Teacher Digital Competence and Learning Outcomes in Philippine Public Secondary Schools

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Abstract.

Using national assessment data linked to a survey of 1,150 teachers, this paper examines how teacher digital competence relates to student outcomes in mathematics and science in Philippine public secondary schools. Evidence on whether investment in teacher digital skills translates into learning gains, and under what conditions, remains limited. The study drew a stratified sample of 1,150 Grade 9 and 10 mathematics and science teachers from 230 public secondary schools across Luzon, Visayas and Mindanao, measured their digital competence with an instrument aligned to the European framework for the digital competence of educators, and linked responses to class-level results from the National Achievement Test. School connectivity was classified from Department of Education infrastructure records and verified by teacher report. Multilevel models with teachers nested in schools showed a positive association between teacher digital competence and class mean achievement in both subjects after controlling for teacher experience, qualifications, class size and school socioeconomic composition. The association was strongly conditional on connectivity: in schools with reliable internet access, a one standard deviation increase in digital competence was associated with 0.14 and 0.12 standard deviation gains in mathematics and science respectively, whereas in schools with unreliable or no connectivity the association was small and not statistically significant. Effects are concentrated in schools with reliable connectivity, highlighting infrastructure as a precondition for the returns to teacher digital competence. The findings imply that teacher training and connectivity investment should be sequenced and targeted together.

Keywords: teacher digital competence, learning outcomes, school connectivity, Philippine public schools, secondary education

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1. Introduction

The Philippines has made teacher digital competence a priority of its education technology policy for more than a decade. The Department of Education has issued professional standards that include the integration of information and communication technology in teaching, has delivered large-scale training programmes and has procured devices and learning platforms for public schools. These investments accelerated during the period of remote learning and have continued as schools returned to in-person instruction with the expectation that digital tools would remain part of teaching practice. At the same time, the country's performance in international assessments of mathematics and science has remained low, and national assessment results show wide disparities between regions and between urban and rural schools.

Whether teacher digital competence contributes to student learning is a question of evident policy relevance, yet the evidence base in the Philippines and in comparable systems is thin. Studies of teacher technology integration have generally measured teacher attitudes or self-reported use rather than competence, and have rarely linked teacher data to student outcomes at scale. International evidence suggests that the effects of technology on learning depend heavily on how it is used and on the conditions under which it is available, which implies that the returns to teacher competence may be conditional on infrastructure. In a country where a substantial share of public schools lack reliable internet access, this conditionality is not a theoretical nicety but a first-order question for the allocation of resources.

This paper addresses that question by linking a survey of 1,150 mathematics and science teachers in 230 public secondary schools to class-level results from the National Achievement Test. It measures teacher digital competence with an instrument aligned to an established international framework, classifies schools by the reliability of their connectivity and estimates the association between competence and achievement across connectivity conditions using multilevel models. The study asks three questions. Is teacher digital competence associated with student achievement in mathematics and science after controlling for teacher and school characteristics? Does the association depend on school connectivity? Which components of digital competence are most strongly associated with achievement?

The paper contributes evidence on the returns to teacher digital competence in a large developing-country system, and it demonstrates empirically that these returns are contingent on infrastructure. The findings have implications for the sequencing of teacher training and connectivity investment and for the design of professional development. The paper proceeds with a review of the literature, a description of the data and methods, the results, a discussion of implications and a conclusion with limitations.

2. Literature Review

2.1 Conceptualising teacher digital competence

Teacher digital competence has been conceptualised in several frameworks. The TPACK model (Mishra & Koehler, 2006) holds that effective technology integration requires the intersection of technological, pedagogical and content knowledge rather than technological skill alone. The European Framework for the Digital Competence of Educators, DigCompEdu (Redecker, 2017), specifies six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners and facilitating learners' digital competence, each with proficiency levels. UNESCO's ICT Competency Framework for Teachers (UNESCO, 2018) offers a similar structure oriented toward developing-country contexts. These frameworks share the premise that competence is multidimensional and that the pedagogically oriented components, rather than technical operation of devices, are those most likely to influence learning. The present study adopts DigCompEdu as its measurement basis because it has been validated across multiple countries and because its areas map directly onto classroom practices.

2.2 Technology, teachers and learning outcomes

Evidence on the effect of educational technology on learning outcomes is mixed. Reviews of experimental evidence in developing countries find that technology has little effect when it substitutes for teachers or is provided without pedagogical integration, but can improve outcomes when it supports personalised practice or is combined with teacher training (Escueta et al., 2020). Analyses of international assessment data have found weak or negative associations between the intensity of school computer use and achievement (OECD, 2015), while studies that measure the quality of teacher technology integration find positive associations. Comi et al. (2017) show in Italian data that the effect of technology on achievement depends on how teachers use it, with practices that support student engagement and feedback associated with gains and practices that replace instruction associated with losses. Tamim et al. (2011) report from a second-order meta-analysis a small positive average effect of technology on learning, with larger effects when technology supports instruction rather than delivering it. This literature implies that teacher competence, particularly its pedagogical components, is the mechanism through which technology may affect learning.

2.3 Infrastructure as a precondition

In many developing-country systems, the constraint on technology use is not teacher skill but access. Trucano (2016) notes that connectivity in schools across Southeast Asia remains uneven and that devices are often under-used because networks are unreliable. In the Philippines, the Department of Education's own reports acknowledge that a substantial proportion of public schools lack stable internet, particularly in rural areas of Mindanao and the Visayas (Department of Education, 2023). Studies of Philippine teachers during remote learning documented high levels of stress and improvisation in the face of connectivity problems (Cahapay, 2020). The implication for research on teacher competence is that its effects should be modelled as conditional on infrastructure. Following this literature, the study hypothesises that teacher digital competence is positively associated with achievement (H1), that the association is stronger in schools with reliable connectivity (H2) and that pedagogically oriented components of competence are more strongly associated with achievement than technically oriented components (H3).

3. Methodology

3.1 Sample and data sources

The study drew a stratified random sample of public secondary schools from the Department of Education's school register, with strata defined by region group (Luzon, Visayas, Mindanao) and urbanicity. Within each of the 230 sampled schools, all Grade 9 and 10 mathematics and science teachers were invited to participate, and 1,150 teachers returned complete surveys, representing 78.4% of eligible teachers. Teacher survey responses were linked, with Department of Education permission and under a data sharing agreement, to class-level mean scores on the National Achievement Test in mathematics and science for the classes each teacher taught in the 2024–2025 school year. School connectivity was classified from Department of Education infrastructure records into three categories, reliable, unreliable and none, and the classification was verified against teacher reports of connectivity during the school day; discrepancies affecting 14 schools were resolved in favour of teacher reports. Table 1 presents the sample profile. Ethical approval was obtained from the University of the Philippines Diliman, and teacher identities were removed after linkage.

Table 1: Sample profile of teachers and schools

Characteristic	Category	Teachers (n)	Teachers (%)	Schools (n)
Region group	Luzon	512	44.5	98
	Visayas	318	27.7	66
	Mindanao	320	27.8	66
Urbanicity	Urban	604	52.5	112
	Rural	546	47.5	118
Subject	Mathematics	586	51.0	

	Science	564	49.0	
School connectivity	Reliable	471	41.0	89
	Unreliable	446	38.8	94
	None	233	20.2	47
Total		1,150	100.0	230

Source: Authors' survey data linked to Department of Education records (2025)

3.2 Measures

Teacher digital competence was measured with a 22-item self-assessment instrument adapted from the DigCompEdu framework (Redecker, 2017) and translated into Filipino with back-translation. Items covered the six DigCompEdu areas, and for analysis were grouped into a technical component (professional engagement and digital resources) and a pedagogical component (teaching and learning, assessment, empowering learners and facilitating learners' digital competence). Responses were on a five-point proficiency scale, and the overall scale had a reliability of 0.93, with component reliabilities of 0.88 and 0.91. The outcome was the class mean score on the National Achievement Test in the teacher's subject, standardised within subject to a mean of zero and standard deviation of one across the national population. Controls included teacher years of experience, highest qualification, participation in digital training in the previous two years, class size, and school socioeconomic composition measured by the proportion of students receiving conditional cash transfers. Prior achievement was proxied by the school's mean score on the Grade 6 assessment for the relevant cohort.

Self-assessment of competence carries a risk of inflation, and two steps were taken to reduce it. Items were written as descriptions of concrete practices with proficiency anchors, for example whether the teacher had designed a digital activity in which students created rather than consumed content, rather than as global judgements of skill. A subsample of 120 teachers also completed a brief performance task requiring them to plan a lesson segment using a digital resource, which was scored by two raters; the correlation between task scores and self-assessed pedagogical competence was 0.58, indicating reasonable validity of the self-assessment for the component that carries the main results.

3.3 Analysis

Because teachers were nested in schools, two-level random intercept models were estimated separately for mathematics and science (Raudenbush & Bryk, 2002). Model 1 included controls only, Model 2 added digital competence, Model 3 added the interaction between competence and connectivity, and Model 4 replaced overall competence with its technical and pedagogical components. Interaction effects were probed by estimating simple slopes within each connectivity category. All continuous predictors were standardised. Robustness checks included re-estimation with region fixed effects, exclusion of the 14 schools with reclassified connectivity, and use of teacher-reported rather than record-based connectivity throughout. Common method concerns are mitigated by the use of an administrative outcome measure independent of the teacher survey (Podsakoff et al., 2003).

4. Results

4.1 Descriptive statistics

Table 2 reports descriptive statistics by connectivity category. Teacher digital competence was moderately high on average but varied substantially, and it was higher in schools with reliable connectivity than in schools with unreliable or no connectivity, a difference that may reflect both selection of teachers into better-resourced schools and the effect of opportunities to practise. Class mean achievement was also higher in reliably connected schools, and these schools had lower proportions of students receiving conditional cash transfers, confirming the importance of controlling for socioeconomic composition. Participation in digital training in the previous two years was similar across connectivity categories at around 60%, indicating that training had been distributed broadly regardless of infrastructure.

Table 2: Descriptive statistics by school connectivity category

Variable	**Reliable (n = 471)**	**Unreliable (n = 446)**	**None (n = 233)**	**All (N = 1,150)**
Digital competence, mean (SD), 1–5	3.62 (0.61)	3.31 (0.66)	3.04 (0.70)	3.38 (0.68)
Pedagogical component, mean (SD)	3.51 (0.66)	3.19 (0.70)	2.91 (0.73)	3.27 (0.72)
Technical component, mean (SD)	3.79 (0.62)	3.49 (0.68)	3.24 (0.72)	3.56 (0.69)
Class mean achievement, mathematics (z)	0.21 (0.72)	−0.06 (0.74)	−0.31 (0.78)	0.00 (0.76)
Class mean achievement, science (z)	0.18 (0.70)	−0.04 (0.73)	−0.27 (0.77)	0.00 (0.74)
Digital training in past two years (%)	61.8	59.4	58.4	60.2
Students receiving cash transfers (%)	28.4	39.7	51.2	37.4
Class size, mean	44.1	46.3	42.7	44.7

Source: Authors' survey data linked to Department of Education records (2025)

4.2 Multilevel model results

Table 3 presents the key estimates. In Model 2, overall digital competence was positively and significantly associated with class mean achievement in both mathematics ($b = 0.09$, $p < 0.001$) and science ($b = 0.08$, $p < 0.001$) after controls, supporting H1. Model 3 showed that the association was strongly conditional on connectivity, supporting H2. In schools with reliable connectivity, a one standard deviation increase in competence was associated with gains of 0.14 standard deviations in mathematics and 0.12 in science, both significant at $p < 0.001$. In schools with unreliable connectivity, the corresponding estimates were 0.05 and 0.04, marginally significant in mathematics only, and in schools with no connectivity they were 0.02 and 0.01 and not significant. Model 4 indicated that the pedagogical component carried the association: within reliably connected schools, the pedagogical component was associated with gains of 0.13 and 0.11 standard deviations, while the technical component was not significant once the pedagogical component was included, supporting H3. Robustness checks produced estimates that did not differ materially.

Table 3: Association between teacher digital competence and class mean achievement by connectivity (standardised coefficients, N = 1,150 teachers in 230 schools)

Estimate	**Mathematics b (SE)**	**p**	**Science b (SE)**	**p**
Overall competence, all schools (Model 2)	0.09 (0.02)	< 0.001	0.08 (0.02)	< 0.001

Competence, reliable connectivity (Model 3)	0.14 (0.03)	< 0.001	0.12 (0.03)	< 0.001
Competence, unreliable connectivity (Model 3)	0.05 (0.03)	0.071	0.04 (0.03)	0.142
Competence, no connectivity (Model 3)	0.02 (0.04)	0.612	0.01 (0.04)	0.803
Pedagogical component, reliable connectivity (Model 4)	0.13 (0.03)	< 0.001	0.11 (0.03)	< 0.001
Technical component, reliable connectivity (Model 4)	0.03 (0.03)	0.294	0.02 (0.03)	0.487
School-level variance explained (Model 3)	0.31		0.29	

Source: Authors' analysis of survey data linked to Department of Education records (2025)

4.3 Additional findings

Participation in digital training was associated with higher competence but had no direct association with achievement once competence was controlled, suggesting that training affects outcomes only insofar as it raises competence. Teacher experience showed a small positive association with achievement, and school socioeconomic composition was the strongest school-level predictor. Region group differences in achievement were largely accounted for by connectivity and socioeconomic composition. Among teachers in reliably connected schools, those who reported using digital tools for formative assessment and feedback at least weekly had classes with higher achievement than those who used tools mainly for presentation, a pattern consistent with the dominance of the pedagogical component.

5. Discussion

The findings provide evidence that teacher digital competence is associated with student achievement in Philippine public secondary schools, but only where infrastructure allows competence to be exercised. The overall association is modest, and it conceals a sharp contrast between reliably connected schools, where the association is meaningful, and schools without reliable connectivity, where it is negligible. This pattern is consistent with the view that technology affects learning through teacher practice rather than through provision (Tamim et al., 2011; Comi et al., 2017), and it adds the observation that practice requires infrastructure. A competent teacher in an unconnected school cannot deploy the practices that competence enables, so the return to competence is close to zero.

The dominance of the pedagogical component over the technical component supports the premise of TPACK (Mishra & Koehler, 2006) and DigCompEdu (Redecker, 2017) that technology integration is a pedagogical rather than technical accomplishment. Teachers who are skilled in using digital tools for teaching, assessment and learner empowerment have classes that achieve more; teachers who are skilled in operating devices and locating resources do not, unless those skills are accompanied by pedagogical ones. This has implications for professional development. Training that focuses on device operation and platform navigation, which characterises much of the large-scale training delivered in the Philippines, is unlikely to affect learning; training that develops pedagogical uses, particularly formative assessment and feedback, is more promising. The finding that training participation had no direct association with achievement once competence was controlled is consistent with this interpretation and suggests that the effectiveness of training should be judged by its effect on pedagogical competence rather than by participation rates.

The policy implication is that teacher training and connectivity investment should be sequenced and targeted together. Training teachers in unconnected schools produces competence that cannot be used, while connecting schools without developing teacher competence produces infrastructure that is under-used, a pattern that Trucano (2016) documents across the region and that the OECD (2015) analysis of computer use and achievement implies. The most efficient allocation would prioritise connectivity for schools whose teachers already have or are acquiring competence, and pedagogical training for schools that are being connected. Given that around 60% of the schools in this sample lacked reliable connectivity, and that these schools also serve poorer students, the current distribution of returns to digital competence widens rather than narrows achievement gaps. The stress and improvisation documented among Philippine teachers during remote learning (Cahapay, 2020) reflected the same mismatch between expectations of digital practice and the infrastructure to support it.

Some caution is warranted in interpreting the connectivity contrast. Teachers with higher competence may select into better-connected schools, and connected schools may differ in unmeasured ways, such as leadership quality, that also raise achievement. The models control for socioeconomic composition and prior cohort achievement, and the pattern is robust to region fixed effects, but the study is observational. What the evidence does establish is that competence and connectivity are complements, and that their complementarity is visible in student outcomes at national scale. Frameworks for teacher digital competence developed for well-connected systems, including those of UNESCO (2018), may need to be accompanied in developing-country contexts by explicit attention to the conditions under which competence can be exercised. The evidence from reviews of technology interventions in developing countries (Escueta et al., 2020) indicates that these conditions include not only connectivity but also devices, maintenance and time, which the present study could not measure separately.

6. Conclusion

This study linked a survey of 1,150 mathematics and science teachers in 230 Philippine public secondary schools to national assessment data and found that teacher digital competence is positively associated with student achievement, that the association is concentrated in schools with reliable connectivity and that the pedagogical component of competence carries the effect. In reliably connected schools, a one standard deviation increase in competence was associated with gains of 0.14 standard deviations in mathematics and 0.12 in science, whereas in schools without reliable connectivity the association was negligible. The findings identify infrastructure as a precondition for the returns to teacher digital competence and imply that training and connectivity investment should be sequenced and targeted together, with training oriented toward pedagogical uses of technology.

The study has limitations. It is cross-sectional and observational, and cannot rule out selection of competent teachers into connected schools or unmeasured school characteristics. Digital competence was self-assessed, and class-level achievement was linked to teachers for a single school year. Connectivity was classified in three categories and does not capture variation in bandwidth, device availability or maintenance. Future research should use longitudinal designs that follow schools through connectivity upgrades, incorporate observed measures of teacher practice, and evaluate training programmes with explicit attention to whether they raise pedagogical competence and whether their effects depend on infrastructure.

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