Indonesian Journal of Entrepreneurship & Startups (IJES)
Vol.4, No.1, 2026: 57-74

Shaping Indonesia's Digital Future: Relationship Between Public Education Expenditures and ICT Competence

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A R T I C L E I N F O

Keywords: Public Expenditures, Information and Communication Technology Based, Education, Poverty

Received : 01, November
Revised : 15, December
Accepted: 31, January

A B S T R A C T

The acceleration of digital transformation has significantly enhanced information and communication technology (ICT) competence among Indonesian citizens, thereby strengthening the nation's overall competitiveness. Despite this progress, there remains a need to understand the extent to which government education spending influences the improvement of ICT skills in both the short and long term. This study investigates the dynamic effects of education expenditure on ICT competence in Indonesia using provincial-level panel data sourced from the Indonesian Central Bureau of Statistics and the Ministry of Finance, covering the period from 2015 to 2023. The analysis employs the Generalized Method of Moments (GMM) to capture both temporal and cross-sectional variations. The results reveal that, in the short term, government education spending has a negative effect on ICT competence, possibly due to implementation delays or inefficiencies in resource allocation. However, in the long term, education spending contributes positively and significantly to the enhancement of ICT competence, indicating the cumulative benefits of sustained investment in education. Furthermore, internet access is consistently found to have a positive impact on ICT competence, emphasizing the importance of digital infrastructure. These results imply that consistent and well-targeted education investments, particularly in digital literacy and infrastructure, are essential for sustaining long-term ICT competence and supporting Indonesia's digital transformation agenda

DOI: https://doi.org/10.55927/ijes.v4i1.15960
E- ISSN: 2985-6809
https://journal.formosapublisher.org/index.php/ijes

INTRODUCTION

With the rapid digital transformation, information and communication technology (ICT) competency has emerged as a crucial aspect for enhancing national competitiveness. Based on Badan Pusat Statistik Indonesia (2025) (Indonesian Central Bureau of Statistics) data, that the proportion of Indonesians with ICT competence will rise significantly, reaching 82.75% by 2024, largely driven by the younger generation. ICT is playing a vital role in accelerating economic growth and enabling social transformation in Indonesia, particularly by improving efficiency across sectors such as manufacturing, distribution, and digital trade (Saputra et al., 2023). Internet usage increased from 25.37% in 2016 to 53.73% in 2020, but the digital divide between urban and rural areas and between western and eastern Indonesia remains high (Anggoro et al., 2022; Ariansyah et al., 2019).

In the education sector, ICT supports learning and administration, although limited infrastructure and low digital literacy among teachers and students pose obstacles (Nuphanudin et al., 2023; Salim et al., 2023). Meanwhile, the Micro Small Medium Enterprises (MSMEs) embarked on adopting ICT, but the digital skills of business actors still need improvement through public-private collaboration (Saputra et al., 2023). The disparity in ICT competence between regions, especially in the eastern region, emphasizes the urgency of affirmative policies for equal access and digital competence throughout Indonesia (Ariansyah et al., 2019; Machfud & Kartiwi, 2018; Sensuse et al., 2019; Tohir et al., 2024; Umiyati et al., 2023; Wilantika et al., 2018).

ICT competence among Indonesia citizens influenced by several factors, one of which is government spending from education sector, which aims to reduce the digital divide and ensure equal access to technological devices, as well as improve mental well-being (Faozanudin et al., 2023; Lumagbas et al., 2019; Tso et al., 2022; Zaragoza Alvarado, 2022). Furthermore, household internet access is also very important in developing digital literacy and ICT competence (de Araujo et al., 2018; İra et al., 2021; Nash & Wakefield, 2025). Schools often serve as ICT resource centers, providing access to computers and the internet, which is then extended to students, teachers, and the community, thereby improving overall ICT literacy (Alderete & Formichella, 2023; Formichella et al., 2020; Hanaysha et al., 2023; Kobayashi & Ogawa, 2025). From a social perspective, poverty is a factor in low ICT competence, poor communities tend to have difficulty accessing the internet, computers, and mobile devices, which then hinders their ability to utilize technology (Hurtado et al., 2023; Kumar et al., 2025; Mariscal Avilés et al., 2016).

This study offers novelty by empirically examining the impact of education spending on community ICT competence at the provincial level in Indonesia. Previous studies have generally focused on digital literacy or technology access, but few have examined ICT competence because of fiscal policy in the education sector. The use of panel data from 34 provinces for 2015–2023 provides advantages in analyzing changes across time and regions. This study also strengthens the model by including important control variables, namely household internet access, education level, and poverty, which are often

overlooked in similar studies. By combining public economics and digital transformation approaches, this study provides theoretical and practical contributions to effectively measure the contribution of government spending on education to ICT competence.

LITERATURE REVIEW

This study draws on the digital inclusion theory, proposed by Warschauer (2003) as a conceptual framework. The theory emphasizes the importance of providing equal access, skills, and use of Information and Communication Technology (ICT) for all levels of society. This approach was born from the development of the digital divide concept, which not only looks at inequality in terms of access to technology but also expands it to the dimensions of digital skills, meaningful use, and institutional support (Garcia, 2003). In the context of ICT competence among Indonesia citizens, the digital inclusive approach views that a person's ability to use ICT depends not only on individual capacity but is also determined by the structural aspect that facilitates learning, training, and the availability of public digital services (UNESCO, 2024). Therefore, state intervention through education policies and digital infrastructure investment plays a crucial role in promoting equitable digital literacy and ICT competence across regions.

Several previous studies have shown that government spending on the education sector has a positive impact on the ICT competence of Indonesia citizens. These studies argue that educational investment influences the development of ICT competence. By addressing regional disparities in access to education, the government can enhance educational outcomes, including ICT competence, across the population (Fan et al., 2023; Hakim & Rosini, 2022; Nguyen, 2025; Reggi & Gil-Garcia, 2021). This aligns with the European Commission's DigComp framework, which emphasizes the importance of developing digital competencies across five key areas: information literacy, communication, digital content creation, safety, and problem-solving (Vuorikari et al., 2022). Based on the statements above, the following hypothesis can be developed.

H1: Government education spending has a positive effect on ICT competence

In addition, household internet access significantly influences the development of individual ICT competence, which in turn affects various aspects of social functioning. Access to digital infrastructure helps reduce digital exclusion by providing the tools necessary to develop ICT competence (Muñoz-Espinoza et al., 2025). Prior research also supports the positive relationship between household internet access and ICT competence TIK masyarakat (de Araujo et al., 2018; Formichella et al., 2020; Nash & Wakefield, 2025; Wamuyu, 2017). Therefore, the following hypothesis can be developed.

H2: Internet access has a positive effect on ICT competence

Another crucial aspect on the development of ICT competence is the access to formal education where ICT competence can be systematically taught and integrated into the curriculum. This includes the use of online educational resources and digital tools to enhance learning efficiency and student

engagement (Blyznyuk & Hotsaniuk, 2024; Mochalina et al., 2025; Priimak & Razina, 2020). Moreover, formal education fosters essential competencies such as digital literacy, problem-solving, and critical thinking, skills that are crucial for lifelong learning and adaptation in an evolving digital landscape (Ayyildiz et al., 2021; Javorcik, 2017). A study by Formichella et al. (2020), found that education has a positive effect on society's ICT competence. Therefore, the following hypothesis can be developed.

H3: Education has positive effects on ICT competence

However, poverty also could affect ICT competence, primarily through limited access to technology and digital literacy. Poverty hinders access to ICT facilities such as the internet, mobile networks, and personal computers, conditions referred to as "digital poverty" (Alao & Brink, 2023; Javorcik, 2017; Kumar et al., 2025). Poor communities often lack the digital literacy needed to use ICT tools effectively, which can hinder ICT development among youth and negatively impact their employability and future opportunities (Alao & Brink, 2022; Mariscal Avilés et al., 2016). Hurtado et al. (2023) also found that poverty has a negative impact on ICT competence within society. The following hypothesis can be developed.

H4: Poverty has a negative effect on ICT competence

METHODOLOGY

This study analyzes empirical model of the influence or impact of government spending on education sector to ICT competence using balanced panel data from 34 provinces in Indonesia, covering the period from 2015 to 2023. The study uses ICT competence as the dependent variable, measured by the proportion of the population with ICT competence. The main independent variable is government education spending, measured by the actual realization of government education expenditure. To produce a robust and unbiased model, this study includes several control variables, such as Internet access, measured by the proportion of households that accessed the internet within the past three months; Education, measured by the school participation rate; and Poverty, measured by the proportion of the population living in poverty. The following is the econometric model constructed in this study:

$$ICTC_{it} = \beta_0 + \beta_1 ICTC_{it-1} + \beta_2 lngoveducexp_{it} + \beta_{3,4,5}(control\ variables)_{it} + \delta_{it} \quad (1)$$

Based on the model, it is known that ICTC is ICT competence and competence, goveducexp is government spending on education and control is control variable which is access to the Internet, education, and poverty.

This study employs dynamic panel data analysis using the General Method of Moments (GMM) approach. This method is chosen for several reasons. First, the dependent variable—ICT competence—is considered a persistent variable, which is a key requirement for conducting GMM analysis. Second, based on the data characteristics, the number of cross-sectional observations (N) is greater than the number of time periods (T), or in other words, N > T, which makes GMM—particularly System GMM (Blundell & Bond,

1998)—a more consistent estimator. Third, GMM is used to address the issue of endogeneity, which has often been overlooked in previous studies.

Table 1. Variable Descriptive

No	Variable	Indicator	Measurement unit	Source
Dependent Variable				
1	ICT competence (ICTC)	Proportion of citizen with ICT competence	Percentage (%)	Indonesian Central Bureau of Statistics
Independent variable				
2	Government expenditure on education (goveducexp)	Realisation of expenditure	Million Rupiah	Ministry of Finance of the Republic of Indonesia
Control Variable				
3	Access to the Internet	Proportion of Households access to the Internet in the Past 3 Months	Percentage (%)	Indonesian Central Bureau of Statistics
4	Education	School participation	Percentage (%)	Indonesian Central Bureau of Statistics
5	Poverty	Proportion of population under poverty	Percentage (%)	Indonesian Central Bureau of Statistics

RESULT AND DISCUSSION

Descriptive Statistic

Table 2. Descriptive Statistic

Variables	N	Mean	Std. dev.	Min	Max
ICTC	306	52.40	20.29	11.43	93.98
Goveducexp	306	2.363e+06	3.171e+06	135,060	2.178e+07
IA	306	66.67	19.44	16.28	98.08
Educ	306	74.48	3.874	61.65	86.37
pov	306	7.299	3.364	2.780	19.24

Based on Table 2 above, the categorization of each variable in the dataset can be explained as follows. The ICT competence variable (ICTC) has a minimum value of 11.43% and a maximum value of 93.98%, with an average of 52.40%, thus it is categorized as medium. Next, the government education expenditure variable

(goveducexp) has a minimum value of 135,060 million rupiah and a maximum value of 21,780,000 million rupiah, with an average of 2,363,000 million rupiah, placing it in the high rate. The internet access variable (IA) ranges from a minimum of 16.28% to a maximum of 98.08%, with an average of 66.67%, and is therefore categorized as high rate. The education variable (educ) has a minimum value of 61.65% and a maximum of 86.37%, with an average of 74.48%, categorizing it as medium. Finally, the poverty variable (pov) has a minimum value of 2.780% and a maximum of 19.24%, with an average of 7.299%, and is therefore categorized as low.

Table 3. Comparison of Dynamic Panel Regresion Results

Variables	**FD-GMM**	**Sys-GMM**
L1.ICTC	0.515***	0.543***
	(0.00582)	(0.00340)
lngoveducexp	-0.0102	-0.115*
	(0.0423)	(0.0587)
IA	0.517***	0.480***
	(0.00626)	(0.00462)
educ	0.474***	0.150**
	(0.117)	(0.0610)
pov	0.119	-0.0346
	(0.0862)	(0.0462)
Constant	-42.09***	-14.07***
	(7.779)	(3.833)
AR (1)	-3.6757	-3.8054
	[0.0002]	[0.0001]
AR (2)	0.60131	0.37144
	[0.5476]	[0.7103]
Sargan Test	31.20406	31.9698
	[0.2628]	[0.5675]
Number of Prov	34	34
Observations	238	272

Standart errors in parentheses
P<0,001, p<0,005, p<0,1

Instrument Validity and Autocorrelation Tests

This study employs the System GMM (Sys-GMM) model over other models to dynamically examine the influence of each variable. Additionally, the number of observations in the Sys-GMM model, totaling 272, is greater than that in other dynamic models (such as FD-GMM). The Sargan test and Arellano-Bond test (abond) are commonly used to assess instrument validity in econometric models, particularly in the context of over-identification, and to examine the potential presence of autocorrelation in System GMM (Sys-GMM) analysis (Blundell & Bond, 1998). Based on the Sargan test, the result shows the result of 31.9698 with a Prob > Chi2 of 0.5675, which is greater than 0.05. This indicates that there is no

over-identification present in the model. Furthermore, the Arellano-Bond test for second-order autocorrelation (AR (2)) yields a z-value of 0.37144 with a Prob > z of 0.7103, which is also greater than 0.05. This implies that the Sys-GMM model is free from autocorrelation (see Table 3). Based on the explanation above, the model could avoid over-identification and autocorrelation.

Dynamic Panel Data Regression Results (Sys-GMM)

Table 3 presents the results using the System GMM (Sys-GMM) model, which examines correlation of each variable in the short-term. The lagged variable of ICT competence (L1ICTC) has a positive and significant effect on ICT competence (ICTC), with a coefficient value of 0.543 and significance level 99% ($p<0.01$). This indicates that an increase in ICT competence in the previous year leads to an increase in ICT competence in the following year. Next, the variable for government education expenditure (lngoveducexp) shows a negative effect, with a coefficient of -0.115 and significance level 90% ($p<0.1$) on ICT competence (ICTC). This suggests that an increase in government spending on education is associated with a decrease in ICT competence.

The control variable for internet access (IA) has a positive and significant effect, with a coefficient of 0.480 and significance level 99% ($p<0.01$) on ICT competence (ICTC). This implies that improved internet access contributes to higher ICT competence. Similarly, the control variable for education (educ) has a positive effect, with a coefficient of 0.150 and significance level 95% ($p<0.05$), indicating that increased education levels lead to improvements in ICT competence. Lastly, the control variable for poverty (pov) has a coefficient of -0.0346 but is not statistically significant ($p>0.01$; 0.05; 0.1), meaning that poverty does not significantly affect ICT competence.

In conclusion, the variables that significantly influence ICT competence are lagged ICT competence, government expenditure on education, internet access, and education level. Meanwhile, poverty does not have a significant impact. The long-term effects of each variable are discussed in Table 4 below.

Table 4. Long-term Effect

Variables	Long Run Effect
lngoveducexp	0.825***
	(0.26391)
IA	1.053***
	(0.01567)
educ	0.067
	(0.08881)
pov	-0.050
	(0.08055)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This study indicates that the lag variable of ICT competence significantly influences current ICT competence in Indonesia. This is because prior ICT competence provides a strong foundation for further learning, experience with ICT helps individuals develop better and faster skills in mastering new technologies (Hübner et al., 2023; Pisár et al., 2018; Zeidmane, 2019). This aligns with constructivist learning theory, which emphasizes that individuals construct new knowledge based on existing experiences and prior understanding. In the context of ICT, previous exposure to technology helps individuals better comprehend and integrate new technologies (Jayasinghe, 2024; Wibowo et al., 2025). Supported by both the empirical evidence and theoretical framework, ICT competence in the previous year is a critical factor influencing ICT competence in subsequent years. Past ICT proficiency serves as the foundation for maintaining and even enhancing the overall ICT competence of society.

Furthermore, the results of this study are consistent with the findings of Kazimova et al., (2024); Steens et al., (2024), who also emphasize that previous ICT competence influences current competence. Prior ICT experience likely forms the basis for ongoing ICT development, with continuous learning and adaptation to new technologies building upon previously acquired skills. ICT development is inherently a continuous process, where earlier experiences serve as capital for navigating and leveraging the latest digital tools and systems (Artacho et al., 2020; Herbert & Herbert, 2020).

The study also reveals that government spending on education sector has a negative impact on ICT competence in the short term but exerts a stronger positive influence in the long term. In the short term, education spending often focuses on immediate outcomes such as investments in ICT infrastructure aimed at specific skill areas but may not result in sustainable ICT competence without a comprehensive, long-term educational strategy (Zhang & Liu, 2016). Additionally, the short-term readiness of educators and students poses challenges in sustaining ICT competence (Fernández-Gutiérrez et al., 2020; Karamti, 2016). Digital inequality remains a major barrier—despite increased funding, technological disparities persist, especially in developing countries like Indonesia, limiting overall ICT competence (Tsinonis, 2018; Voto & Ngepah, 2024; Zeidmane, 2019). Economic crises and policy constraints also play a role. For example, during the COVID-19 pandemic, government budgets were redirected towards healthcare, reducing allocations for ICT-related education (Loukis & Chryso, 2024). On the user side, Zeidmane (2019) noted that much of the ICT usage of citizens was non-academic, which affects overall competence development.

Over time, improvements in infrastructure and teacher training have supported more effective ICT integration into learning processes, resulting in more innovative teaching methods, better student engagement, and improved learning outcomes (Srijamdee & Pholphirul, 2020; Tavdgiridze et al., 2020). Long-term investment in teacher professional development is a key element in realizing the long-term impacts of ICT. As ICT becomes more embedded in the curriculum, it enriches learning experiences and equips students with relevant digital skills (Fernández-Gutiérrez et al., 2020). Government and educational institutions continue to adjust policies and strategies in response to initial implementation

challenges, creating a more adaptive education ecosystem responding to technological change. The synergy between public education spending and ICT investment has a cumulative effect on improving education quality, helping to reduce inequality and promote equitable learning outcomes across regions (Altwaijri et al., 2024; Voto & Ngepah, 2024).

The study also finds that internet access positively affects ICT competence both in the short and long term, though the long-term effect is stronger. This aligns with Diffusion of Innovation Theory by Everett M. Rogers, which explains how technological innovations, including the internet, are adopted by individuals in a social system. In the context of ICT, internet access enables individuals to actively explore and adopt ICT usage, thereby improving their competence. Equitable access accelerates the diffusion of ICT usage in society (Aivazidi & Michalakelis, 2022). These findings are consistent with those of Alderete et al., (2017); Buarki, (2016); Kritzinger, (2024); Malamud et al., (2019), who argue that internet access enhances ICT competence. For instance, individuals who received internet access (e.g., through a laptop) demonstrated greater improvement in computer and internet skills than those without access (Malamud et al., 2019).

Another key finding is that education has a positive impact on ICT competence in the short term, but not in the long term. In the short term, formal education plays a vital role in boosting ICT competence through systemic interventions such as teacher training, provision of digital infrastructure, and curriculum integration. These effects are immediate as learners and teachers are directly exposed to digital technologies (Almerich et al., 2020, 2021; Casillas-Martín et al., 2022; Díaz-García et al., 2023; Flogie et al., 2018; Flores et al., 2020; Salam et al., 2017). However, in the long term, these effects tend to diminish due to the growing influence of external factors such as personal internet access, social media use, and informal learning driven by intrinsic motivation. Zakir et al. (2025) found that technological self-efficacy and independent learning experiences are more strongly correlated with digital literacy than formal education backgrounds. Additionally, the phenomenon of diminishing returns contributes to the declining effect of formal education—Göltl et al. (2024) showed that overly extended professional training does not significantly enhance certain digital competencies, such as facilitating students' digital literacy. Therefore, sustaining the impact of education on ICT competence requires a hybrid approach that combines formal education, equitable digital access, and support for lifelong learning.

The final finding of this study shows that poverty does not significantly affect ICT competence, either in the short or long term. This can be explained by several structural and contextual factors. First, access to ICT is no longer limited to high-income groups. A survey by Asosiasi Penyelenggara Jasa Internet Indonesia (2024) found that more than 82.6% of residents in underdeveloped areas now have internet access through low-cost mobile devices and affordable data packages, meaning economic constraints are no longer a definitive barrier to digital access. Second, the influence of poverty on ICT competence is often mediated by other factors such as education, school environment, and social support. Livingstone & Helsper (2007) showed that when mediating factors such as informal learning and social environment are considered, the correlation between economic background

and digital skills becomes insignificant. Third, the growing digital culture among the poor is also a key driver. The use of social media applications has become a daily activity across all social classes, even used productively for online marketing and job-related communication. This indicates that ICT usage intensity among low-income populations is high enough to build technical skills, even if acquired outside formal education pathways (Anh Vinh et al., 2023). Thus, the non-significant relationship between poverty and ICT competence reflects a new reality, where digital inclusion has expanded beyond traditional economic boundaries.

CONCLUSSION AND RECOMENDATION

Based on the results and discussion, it can be concluded that Information and Communication Technology (ICT) competence in the previous year exerts a positive and significant influence on ICT competence in subsequent years. This finding highlights the cumulative and path-dependent nature of ICT development, suggesting that past achievements in digital capacity building contribute meaningfully to future improvements. Moreover, the study reveals a contrasting temporal effect of government education spending. In the short term, government spending on education demonstrates a negative relationship with ICT competence, which may be attributed to the time lag between policy implementation, resource allocation, and measurable outcomes. However, in the long term, education expenditure yields a significant and positive effect, indicating that sustained and well-targeted investments in education infrastructure, teacher training, and digital literacy initiatives enhance ICT competence over time.

Internet access consistently shows a positive and significant effect on ICT competence in both the short and long term. This finding underscores the essential role of digital connectivity as a catalyst for skill development and technological empowerment. It emphasizes the need for policies that ensure equitable, affordable, and high-quality internet access, particularly in rural and marginalized regions. In contrast, education level exhibits a positive short-term impact but becomes statistically insignificant in the long run. This result suggests that while formal education provides a foundational understanding of ICT, continuous professional training, upskilling, and lifelong learning are crucial to maintaining and advancing digital competence. Furthermore, poverty does not exhibit a significant effect on ICT competence in either the short or long term, implying that structural and institutional factors—such as access to infrastructure and government support—may play a more decisive role than income levels alone.

In light of these findings, several policy implications emerge. First, governments should sustain and enhance long-term investments in ICT-oriented education, prioritizing digital literacy, teacher capacity building, and the integration of ICT into curricula at all levels. Second, equitable internet access should be expanded as a strategic priority to bridge the digital divide and support inclusive ICT development. Third, lifelong learning programs and vocational ICT training must be strengthened to complement the short-term effects of formal education and ensure adaptability to evolving technological demands. Fourth, the establishment of robust monitoring and evaluation frameworks is essential for

assessing the long-term effectiveness of education and ICT policies, enabling evidence-based adjustments. Finally, fostering public–private partnerships can accelerate infrastructure development, digital training initiatives, and innovation ecosystems.

FURTHER STUDY

This study acknowledges several limitations that should be considered when interpreting the results. First, the use of aggregate provincial-level data may mask individual-level variations in ICT competence, limiting the analysis to regional trends rather than personal differences in digital access or literacy. Second, the indicators used for education and ICT competence are restricted in scope and fail to capture qualitative aspects such as education quality, pedagogical innovation, or advanced digital skills. Third, the model excludes socio-cultural characteristics and local policy variations that may influence ICT development, and it assumes linear relationships without testing potential non-linear or interaction effects among variables.

Future research should therefore employ micro-level or longitudinal data to capture individual heterogeneity and include more comprehensive indicators of education quality and digital capability. Incorporating contextual and institutional factors, as well as exploring dynamic and non-linear models, would provide deeper insights into the determinants of ICT competence and enhance the formulation of evidence-based policy interventions.

ACKNOWLEDGEMENTS

The authors would like to express their sincere appreciation to the editor and reviewers for their valuable comments and constructive suggestions, which have significantly improved the quality and clarity of this manuscript. Their insightful feedback provided important guidance throughout the revision process. The authors also wish to acknowledge the support and data availability provided by Indonesian Central Bureau of Statistics and the Ministry of Finance of the Republic of Indonesia, which were instrumental in completing this study. The accessibility and reliability of these official datasets greatly contributed to the robustness and validity of the analysis.

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