problem-solving, curiosity, non-school, ICT.

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1. Introduction

Background

With continuing advancements in technology, including the integration within the last year of Generative AI tools into many web applications and most Information and Communication Technology (ICT) tools, there is an increasing need for students to understand these tools and to be able to use them effectively. As learners move into higher education and their prospective career fields, they will be expected to implement these new technologies into their learning and future careers. The National Association of Educational Progress (NAEP) measures 8th-grade students' technology and engineering literacy, providing an early indicator of student proficiency in digital and technical literacy skills. While many studies focus on teachers' digital literacy skills or the impact of having technology access at school and/or at home, few studies have examined the impact of problem-solving and digital communication skills on student technology scores. This study examines student-reported non-school factors, such as problem-solving and digital communication use, to identify the impact these factors have on technology skill outcomes in order to identify areas of focus for future instruction and development.

Research Problem

This study seeks to understand the impact of non-school factors, such as the exploration of technology and digital communication tools, problem-solving skills as applied to technological problems, and digital communication use on student technology scores.

Evidence Justifying My Research

Studies have shown that problem-solving skills have been found to be highly correlated with academic achievement (Alexandre and Enslin, 2017; Dikmen, 2022). Problem-solving is seen as an essential 21st Century skill (Ergin et al. 2020) and is a key skill for engineering and information technology (Veerasamy et al. 2019). Similarly, ICT skills have been shown to be positively correlated with academic performance (Erdoğan and Erdoğan, 2015; Park and Weng, 2020; Skryabin et al., 2015; Youssef et al., 2022), with some studies noting a specific impact on reading, science, and math outcomes (Erdoğan and Erdoğan, 2015; Skryabin et al., 2015).

Deficiencies in Evidence

Most studies examine the impact of these skills on high school or college students, many of whom are in courses focused on



technology, programming, or other related skills. Few studies have looked at the impact that independent student development of these skills outside of the classroom has on technology proficiency. Additionally, there is little examination of how these skills might impact technology skill acquisition at younger ages, such as middle school.

The Audience

This research has potential applications for both teachers and parents, particularly of elementary and middle school age students. By determining the impact of problem-solving skills and digital communication skills on 8th grade technology scores, elementary and middle school teachers can better understand the influence of these skills, thus designing instruction and curriculum that encourages these skills at younger ages. Additionally, parents of children in these age groups could better understand the impacts of these skills, providing opportunities for them to foster these skills at home as part of their children's cognitive development, better preparing the students for academic success and future career success.

Research Questions

Three questions taken from the 2018 NAEP TEL-ICT assessment were used to guide the research for this study. ID numbers listed below correspond to the ID numbers of each question from the NAEP database:

1. Outside of school, how often have you ever figured out why something is not working in order to fix it? (student-reported)ID: D810201
2. Outside of school, how often have you ever taken something apart in order to fix it or see how it works? (student-reported)ID: D810401
3. Outside of school, how often have you ever built or tested a model to see if it solves a problem? (student-reported) ID: D810301

2. Literature Review

This literature review supports the examination of NAEP data on non-student factors influence on 8th grade technology scores. Based on the research questions, two themes have emerged as having a potential impact on technology scores. This review will examine the impact of problem-solving skills and information and communication technology skills on academic achievement.

Problem-Solving

Multiple sources were found that discuss the impact of problem-solving on students' academic achievement. According to Alexandre and Enslin (2017), positive relationships were found between experiential learning, individualized learning, independent study, and problem-solving skills. For each method of learning, problem-solving was found to be correlated with higher success (Alexandre & Enslin, 2017). The study found "[a]cross academic classes, there was a high correlation between academic achievement and problem-solving skills" (Alexandre & Enslin, 2017, p. 12) suggesting that problem-solving abilities may have a strong impact on academic achievement.

Ergin et al. (2020) look at the connection between emotional intelligence, problem-solving, and academic performance in engineering students. They note problem-solving as a key skill

needed by modern engineers, and, like creative thinking, it is considered a 21st century skill that students need to possess (Ergin et al., 2020). They also discuss creative problem solving, connecting it to the first theme, a skill that allows engineers to adjust their knowledge and develop results (Ergin et al., 2020). However, while emphasizing the importance of problem-solving abilities, Ergin et al. (2020) found a weak negative correlation between problem-solving skills and academic achievement in engineering students, though they also noted a weak positive correlation and emotional intelligence, which was connected to positive outcomes in academic achievements in general.

Dikmen (2022) looks at several qualities (stress, mindfulness, and problem-solving) and their relationships with one another and on academic success. Dikmen (2022) points out the negative impact of high stress levels on academic achievement and emphasizes the importance of problem-solving skills to help reduce stress and increase academic success, noting problem-solving's engagement of cognitive and behavioral dimensions in learning, that impact higher-order thinking, as well as its impact on mental health, and it's positive correlation to GPA (Dikmen, 2022). Overall, Dikmen (2022) found that "mindfulness and problem-solving skills enable individuals to generate new solutions and new perspectives in case of difficulties they encounter. This, in turn, can help individuals to control repetitive and non-productive thoughts that cause stress and increase their academic success" (p. 53).

Veerasamy et al. (2019) discusses the connection between a student's perceived problem-solving skills and the academic performance in introductory programming courses. Similar to Ergin et al. (2020), Veerasamy et al. (2019) talk about problem-solving as a desirable skill for both learning and future employment and discuss it as a key skill for computer engineering and information technology. The study suggests that students with problem-solving competencies learn and perform better in programming and their results "suggest that student [problem-solving skills] could be a possible predictor for student achievement in [final exams] of programming" (Veerasamy et al., 2019, p. 252), and they were able to conclude that students with stronger and more effective problem solving skills averaged higher scores than those with poor problem solving skills. Veerasamy et al. (2019) did note, however, the potential for poor transferability of problem-solving skills when it comes to nonroutine problems if students failed formative assessment problems, though this was attributed to assessments that were poorly aligned to the final exam, rather than to an issue with students' computational thinking, which they note as a subset of problem-solving skills.

ICT Skills

Like problem-solving skills, ICT has been found to have a positive impact on students' general academic achievement. Erdoğan and Erdoğan (2015) explore how access to information and communication technology (along with other factors) correlates with academic success in math, science, and reading. The authors stress the positive impact of an internet connection at home and at school, noting direct correlations to math and science scores (Erdoğan & Erdoğan, 2015). While there were some negative correlations associated with internet use at school, Erdoğan and Erdoğan (2015) suggest this might be due to students using the internet for non-school related browsing. Similarly, Park and Weng (2020) found that ICT proved a distraction when used for entertainment. However, they found overall that ICT interest,

perceived competence, and autonomy had positive impacts on academic performance, noting higher levels of perceived autonomy in ICT led to better outcomes (Park & Weng, 2020).

Skryabin et al. (2015) also examined the impact of ICT on academic performance in three subjects, reading, mathematics, and science. As part of their study, Skryabin et al. (2015) examined the impacts of national ICT development, and found that students living in countries with higher ICT development tend to achieve higher scores across the three subject areas. They also examined individual ICT usage, finding "ICT usage at school showed a negative influence on students' academic performances; [...] However, if students tended to use ICT more frequently at home for working on school-related tasks, their achievements were more likely to be better" (Skryabin et al., 2015, p. 56), aligning with findings from Erdoğan and Erdoğan (2015).

Youssef et al. (2022) found that student performance improves when there is innovative and collaborative use of ICT, though noted that these skills were most often beneficial outside of the university, and learning how to use these tools was often through informal collaboration rather than training or through class instruction. Youssef et al. (2022) specifically noted the social nature of ICT tools as a benefit, concluding that collaborative and interactive learning had specific benefits, suggesting "the work/leisure balance enabled by ICTs and mobile Internet is improving students' exam success significantly" (p. 129). Overall, their study suggests that collaborative, innovative, and creative uses result in a positive result from ICT use on students' academic achievement.

The studies above indicate that there are positive correlations between student problem-solving ability, ICT use, and academic achievement, as well as technology competency. The sources also reveal that there is an overlap among these themes, particularly regarding the role of creativity when it comes to problem-solving or innovative ICT use. Both themes suggest a benefit to students' academic achievement.

3. Methods

Beginning in 1867, the National Center for Education Statistics (NCES) has collected data on American Educational outcomes for the full range of learners, spanning from early childhood education to adult learning with a goal of improving those outcomes (National Center, 2020). This data is collected from various assessments of student and teachers from a range of disciplines, including arts, civics, economics, geography, reading, mathematics, science, technology, US history, and writing, and this data is analyzed and reported, most notably in a report from the National Assessment of Educational Progress (NAEP) called The Nation's Report Card (National Assessment, 2025). In 2018, NCES assessed 8th grade scores in Technology and Engineering Literacy (TEL), reporting on three primary areas: Technology and Society, Design and Systems, and Information and Communication Technologies (What does the NAEP, 2019). This study focuses on NAEP data focused specifically on the ICT assessment.

Participants and Sampling

Participants are selected using a multistage probability sample design, which ensures that every student and school has the same probability of being selected (Select the Participants, 2025). The NAEP TEL assessment was last conducted in 2018, at which time approximately 15,400 8th grade students participated (Technology

and Engineering Literacy, 2024). This study focuses on the TEL scores of 8th grade students in the nation's public schools.

NAEP Sampling and Data Collection

From January through March 2018, the TEL assessment was administered to approximately 15,400 8th grade students from approximately 600 schools from across the United States. Students answered questions designed to assess their knowledge and skills of TEL principles, TEL problem solving, and TEL-based communication and collaboration skills. The assessment consisted of 77 discrete questions and 15 scenario-based tasks, and students were given 60 minutes to complete the survey, which was delivered via laptop computer (NAEP Technology & Engineering Literacy (TEL) Report Card, n.d.).

Public School Selection in State Assessment Years

Schools are selected for participation in NAEP through a multistep process that begins by verifying schools listed in the US Department of Education's public school system database. NAEP also verifies a sample of national private schools as well for grades 4, 8, and 12. Once verified, schools are classified into two strata: location (city, suburb, town, or rural) and racial/ethnic composition. All levels of school performance should be represented in the NAEP data, so schools are then sorted based on school-level results on state achievement tests. Once schools have been classified and arranged, these strata, along with achievement ratings, schools are then arranged into an ordered list. A separate sample is then drawn from each stratum by NCES using probability proportional to school size to ensure that schools that have small populations, high percentages of minority students, and private schools are adequately represented in the NAEP data. Schools with lower than an 85% participation rate are excluded from the sample. State departments of education are then sent a list of selected schools to confirm their eligibility (Sampling, 2022).

When a school is selected, all students are considered eligible for participation. Students are selected from designated schools for each subject area based on their grade levels (4, 8, or 12), and from students in these grades, NCES randomly selects the sample to participate in the assessment. From the sample, students are assigned one subject area, with approximately 30 students selected per grade for each subject from each school (Sampling, 2022).

Data Analysis

NAEP Data Explorer

The NAEP Data Explorer is a web-based system that allows users to interact with and analyze data collected through the NAEP assessments. The data collected is based on students, teachers, and school responses to surveys, and makes up a large database that can be used to compute statistics on all collected variables for assessments going back to 1990. and provides detailed assessment results based on selected criteria (NAEP Data Explorer, 2025).

In this study, the following student self-reported questions were selected for analysis using the NAEP Data Explorer:

1. Outside of school, how often have you ever figured out why something is not working in order to fix it? (student-reported) ID: D810201
2. Outside of school, how often have you ever taken something apart in order to fix it or see how it works? (student-reported) ID: D810401

3. Outside of school, how often have you ever built or tested a model to see if it solves a problem? (student-reported) ID: D810301

Effect Size Tools

Cohen's d is used to determine effect size and is calculated as the difference between two means, where one mean is the control group and the other mean is the experimental group, divided by the standard deviation of either group, thus providing a standardized difference between the two groups. This study used the effect size calculators developed by The University of Colorado at Colorado Springs to determine the effect sizes between groups analyzed using the NAEP Data Explorer. For the analysis, effect sizes are classified as small (.2), medium (.5), and large (.8) and are then translated into percentile standings (Becker, 2000).

4. Results

Table 1: Average scale scores and standard deviations for grade 8 technology and engineering literacy – information and communication technology scale, by all students [TOTAL] and jurisdiction: 2018

Year	Jurisdiction	Student group	Average scale score	Standard deviation
2018	National Public	All Students	151	37

NOTE: Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2018 Technology and Engineering Literacy Assessment.

Exploration of Technology

The group of variables to be analyzed focuses on problem solving and ICT tools not related to school use. Three variables representing independent exploration of ICT tools beyond school assignments will be used to examine the relationship between students' independent problem-solving and average scores on the NAEP TEL assessment. The first variable represents students' independent frequency of figuring out why something is not working in order to fix it. The second variable represents students' independent frequency for taking something apart to fix it or see

This section will report the results from the NAEP 2018 assessment of Technology and Engineering Literacy (TEL) and will focus on the findings limited to the Information and Communication Technology (ICT) Scale, specifically reporting on the impacts of factors beyond school. The purpose of this reporting will be to determine whether or not there is a direct correlation between time spent out of school working with digital technology tools or problem solving with technology scores of 8th grade students. The results below represent three beyond school uses of technology and will include average scores based on time spent outside of school.

Data Analysis

Table 1 represents the overall average scale score for the information and technology scale from the 2018 NAEP TEL assessment, within the National Public jurisdiction, representing national public schools. Overall results reflect an average assessment score of 151 with a standard deviation of 37.

how it works. The third variable represents students' independent frequency for building and testing models to see if they solve a problem.

RQ3 – Outside of school, how often have you ever figured out why something is not working in order to fix it?

Table 8 shows the 2018 TEL – ICT scale score and standard deviation for 8th grade national public schools students based on their reported frequency of figuring out why something is not working in order to fix it outside of school.

Table 8: Average scale scores and standard deviations for grade 8 TEL – ICT scale, by figured out why not working in order to fix it-out of school [D810201] and jurisdiction: 2018

Year	Jurisdiction	Figured out why not working in order to fix it – out of school	Average score	scale	Standard deviation
2018	National public	Never	141		36
		Once or twice	146		37
		Three to five times	153		36
		More than five times	161		36

NOTE: Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2018 Technology and Engineering Literacy Assessment.

As self-reported by 8th grade students in 2018, those who indicated that they figured out why something is not working in order to fix it outside of school work more than five times had the highest average scale score at 161 (SD=36). Students who reported that they never figured out why something is not working in order to fix it had the lowest average scale score at 141 (SD=36). Similarly, students who reported a frequency of figuring out why something

is not working once or twice had a similar score at 146 (SD=37), while students who reported having done so three to five times fell in the middle with an average scale score of 153 (SD=36).

Table 9 shows the differences in means and independent t-test results for the frequency of figuring out why something is not working in order to fix it.

Table 9: Difference in average scale scores between variables, for figured out why not working in order to fix it-out of school [D810201], National public, 2018

	Never	Once or twice	Three to five times	More than five times
Never				
Once or twice	> Diff = 5 P-value = 0.0069 Family size = 6			
Three to five times	> Diff = 12 P-value = 0.0001 Family size = 6	> Diff = 7 P-value = 0.0001 Family size = 6		
More than five times	> Diff = 20 P-value = 0.0001 Family size = 6	> Diff = 15 P-value = 0.0001 Family size = 6	> Diff = 8 P-value = 0.0001 Family size = 6	
LEGEND:				
<	Significantly lower.			
>	Significantly higher.			
x	No significant difference.			

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2018 Technology and Engineering Literacy Assessment.

Multiple independent t-tests show that 8th grade students who more often figure out why something isn't working in order to fix it have significantly higher TEL scores than those who do so less frequently. Students who reported that they figured out why something isn't working in order to fix it more than five times had significantly higher TEL scores (20 points more) than those who create reported never doing so ($p < .05$). Similarly, 8th grade students who reported having figured out why something isn't working more than five times scored significantly higher (15

points more) than those who reported doing so only once or twice and (8 points more) than those who reported frequencies of three to five times ($p < .05$). Students reporting figuring out why something isn't working three to five times, however, scored significantly higher (12 points more) than those who reported never doing so, and (7 points more) than those who reported doing so only once or twice ($p < .05$). Though only scoring 5 points more than those who never figured out why something isn't working in order to fix it,

those who did so once or twice still had a significantly higher score ($p < .05$).

Cohen's d effect size was calculated to determine the strength of the significance indicated in the independent t -tests. Table 10 shows Cohen's d effect size of the significant mean score differences for 8th grade students figuring out why something isn't working in order to fix it.

Table 10: *Effect sizes of significant mean score differences figured out why not working in order to fix it-out of school [D810201], National public, 2018*

		Cohen's d
Once or twice	Never	0.14
Three to five times	Never	0.33
Three to five times	Once or twice	0.19
More than five times	Never	0.56
More than five times	Once or twice	0.41
More than five times	Three to five times	0.22

For students figuring out why something doesn't work in order to fix it, the effect size for mean score differences between those

reporting a frequency of a once or twice and never was 0.14. The effect size for mean score differences for students reporting a frequency of three to five times and once or twice was 0.19, and the effect size for mean score differences for students reporting having figured out why something isn't working more than five times and those reporting three to five times was 0.22. While the independent t -tests did indicate significant differences in test scores between these reported frequencies, the effect size for each was 0.2 or less, indicating a relatively small effect size in each case. However, the effect size for mean score differences for students reporting a frequency more than five times and those reporting never was 0.56, indicating a medium effect size. The effect size for mean score differences of students reporting having figured out why something isn't working three to five times and those reporting having never done so was 0.33, while the effect size for those reporting more than five times and those reporting once or twice was -.41. The independent t -tests indicated significant differences in test scores between these reported frequencies, and the effect size for each fell between 0.2 and 0.5, indicating a small to medium effect size.

RQ4 - *Outside of school, how often have you ever taken something apart in order to fix it or see how it works?*

Table 11 shows the 2018 TEL – ICT scale score and standard deviation for 8th grade national public schools students based on their reported frequency of taking something apart in order to fix it or see how it works outside of school.

Table 11: *Average scale scores and standard deviations for grade 8 TEL – ICT scale, by took apart to fix or see how it works-out of school [D810401] and jurisdiction: 2018*

Year	Jurisdiction	Took apart to fix or see how it works – out of school	Average scale score	Standard deviation
2018	National public	Never	150	36
		Once or twice	152	37
		Three to five times	152	37
		More than five times	157	36

NOTE: Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2018 Technology and Engineering Literacy Assessment.

As self-reported by 8th grade students in 2018, those who indicated that they took something apart to fix it or see how it works outside of school more than five times had the highest average scale score at 157 (SD=36). Students who reported that they never took something apart to fix it or see how it worked had the lowest average scale score at 150 (SD=36). Students who reported having

done so only once or twice had the same average scale score as those who did so three to five times at 152 (SD=37).

Table 12 shows the differences in means and independent t -test results for the frequency of taking something apart in order to fix it or see how it works outside of school.

Table 12: Difference in average scale scores between variables, for took apart to fix or see how it works-out of school [D810401], National public, 2018

	Never	Once or twice	Three to five times	More than five times
Never				
Once or twice	x Diff = 3 P-value = 0.0482 Family size = 6			
Three to five times	x Diff = 2 P-value = 0.1586 Family size = 6	x Diff = -1 P-value = 0.6291 Family size = 6		
More than five times	> Diff = 7 P-value = 0.0001 Family size = 6	> Diff = 4 P-value = 0.0020 Family size = 6	> Diff = 5 P-value = 0.0001 Family size = 6	
LEGEND:				
<	Significantly lower.			
>	Significantly higher.			
x	No significant difference.			
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2018 Technology and Engineering Literacy Assessment.				

Multiple independent t-tests show that 8th grade students who took something apart to fix it or see how it works outside of school more than five times have significantly higher TEL scores (7 points more) than those who never took something apart to fix it or see how it works outside of school only ($p < .05$). Similarly, 8th grade students who report taking something apart to fix it or see how it works outside of school more than five times scored significantly higher (4 points) than those who did so only once or twice and (5 points more) than those who did so three to five times ($p < .05$). However, no significant difference was found between student scores for those reporting three to five times and never or once or twice, or between those reporting once or twice and never ($p > .05$).

Cohen's d effect size was calculated to determine the strength of the significance indicated in the independent t-tests. Table 13 shows Cohen's d effect size of the significant mean score

differences for 8th grade taking something apart to fix it or see how it works outside of school.

Table 13: Effect sizes of significant mean score differences for took apart to fix or see how it works-out of school [D810401], National public, 2018

		Cohen's d
More than five times	Never	0.19
More than five times	Once or twice	0.13
More than five times	Three to five times	0.13

For students taking something apart in order to fix it or see how it works, the effect size for mean score differences between those reporting a frequency more than five times and never was 0.19.

The effect size for mean score differences for students reporting a frequency of more than five times and once or twice was 0.13, which was the same as the effect size for mean score differences between reported frequencies of more than five times and three to five times. While the independent t-tests did indicate significant differences in test scores between these reported frequencies, the effect size for each was less than 0.2 or less, indicating a relatively small effect size in each case.

RQ5 - *Outside of school, how often have you ever built or tested a model to see if it solves a problem?*

Table 14 shows the 2018 TEL – ICT scale score and standard deviation for 8th grade national public schools students based on their reported frequency of building or testing a model to see if it solves a problem outside of school.

Table 14: Average scale scores and standard deviations for grade 8 TEL – ICT scale, by built/tested model to check solution-out of school [D810301] and jurisdiction: 2018

Year	Jurisdiction	Built/tested model to check solution – out of school	Average scale score	Standard deviation
2018	National public	Never	150	36
		Once or twice	154	37
		Three to five times	151	38
		More than five times	158	36

NOTE: Some apparent differences between estimates may not be statistically significant.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2018 Technology and Engineering Literacy Assessment.

As self-reported by 8th grade students in 2018, those who indicated that they built or tested a model to see if it solves a problem outside of school more than five times had the highest average scale score at 158 (SD=36). Students who reported that they never built or tested a model to see if it solves a problem had the lowest average scale score at 150 (SD=36). Students who reported having done so three to five times scored close to the same as those who never did

so at 151 (SD=38), while those who reported having done so only once or twice scored slightly higher at 154 (SD=37).

Table 15 shows the differences in means and independent t-test results for the frequency of building or testing a model to see if it solves a problem outside of school.

Table 15: Difference in average scale scores between variables, for built/tested model to check solution-out of school [D810301], National public, 2018

	Never	Once or twice	Three to five times	More than five times
Never				
Once or twice	>			
	Diff = 3			
	P-value			
	= 0.0218			
	Family size = 6			
Three to five times	x	x		
	Diff = 1	Diff = -3		
	P-value	P-value		
	= 0.6282	= 0.0545		
	Family size = 6	Family size = 6		

More than five times	>	>	>
	Diff = 8	Diff = 4	Diff = 7
	P-value	P-value	P-value
	= 0.0001	= 0.0019	= 0.0001
	Family size = 6	Family size = 6	Family size = 6

LEGEND:

<	Significantly lower.
>	Significantly higher.
x	No significant difference.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2018 Technology and Engineering Literacy Assessment.

Multiple independent t-tests show that 8th grade students who built or tested a model in order to solve a problem outside of school more than five times have significantly higher TEL scores (8 points more) than those who never built or tested a model to see if it solves a problem outside of school only ($p < .05$). Similarly, 8th grade students who report building or testing a model in order to see if it solves a problem outside of school more than five times scored significantly higher (4 points) than those who did so only once or twice and (7 points more) than those who did so three to five times ($p < .05$). Students who reported building or testing a model in order solve a problem outside of school once or twice also scored significantly higher (3 points more) than those who never did so ($p < .05$). However, no significant difference was found between student scores for those reporting three to five times and either never or once or twice ($p > .05$).

Cohen's d effect size was calculated to determine the strength of the significance indicated in the independent t-tests. Table 16 shows Cohen's d effect size of the significant mean score differences for 8th grade taking building or testing a model to see if it solves a problem outside of school.

Table 16: Effect sizes of significant mean score differences for built/tested model to check solution-out of school [D810301], National public, 2018

		Cohen's d
Once or twice	Never	0.11
More than five times	Never	0.22
More than five times	Once or twice	0.11
More than five times	Three to five times	0.19

For students building or testing a model to see if it solves a problem outside of school, the effect size for mean score differences between those reporting a frequency of once or twice and never was 0.11. The effect size for mean score differences for students reporting a frequency of more than five times and never

was 0.22. The effect size for mean score differences for students reporting a frequency of more than five times and once or twice was 0.11, and the effect size for mean score differences for students reporting a frequency of more than five times and three to five times was 0.19. While the independent t-tests did indicate significant differences in test scores between these reported frequencies, the effect size for each was 0.2 or less, indicating a relatively small effect size in each case.

5. Discussion

The purpose of this research project is to examine the impact of non-school factors, such as problem-solving skills as applied to technological problems and digital communication use on student technology scores. The following questions were explored using data from the NAEP 2018 assessment of Technology and Engineering Literacy, focusing specifically on the Information and Communication Technology scale.

1. Outside of school, how often have you ever figured out why something is not working in order to fix it?
2. Outside of school, how often have you ever taken something apart in order to fix it or see how it works?
3. Outside of school, how often have you ever built or tested a model to see if it solves a problem?

Exploration of Technology

Research questions 1-3 focused on Exploration of Technology, and the results reflect the impact of students' problem solving on TEL-ICT scores. As Alexandre and Enslin (2017) note, problem-solving skills allow students to evaluate their environment academically, connecting also to positive relationships in experiential learning, individualized instruction, and independent study, such as exploring how something works or testing a model. Regular exploration of technology in order to see how it works or to solve a problem yielded consistent results on the TEL-ICT assessment, with scores increasing significantly as frequency increased across all three questions. Research question 1 explored how often students have figured out why something is not working in order to fix it, and the results reflected significant increases across all

variables as frequency increased as shown in Table 9, with the biggest difference reflected between those who did so more than five times ($M=161$) and those who never did so ($M=141$). As table 10 indicates, this difference in mean scores had a medium effect size ($d=0.56$), reflecting a meaningful positive relationship between increased frequency and test scores. This same relationship between the highest and lowest frequencies was also reflected in the outcomes for questions 2 and 3, though in both of these cases, the effect size was relatively small between differences. Question 2 examined the impact of how often students took something apart in order to fix it or see how it works on TEL-ICT scores, and though the overall difference was less than the differences in scores under question 1, a significant difference was found between students who took something apart outside of school to fix it or see how it works more than five times ($M=157$) and those who never did so ($M=150$). Similarly, results for question 3 indicated positive significant differences between students who built or tested a model to see if it solves a problem more than five times ($M=158$) and those who never did so ($M=150$). Overall, when looking at the combined impact of exploration of technology to solve a problem or see how something works, the TEL-ICT results suggest that time spent outside of school exploring technology for these purposes has a positive impact on student scores, reflecting a stronger understanding of technology. This confirms the findings by Ergin et al. (2020), which found that problem-solving impacts higher order thinking and has a positive correlation to GPA, and by Alexandre and Enslin (2017), who noted problem-solving as highly correlated to academic achievement. According to the NAEP outcomes, students who are more curious and motivated to solve problems tend to demonstrate higher technological and engineering literacy, supporting Veerasamy et al.'s (2019) finding that students with problem solving competencies perform better in programming.

Information and Communication Technology

Overall, the results seem to suggest that there is an overall positive correlation between time spent working with digital technology outside of school and ICT literacy, which supports Erdoğan and Erdoğan's (2015) assessment that access to ICT correlates to academic success, noting the particular impact in math and science when students had access at home and school. Students who spent more time working to problem-solve and explore technology to see how it works tended to score higher on the ICT scale of the TEL assessment. The results seem to clearly indicate though that students who exhibit curiosity and a desire to problem-solve more frequently may have stronger technology and engineering literacy, especially when it comes to ICT use.

6. Conclusions and Future Research

For many years, technology has been an increasing element of classroom learning. As parents and educators, we often assume that students of this generation are digital natives, and that they have a more advanced understanding of technology and ICT tools because they have grown up in the age of tablets and smartphones. However, while students understand the basic functionality of these tools, many still struggle with more specific skills needed to succeed in school and beyond school environments. Now, with the rapid ubiquity of AI tools, it becomes more important than ever to assess how well students are understanding the technology that they are engaging with. Students are asked to engage with technology in a variety of ways in the classroom. However, the

focus of this study has been to examine the impact that time spent on non-school related use of technology has had on 8th grade technology literacy scores, as collected through the 2018 NAEP Technology and Engineering Literacy assessment.

Conclusions

1. Time spent outside of school exploring technology and using problem-solving skills has a positive impact on overall student understanding of technology.

Students who exhibited a curious exploration of technology, its components, and how it works on their own, consistently demonstrate a stronger understanding of technology and ICT tools. As expected, students who consistently used problem-solving skills to fix or understand how things work or who consistently used technology to solve a problem scored higher on the TEL-ICT assessment. Guiding students toward a stronger problem-solving skill base or mind-set may, then, lead to more independent exploration of technological tools beyond their basic uses and could lead to stronger overall ICT skills in the future.

2. While curiosity, and problem-solving skills all support stronger ICT understanding, repetitive use of ICT tools is not enough to increase scores or overall understanding.

Overall, the results of the study demonstrate that students who exhibit a curiosity about how technology works, a desire to problem-solve or fix something that isn't working properly, or who use technology for creative purposes more often than those who do not tend to demonstrate higher scores and a deeper understanding of ICT tools than those who do so less often. However, when encouraging more frequent use of technology and ICT tools specifically, it is important to encourage students to experiment with and explore the possibilities these tools offer, rather than simply replicating the similar processes for different projects, as rote use of the tools can lead to less creativity and a weaker overall understanding of the technology.

Implications

The results of this study have implications for a number of stakeholders, though most directly for parents and teachers. Problem-solving skills are essential in the 21st century (Ergen et al., 2020). By encouraging problem-solving exploration at home in regard to ICT, parents and teachers can guide students toward a more intrinsic sense of curiosity, which may translate to higher levels of academic achievement on technology scores and overall academic outcomes.

Recommendations

1. Encourage independent technology and ICT use outside of classroom environments to improve overall understanding of ICT tools.
2. Provide opportunities for students to take apart and explore technology to gain an understanding of how it works.
3. Promote a culture of curiosity at school to build intrinsic motivation to explore and build creative problem-solving skills.
4. Demonstrate innovative uses of ICT tools that go beyond surface-level functionality to promote more dynamic use and less reliance on rote ICT skills.

Limitations

There were several limitations impacting the analysis of data and resulting findings in this study. First, the NAEP, TEL assessment was only conducted twice, in 2014 and again in 2018. For the purposes of this study, only the most recent year's information was used to represent a more current snapshot of the results. While an understanding of trends would have been preferable, a statement from the NAEP Governing Board explains: "Over time, the multi-year processes to keep NAEP assessment frameworks and test items updated did not align to that exponential pace of change in technology. Additionally, operational constraints prevented reporting future data points on score trends for TEL, thus not allowing the ability to measure progress over time" (*Governing Board Decides*, 2023). As a result, the NAEP board also discontinued the NAEP-TEL assessment, as it was too difficult to keep up with the evolving nature of technology.

The NAEP TEL assessments were also only administered to 8th grade students, limiting the scope of the study. As with longitudinal study, more could be learned from assessing students in other grade levels as well.

Finally, while the data gathered from the NAEP questionnaire provides insight into students' broad use of technology, more could be learned from taking a qualitative look at factors influencing students' motivations to explore and use technology outside of school.

Recommendations for Future Research

While there are several studies on the impact problem-solving skills on academic achievement, few studies have focused specifically on the impact these skills have on technology achievement among students. Fewer studies focused on student use of technology for problem-solving purposes on their own time, and most that do connect problem-solving to technology outcomes focus on classroom projects and work done for school. While this study only touches on the impacts of non-school related problem-solving skills on technology scores, it serves as a starting point for further study. Additionally, more work should be done to explore:

- The reasons students use ICT at home.
- The specific impacts of curiosity on ICT skills.
- Updated ICT technologies, such as social media and AI-enhanced tools.
- A more consistent look at problem-solving impacts on ICT skills over time.

Additionally, while the NAEP TEL assessment provides interesting and useful information about the impacts of problem-solving on student TEL-ICT scores, an assessment designed to address the evolving nature of technology that includes data on the types of tools students are using would be a benefit to future researchers.

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