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How is School ICT Availability and Use Associated with Students' Mathematics Achievement?

-- An Empirical Study Based on PISA 2022 East Asian Data

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Abstract: Education digitalization has become an important direction of school governance and classroom reform, yet whether school ICT resources can be transformed into learning gains remains an empirical question. Using PISA 2022 student-level data from East Asia, this study examines the association between school ICT availability and use and students' mathematics achievement. The baseline dependent variable is PV1MATH, and the core explanatory variable is ICTAVSCH. The models control for gender, mother's education, father's education, and regional fixed effects. The final sample contains 26,518 students from Chinese Taipei, Hong Kong (China), Japan, Korea, and Macao (China). Results show that ICT availability and use are not monotonically associated with higher mathematics achievement. Medium ICT use is associated with the highest average score, while the highest ICT group performs lower. OLS, nonlinear and grouped regressions, ten-plausible-value robustness checks, quantile regression, and heterogeneity analysis all point to a similar conclusion. The findings suggest that digital education policy should move from an input-oriented logic to an instructional integration logic.

Keywords: School ICT Availability and Use; Mathematics Achievement; PISA 2022; OLS Regression; Quantile Regression.

1. Introduction

Digital technology has become a central component of global education policy. Learning devices, online platforms, educational software, and digital assessment systems are often expected to improve classroom efficiency and expand access to high-quality learning resources. However, the presence of technology in schools does not automatically improve learning quality. The frequency, purpose, teacher guidance, and task design of ICT use may all affect whether digital resources are converted into academic performance [1].

PISA 2022, with mathematics as its major assessment domain, provides comparable data for examining this issue. East Asian systems are especially relevant because they generally have strong basic education and relatively developed digital infrastructure. The key question is whether higher levels of school ICT availability and use are still associated with better mathematics performance when ICT resources are already widely available [2].

This question matters because digital education policy is often evaluated through input indicators such as device numbers, internet access, platform coverage, and reported frequency of use. These indicators describe resource input, but they do not show whether students use digital tools for meaningful mathematical thinking. The East Asian sample is therefore valuable: ICT infrastructure is already relatively widespread, so the central issue shifts from equipment coverage to instructional integration. This study asks whether higher school ICT availability and use remain associated with mathematics achievement after student background and regional differences are considered, and whether the relationship is linear or conditional.

2. Literature Review and Hypotheses

Existing studies do not reach a uniform conclusion on the relationship between ICT use and academic performance. ICT may provide feedback, visualization, diagnostic practice, and individualized learning support. At the same time, excessive or poorly integrated ICT use may create distraction, shallow interaction, and fragmented learning tasks. For mathematics learning, the effect of ICT depends strongly on whether digital tools support conceptual understanding, reasoning, and structured practice [3,4].

A first line of research emphasizes resource availability. From this perspective, computers, internet access, learning software, and digital assessment tools expand students' opportunities to access information and receive practice. The implied mechanism is a resource-support effect: digital tools can reduce learning costs, provide instant feedback, visualize abstract mathematical relationships, and make differentiated practice easier to organize. This mechanism is plausible, especially in contexts where access to learning resources was previously limited. However, the resource view becomes less sufficient when most schools already have relatively high ICT availability. At that stage, the quality of use may matter more than the mere presence of resources [5].

A second line of research stresses use quality and excessive use. ICT activities are not homogeneous. Some activities help students test conjectures, observe patterns, and receive diagnostic feedback, while others may replace deeper mathematical reasoning with short, fragmented tasks. The same device can support high-quality learning or become a source of distraction. This is why several studies report nonlinear or even negative associations between ICT use and achievement. The core issue is not whether technology is used, but whether it is used for cognitively meaningful tasks under appropriate teacher guidance [6,7].

A third consideration is selection. Students with weaker achievement, schools facing learning difficulties, or classrooms implementing remedial programs may rely more heavily on ICT-based practice. In such cases, high ICT use

partly reflects pre-existing learning difficulties rather than causing them. Cross-sectional data cannot fully separate this selection mechanism from the effect of ICT itself. Therefore, we interpret the empirical results in this paper as conditional associations rather than strict causal effects.

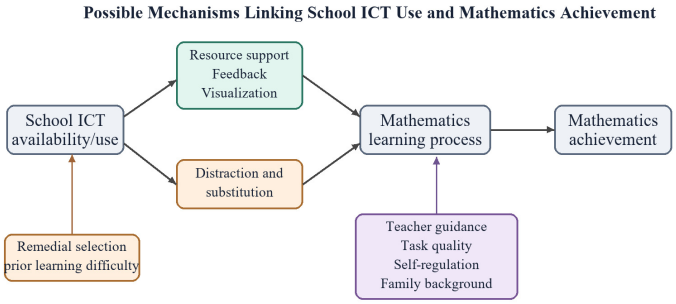


Figure 1. Possible Mechanisms Linking School ICT Use and Mathematics Achievement

Figure 1 is used as the organizing framework for the empirical analysis. It shows why the same ICT indicator may be linked to achievement through opposite channels: resource support may improve learning, while distraction, substitution, and remedial selection may weaken the observed association.

This paper therefore does not assume that ICTAVSCH must be positively associated with mathematics achievement. Instead, it proposes that the relationship may be nonlinear; that higher ICTAVSCH may remain negatively associated with achievement after controls; that the negative association may be stronger among lower-performing students; and that the relationship may vary by gender and parental education.

H1. Nonlinear association. School ICT availability and use do not have a simply positive relationship with mathematics achievement. Moderate use may support feedback and visualization, while excessive or poorly structured use may weaken learning quality.

H2. Conditional negative association. After controlling for gender, parental education, and regional fixed effects, higher ICTAVSCH may remain negatively associated with mathematics achievement. This expectation follows from the possibility that high frequency does not necessarily indicate high instructional value.

H3. Achievement-position heterogeneity. The negative association may be stronger among lower-performing students. These students may face greater remedial needs and may be more vulnerable to weak self-regulation in digital environments.

H4. Subgroup heterogeneity. The association may differ by gender and parental education. If the result reflects a broad problem of instructional integration, however, it should not be confined to only one narrow subgroup.

3. Research Design

The data are from PISA 2022 student-level files. The original data cover six East Asian regions, but Mongolia is excluded from the complete-case sample because the core ICT variable is missing. After excluding observations with missing values in PV1MATH, ICTAVSCH, gender, mother's education, father's education, and region, the final sample contains 26,518 students [2,8].

Table 1. Sample Screening Process

Screening step	N	Retention	Reduction
Original sample	35,361	100.00%	0
PV1MATH non-missing	35,361	100.00%	0
ICTAVSCH non-missing	27,358	77.37%	8,003
Gender included	27,358	77.37%	0
Mother's education included	26,940	76.19%	418
Father's education included	26,518	74.99%	422

Note: The final sample is the complete-case sample used in the empirical analysis

The sample-screening process shows that the major loss of observations comes from the ICTAVSCH variable rather than from mathematics scores or gender. This point is important because the final sample should not be mistaken for the full PISA East Asian sample. It is the subset for which the dependent variable, the key ICT variable, and the basic control variables are simultaneously observed. The analysis is therefore internally consistent, but its external interpretation should be tied to this complete-case sample.

The dependent variable in the baseline model is PV1MATH. The core explanatory variable is ICTAVSCH, ranging from 0 to 7. Gender is coded as female = 1. Parental education variables are recoded so that larger values indicate higher education. ICTAVSCH is also divided into three groups: low level (0-3), medium level (4-6), and high level (7). The baseline model is estimated by OLS with robust standard errors and regional fixed effects.

ICTAVSCH is treated in two ways. In the baseline regression, it is used as a continuous indicator from 0 to 7, so the coefficient can be interpreted as the average score difference associated with one additional unit of school ICT availability and use. In the nonlinear analysis, it is also divided into low, medium, and high groups. The grouped specification is easier to interpret because it directly compares the medium and high ICT groups with the low ICT reference group. This design is especially useful when the true relationship may not be linear.

Because the compact dataset does not include student weights, replicate weights, school identifiers, or richer socioeconomic controls, the results are interpreted as correlations rather than strict causal effects. To improve the treatment of PISA plausible values, the robustness analysis estimates the same model separately for PV1MATH to PV10MATH and combines coefficients and variances using

the plausible-value rule [8].

The empirical model is an ordinary least squares model with robust standard errors. It relates mathematics achievement to ICTAVSCH, gender, mother's education, father's education, and regional fixed effects. Regional fixed effects are included because the five regions differ in average performance, ICT distribution, curriculum context, and institutional environment. By absorbing region-level mean differences, the model focuses on within-sample associations net of broad regional differences.

The limitations of the model are made explicit. The available file does not contain student final weights, replicate weights, school identifiers, or a fuller socioeconomic-status index. Therefore, the analysis cannot claim to reproduce the official PISA complex-sampling estimates. It is best understood as a transparent empirical analysis under data constraints: it uses available variables consistently, reports robust standard errors, combines plausible values for sensitivity, and avoids causal language.

4. Empirical Results

4.1. Descriptive Differences and Nonlinear Patterns

This section first describes regional differences, the distribution of ICTAVSCH, group differences in mathematics achievement, and the nonlinear pattern suggested by the data. These descriptive results are not treated as causal evidence. Their purpose is to show whether the data are consistent with the simple assumption that more ICT is always associated with better mathematics performance.

Table 2. Regional Descriptive Statistics

Region	N	PV1 mean	PV1 SD	Mean of 10 PVs	ICT mean
Chinese Taipei	5,558	536.758	110.741	536.551	6.283
Hong Kong (China)	5,215	549.001	102.783	549.811	6.094
Japan	5,368	538.871	93.027	538.051	6.608
Korea	6,069	533.481	104.260	533.217	6.621
Macao (China)	4,308	552.498	91.780	552.821	6.152

Note: Regional means are calculated within the final complete-case sample.

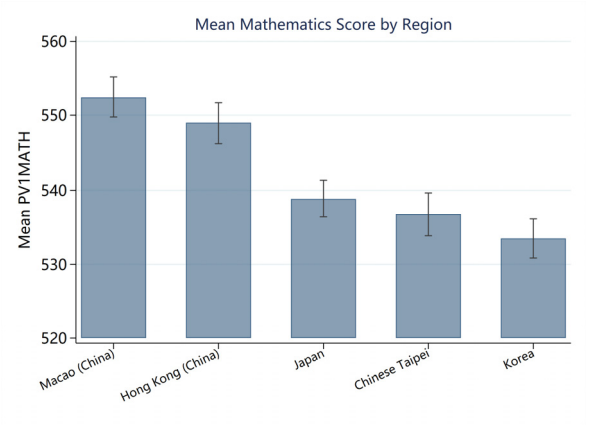


Figure 2. Mean Mathematics Score by Region

The regional statistics show that mathematics achievement and ICT availability are not distributed uniformly across the five regions. Macao (China) and Hong Kong (China) have relatively high PV1 mathematics means, while Korea has a lower mean in this complete-case sample. ICTAVSCH is high in all regions, but Japan and Korea report slightly higher average ICT levels than Hong Kong (China) and Macao (China). These differences justify the use of regional fixed effects in the regression models.

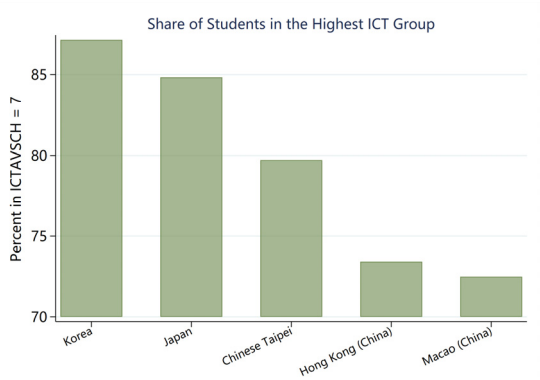


Figure 3. Share of Students in the Highest ICT Group by Region

Figures 2 and 3 visualize the two regional contrasts reported in Table 2: regions with higher average mathematics scores are not necessarily those with the highest share of students in the maximum ICT group. Keeping only these two figures avoids repeating the same regional ICT distribution in multiple visual formats.

Table 3. Detailed Distribution of ICTAVSCH and Mathematics Achievement

ICT level	N	Share	PV1 mean	PV1 SD	Parental edu. mean
0	632	2.38%	529.537	108.850	4.175
1	522	1.97%	548.678	102.211	4.280
2	451	1.70%	555.177	99.055	4.212
3	455	1.72%	564.699	90.975	4.323
4	549	2.07%	566.996	91.468	4.310
5	808	3.05%	567.305	93.631	4.230
6	1,876	7.07%	558.018	97.662	4.290
7	21,225	80.04%	537.666	101.924	4.334

Note: Parental education mean is the average of the recoded mother and father education variables

The detailed distribution clearly warns against a linear interpretation. The sample is heavily concentrated at ICT

level 7, which accounts for 80.04% of students.

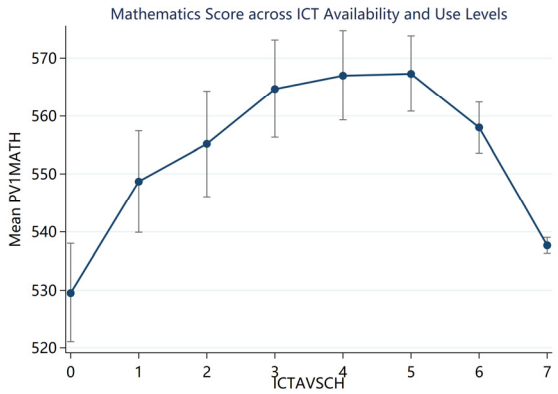


Figure 4. Mathematics Score across ICT Availability and Use Levels

However, the highest ICT level does not have the highest mathematics mean. The mean rises from level 0 to the middle levels, reaches more than 566 points at levels 4 and 5, and then falls to 537.666 at level 7. This pattern suggests that the marginal meaning of ICTAVSCH changes when it reaches the maximum category. At the top level, the indicator may reflect intensity of use, remedial reliance, or broad availability rather than high-quality mathematical learning.

Figure 4 gives a direct visual counterpart to Table 3. The curve rises from low ICT levels to the middle range, but drops sharply at level 7. This visual pattern is the main reason for estimating the nonlinear and grouped models below rather than relying only on a linear specification.

Table 4. ICT Groups and Mathematics Achievement

ICT group	N	Share	PV1 mean	PV1 SD	Mean of 10 PVs
Low (0-3)	2,060	7.77%	547.767	102.086	547.198
Medium (4-6)	3,233	12.19%	561.863	95.714	562.383
High (7)	21,225	80.04%	537.666	101.924	537.569

Note: The robust F test for PV1 mathematics differences across the three ICT groups is 92.014, $p < 0.001$

The medium ICT group has the highest mean mathematics score, while the high ICT group performs lower than both the low and medium groups. This pattern is inconsistent with a simple 'more ICT is better' assumption. The nonlinear model also shows that the centered ICT term and its squared term are both negative and significant, and R-squared increases from 0.023 to 0.029. In the grouped regression, using the low ICT group as the reference, the medium group coefficient is 14.722, while the high group coefficient is -8.410. This pattern is consistent with studies that emphasize nonlinear and excessive-use mechanisms [9].

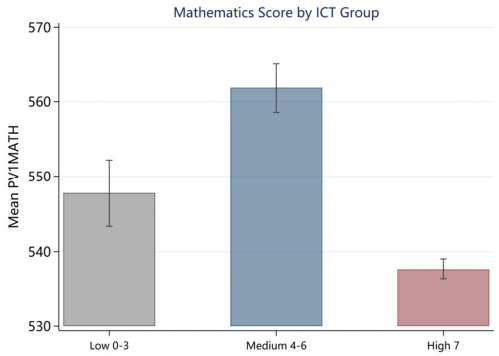


Figure 5. Mathematics Score by ICT Group

Table 5. Nonlinear and Grouped Regression Results

Variable	Linear model	Quadratic model	Grouped model
ICTAVSCH	-2.013*** (0.401)		
Centered ICT		-14.991*** (1.045)	
Centered ICT squared		-2.895*** (0.225)	
Medium ICT group			14.722*** (2.780)
High ICT group			-8.410*** (2.349)
Female	-9.701*** (1.231)	-10.251*** (1.228)	-10.203*** (1.229)
Mother's education	6.566*** (0.773)	6.567*** (0.771)	6.607*** (0.772)
Father's education	10.571*** (0.764)	10.549*** (0.763)	10.580*** (0.763)
Region fixed effects	Yes	Yes	Yes
N	26,518	26,518	26,518
R-squared	0.023	0.029	0.028

Note: The grouped model uses the low ICT group (0-3) as the reference category

Figure 5 further compresses the same pattern into the low, medium, and high ICT groups used in the regression model. It shows that the medium group has the clearest achievement advantage, whereas the high group is visibly lower. The grouped regression in Table 5 tests whether this visual difference remains after controls.

The quadratic model confirms that the linear model omits some nonlinear information. Both the centered ICT term and the squared term are significantly negative, and the R-squared rises from 0.023 to 0.029. The grouped model is easier to read: compared with the low ICT group, the medium group is associated with a 14.722-point advantage, whereas the high ICT group is associated with an 8.410-point disadvantage. Since one PISA standard deviation is roughly 100 points, these differences are not enormous, but they are meaningful in a large cross-regional sample.

4.2. Baseline OLS and Plausible-Value Robustness

Table 6. Baseline OLS Results

Variable	Model (1)	Model (2)	Model (3)
ICTAVSCH	-2.346*** (0.401)	-2.571*** (0.400)	-2.013*** (0.401)
Female		-9.737*** (1.236)	-9.701*** (1.231)
Mother's education		4.707*** (0.760)	6.566*** (0.773)
Father's education		8.861*** (0.755)	10.571*** (0.764)
Region fixed effects	No	No	Yes
N	26,518	26,518	26,518
R-squared	0.001	0.015	0.023

Note: Robust standard errors are in parentheses. *** $p < 0.01$.

The OLS results show a stable negative association between ICTAVSCH and mathematics achievement. After adding gender, parental education, and regional fixed effects, the coefficient remains negative and significant. In Model (3), each additional unit of ICTAVSCH is associated with a decrease of about 2.013 points in PV1MATH.

The stepwise models also show why controls are necessary. Model (1) only includes ICTAVSCH and captures a raw association. Model (2) adds gender and parental education, which reduces omitted-variable bias from basic family and individual characteristics. Model (3) further adds regional fixed effects, absorbing average differences across Chinese Taipei, Hong Kong (China), Japan, Korea, and Macao (China). The fact that ICTAVSCH remains negative and significant in all three specifications indicates that the result is not produced solely by regional mean differences or parental education composition.

Table 7. Combined Estimates Using Ten Mathematics Plausible Values

Variable	Model (1)	Model (2)	Model (3)
ICTAVSCH	-2.293*** (0.424)	-2.518*** (0.423)	-1.918*** (0.424)
Female		-9.854*** (1.285)	-9.814*** (1.280)
Mother's education		4.804*** (0.798)	6.791*** (0.822)
Father's education		8.703*** (0.774)	10.489*** (0.782)
Region fixed effects	No	No	Yes
N	26,518	26,518	26,518
R-squared	0.001	0.014	0.024

Note: The combined standard error incorporates within-model variance and between-plausible-value variance.

The ten-plausible-value robustness check supports the baseline conclusion. After combining PV1MATH to PV10MATH, the ICTAVSCH coefficient in the full model is -1.918 and remains significant at the 1% level. This indicates that the baseline result is not driven by the choice of a single plausible value.

This check is important because PISA achievement is measured with plausible values rather than a single observed score. If the result appeared only when PV1MATH was used, the conclusion would be fragile. Instead, the combined coefficient remains close to the baseline estimate and keeps the same sign and significance. The difference between -2.013 and -1.918 is small in substantive terms, suggesting that the negative association is robust to this basic treatment of measurement uncertainty.

At the same time, the robustness check should not be overstated. The combined plausible-value procedure improves the handling of achievement measurement, but it still does not replace the official PISA complex-sampling variance estimation because student weights and replicate weights are unavailable in the working dataset. The proper interpretation is therefore limited but clear: within the available complete-case sample, the negative ICTAVSCH association is not an artifact of selecting only one mathematics plausible value.

4.3. Quantile Regression

Table 8. Quantile Regression Results

Variable	Q25	Q50	Q75
ICTAVSCH	-2.959*** (0.567)	-2.083*** (0.502)	-1.595*** (0.491)
Female	-1.164 (1.796)	-13.198*** (1.588)	-19.892*** (1.554)
Mother's education	6.785*** (1.130)	6.675*** (1.000)	6.285*** (0.978)
Father's education	11.469*** (1.136)	11.274*** (1.005)	10.988*** (0.983)
Region fixed effects	Yes	Yes	Yes
N	26,518	26,518	26,518

Note: Q25, Q50, and Q75 refer to the 25th, 50th, and 75th conditional quantiles.

Quantile regression shows that the negative association is stronger among lower-performing students. The ICTAVSCH coefficient is -2.959 at Q25, -2.083 at Q50, and -1.595 at Q75. This pattern may reflect remedial use among low-achieving students or weaker self-regulation in digital learning environments.

The quantile results add information that cannot be seen from OLS alone. OLS describes the conditional mean, whereas quantile regression asks whether the association differs across the achievement distribution. The larger negative coefficient at Q25 indicates that students at the lower end of the mathematics distribution are more strongly associated with high ICTAVSCH. This is consistent with the hypothesis that lower-performing students may use digital tools more often for remedial or repetitive practice, or may be more vulnerable to distraction when ICT tasks are not well structured.

4.4. Heterogeneity Analysis

Table 9. Heterogeneity by Gender and Parental Education

Variable	Male	Female	Lower parental edu.	Higher parental edu.
ICTAVSCH	-2.265*** (0.586)	-1.759*** (0.540)	-1.586*** (0.584)	-2.413*** (0.549)
Mother's education	6.693*** (1.165)	6.312*** (1.015)	6.944*** (1.094)	-2.269 (2.695)
Father's education	11.445*** (1.137)	9.705*** (1.018)	9.591*** (1.095)	5.475* (2.848)
Region fixed effects	Yes	Yes	Yes	Yes
N	13,432	13,086	11,876	14,642
R-squared	0.024	0.018	0.028	0.017

Note: Parental education groups are divided by the sample median of average parental education

The negative association is not limited to a single subgroup. ICTAVSCH is negative and significant for both male and female students and for both lower and higher parental education groups. This strengthens the view that the key issue is not only who uses ICT, but how ICT is embedded in classroom tasks and learning processes.

The gender subgroup results show that the coefficient is somewhat larger in absolute value for male students than for female students, but both coefficients are negative and statistically significant. This means that the main conclusion does not depend on one gender group. In the parental education subgroup analysis, the negative coefficient is also present in both groups and is larger for students from higher parental education backgrounds. One possible interpretation is that high-education families already provide substantial learning support, so additional high-frequency school ICT use is less likely to create extra gains unless it is carefully integrated with instruction.

5. Discussion

The evidence supports the main hypotheses. Descriptive statistics and nonlinear models show that the relationship between ICT and mathematics achievement is not simply positive. Baseline OLS and plausible-value robustness checks show a stable negative association after controls. Quantile regression suggests that the association is stronger among lower-performing students, and subgroup regressions show that the pattern exists across gender and parental education groups.

These results warn against input-centered digitalization. In the sample, the highest ICT group is very large, which indicates that school ICT availability is already widespread. Yet this group does not show the highest mathematics achievement. The medium ICT group performs better in descriptive statistics and in grouped regression. This pattern is more consistent with an instructional-integration perspective than with a simple resource-accumulation perspective. Digital resources may be valuable when they are used with clear learning goals, but high availability alone does not guarantee that students engage in deeper mathematical thinking.

These findings do not mean that ICT is inherently harmful. Rather, they indicate that access and high frequency alone are insufficient indicators of learning quality. Education digitalization should shift from a resource-input logic to an instructional integration logic. Schools should evaluate whether digital tools support conceptual understanding, reasoning, feedback, and problem solving. Teacher guidance and task quality are especially important.

There are at least three possible explanations for the

negative association. First, high ICTAVSCH may reflect excessive or poorly structured use. When digital tasks are fragmented, students may spend time clicking, searching, or completing procedural exercises without developing mathematical reasoning. Second, high ICTAVSCH may partly represent remedial use. Schools or students with learning difficulties may rely more on ICT-based exercises, so the negative coefficient may reflect prior achievement problems. Third, high ICTAVSCH may coexist with strong device access but weak teacher integration. Without teacher planning, digital tools may replace rather than enrich mathematical discussion, proof, modeling, and problem solving.

6. Conclusion

In conclusion, the empirical evidence from the PISA 2022 East Asian complete-case sample suggests that school ICT availability and use are not automatically associated with higher mathematics achievement. Moderate ICT use is linked with better performance, while the highest ICT group performs worse after controls. The negative association remains in OLS models, ten-plausible-value robustness checks, quantile regression, and subgroup analysis. The central message is therefore not anti-technology. It is that educational technology should be evaluated by its instructional value, not by its visibility or frequency of use.

7. Policy Implications and Limitations

The policy implication is not to reduce ICT investment mechanically, but to change the evaluation criteria. Education authorities should avoid judging digital education mainly by device counts or usage frequency. More attention should be given to the instructional purpose of ICT activities, the alignment between digital tasks and curriculum goals, and the degree of teacher guidance. For mathematics, useful ICT applications should help students visualize structures, test conjectures, receive timely feedback, and connect procedures with concepts [10,11].

Schools also need differentiated support for lower-performing students. The quantile regression indicates that the negative ICT association is stronger at the lower part of the achievement distribution. This suggests that digital learning for low-achieving students should not simply increase screen time or repetitive practice. It should include clearer learning paths, teacher monitoring, feedback on misconceptions, and support for self-regulation. Otherwise, ICT-based remedial learning may become another form of low-quality repetition.

The study has limitations. It uses cross-sectional data and cannot identify strict causal effects. The available data do not include richer socioeconomic controls, school-level variables, student weights, or replicate weights. Although the study combines ten plausible values, it does not fully implement official PISA complex-sampling variance estimation. Future research should incorporate school-level data, weights, and more detailed indicators of ICT use purposes.

References

[1] OECD. (2019). OECD skills outlook 2019: Thriving in a digital world. https://doi.org/10.1787/df80bc12-en.

[2] OECD. (2023). PISA 2022 assessment and analytical framework. https://doi.org/10.1787/dfe0bf9c-en.

[3] Biagi, F., & Loi, M. (2013). Measuring ICT use and learning outcomes: Evidence from recent econometric studies. European Journal of Education, 48(1), 28–42. https://doi.org/10.1111/ejed.12016.

[4] OECD. (2015). Students, computers and learning: Making the connection. https://doi.org/10.1787/9789264239555-en.

[5] Wenglinsky, H. (1998). Does it compute? The relationship between educational technology and student achievement in mathematics. ETS Research Report Series, 1998(1), i-31. https://doi.org/10.1002/j.2333-8504.1998.tb01722.x.

[6] Comi, S. L., Argentin, G., Gui, M., Origo, F., & Pagani, L. (2017). Is it the way they use it? Teachers, ICT and student achievement. Economics of Education Review, 56, 24–39. https://doi.org/10.1016/j.econedurev.2016.11.007.

[7] Falck, O., Mang, C., & Woessmann, L. (2018). Virtually no effect? Different uses of classroom computers and their effect on student achievement. Oxford Bulletin of Economics and Statistics, 80(1), 1–38. https://doi.org/10.1111/obes.12192.

[8] OECD. (2024). PISA 2022 technical report and database guide. OECD Publishing.

[9] Gorjon, L., & Oses, A. (2023). ICT use and mathematics achievement: Evidence on nonlinear and excessive-use patterns.

[10] OECD. (2023). PISA 2022 results (Volume II): Learning during and from disruption. https://doi.org/10.1787/a97db61c-en.

[11] Boeskens, L. (2025). Using digital resources for learning: Policy insights from PISA 2022 (OECD Education Working Papers). OECD Publishing.