ISSN: 3116-3475
International Journal
of Education, Research, and Innovation Perspectives
Volume 2 Issue 7 (July 2026)

Information and Communication Technology Literacy and Science Academic Performance of Grade 10 Students

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Date Submitted:
March 23, 2026

Date Accepted:
May 11, 2026

Date Published:
July 20, 2026

DOI:
10.5281/zenodo.21459569

ABSTRACT

This study determined the Information and Communication Technology (ICT) literacy and science academic performance of Grade 10 students and identified the variables that predicted achievement in science. A quantitative descriptive-predictive design was employed among 300 Grade 10 students selected through simple random sampling from eight medium to very large public secondary schools in Northern Nueva Vizcaya. Data were obtained through a researcher-made ICT literacy questionnaire patterned after Fekete (2020), validated by five experts, translated into Filipino, and pilot-tested with 100 students, yielding a Cronbach's alpha of .921. Science final grades were retrieved from school records. Frequency, percentage, mean, standard deviation, independent-samples t-test, analysis of variance with Tukey post hoc test, Pearson correlation, and multiple linear regression were used. Most respondents were female, used one gadget—primarily a smartphone—accessed the internet through Wi-Fi, reported stable connectivity, had used the internet for learning for four to five years, and spent less than two hours daily on a computer. Overall ICT literacy was very satisfactory ($M = 2.95$, $SD = 0.87$), with willingness for skills development rated highest and information creation lowest. Science performance was also very satisfactory ($M = 86.60$, $SD = 5.65$). ICT literacy was positively related to science performance ($r = .44$, $p < .01$), with information creation showing the strongest component-level association ($r = .57$, $p < .01$). The regression model explained 38% of the variance in science achievement, $F(14, 285) = 12.63$, $p < .001$. Sex, acceptance of ICT devices, ICT use for science learning, and ability to create information were significant predictors. The findings indicate that meaningful, productive, and subject-specific use of technology is more influential than access alone, supporting targeted instruction in digital content creation, science-focused technology use, and equitable connectivity.

Keywords: *ICT literacy, science academic performance, Grade 10 students, digital competence, technology acceptance, predictive analysis*

INTRODUCTION

Information and Communication Technology has transformed how students access information, communicate, collaborate, and construct knowledge. In science education, digital tools can extend learning beyond textbooks and lectures through simulations, virtual laboratories, multimedia explanations, online databases, and collaborative platforms. Meta-analytic evidence indicates a positive relationship between ICT literacy and academic achievement, although the magnitude of this relationship depends on how technology is integrated into instruction and how effectively students use digital resources (Lei et al., 2021). Technology-supported learning is therefore most valuable when it develops not only access skills but also the ability to evaluate, manage, communicate, and create information.

The need for stronger digital competence is particularly important in the Philippine context. Results from the Programme for International Student Assessment continued to show low science proficiency among Filipino learners, with only a minority reaching the baseline level needed to recognize familiar scientific explanations and evaluate simple conclusions (OECD, 2024). At the same time, national initiatives such as the DepEd Computerization Program and the MATATAG Curriculum emphasize digital literacy and the meaningful use of ICT as central competencies for contemporary learners (Department of Education, 2018, 2023). These reforms recognize that digital skills are increasingly necessary for scientific inquiry, communication, and lifelong learning.

However, access to devices does not automatically lead to academic improvement. Students differ in the number and type of gadgets they use, the reliability of their internet connections, the length of their exposure to technology, and the amount of time they spend on computers. They also vary in their willingness to develop ICT skills and in their capacity to search, judge, manage, and create digital information. Studies have shown that digital inequalities increasingly involve differences in the quality and purpose of technology use rather than access alone (Selwyn, 2004; van Deursen & van Dijk, 2014). These differences may be especially consequential in science, where students are expected to investigate evidence, visualize processes, analyze data, and communicate explanations.

The Technology Acceptance Model explains that perceived usefulness and perceived ease of use shape individuals' willingness to adopt technology (Davis, 1989). In an educational setting, students who view ICT as useful and manageable are more likely to integrate it into their study routines. Technology acceptance, however, must be accompanied by actual opportunities to develop skills and apply them to authentic learning tasks. Research on students' digital engagement has found that active use for research, problem solving, collaboration, and content creation is more strongly associated with learning outcomes than passive or recreational use (Bayanova et al., 2019; Youssef et al., 2022).

Against this background, the study examined the ICT literacy and science academic performance of Grade 10 students in selected public secondary schools in Northern Nueva Vizcaya. It described students' profiles and ICT literacy across eight dimensions, tested differences according to profile variables, determined the relationship between ICT literacy and science achievement, and identified significant predictors of performance. The findings were intended to provide an evidence base for strengthening digital infrastructure, ICT skills development, and the purposeful integration of technology in science instruction.

Literature Review

ICT Literacy, Digital Learning, and Technology Acceptance

ICT literacy is a multidimensional competency involving the ability to access, manage, integrate, evaluate, communicate, and create information through digital technologies. It is not limited to basic device operation but includes critical judgment, ethical information use, problem solving, and digital content production. The Partnership for 21st Century Learning identifies information, media, and technology skills as essential for academic success, work readiness, and responsible participation in contemporary society (Battelle for Kids, 2019). Similarly, the OECD digital-skills framework stresses that technology use should support cognitive performance, student well-being, and meaningful participation in learning (OECD, 2022).

The Technology Acceptance Model provides a useful explanation for students' adoption of ICT. Perceived usefulness refers to the belief that technology can improve performance, while perceived ease of use concerns the effort required to operate it (Davis, 1989). Although the model was originally developed for workplace information systems, later studies have confirmed its relevance to educational technology adoption (Scherer et al., 2019). Students who recognize the value of ICT and feel confident using it are more likely to engage in digital learning activities, seek additional skills, and persist when using unfamiliar applications.

Digital literacy develops through exposure, guided practice, and opportunities to apply skills in meaningful contexts. Fekete (2020) emphasized the importance of validating ICT literacy measures that capture practical and perceived competencies. Research among junior high school learners has similarly shown that students may possess moderate to high confidence in everyday technology use while still needing systematic support in advanced information management and content creation (Hero, 2022). This distinction is important because familiarity with smartphones or social media does not necessarily translate into competence with productivity applications, data analysis, or academic communication.

Access, Connectivity, and Opportunities for ICT Skills Development

Access to devices and reliable connectivity shapes the frequency and depth of students' engagement with digital learning. Students with stable internet and regular device access can more readily retrieve resources, participate in online activities, complete assignments, and communicate with teachers and peers. Asio et al. (2021) found that smartphones were the most commonly available learning devices and that differences in connectivity influenced students' participation in flexible learning. Keya and Uddin (2020) further identified device availability, parental support, school infrastructure, practical exposure, and perceived usefulness as important factors in students' acceptance of ICT.

Despite expanded access, the digital divide persists through unequal infrastructure, device quality, software availability, and opportunities for guided practice. Learners in geographically isolated or under-resourced areas may depend on a single smartphone or unstable mobile data, limiting their ability to perform complex tasks. Rahiem (2020) documented how device limitations, connectivity problems, and weak technical skills constrained students' access to learning information. These conditions suggest that the educational value of technology depends on both material access and institutional support for effective use.

Students' willingness to develop ICT skills is also shaped by self-efficacy and perceived relevance. Fu (2013) argued that learners are more likely to pursue digital skills when they see technology as useful for academic goals. Opportunities provided through school activities, teacher guidance, collaborative tasks, and hands-on use can strengthen confidence and encourage exploration. In contrast, limited time, few structured learning opportunities, and insufficient exposure to new applications can restrict students' progression from basic consumption to advanced digital production.

ICT Use in Science Learning and Information Creation

Science learning benefits from ICT because abstract and complex processes can be represented through simulations, multimedia, digital microscopes, visualization tools, and virtual experimentation. Boruah (2022) reported that ICT can enhance engagement and understanding when it is aligned with appropriate teaching strategies. Rafiq et al. (2024) likewise emphasized that digital platforms and tools can improve access to content, interaction, and learning outcomes. In science classrooms, these resources allow students to investigate phenomena, review explanations, practice concepts, and connect evidence with scientific reasoning.

The ability to manage and create information is especially important in inquiry-based science. Students must organize files, evaluate online sources, analyze information, prepare reports, create presentations, and communicate findings. Zizikova et al. (2023) argued that educational digitalization supports personalized learning and develops competencies such as independence, innovation, and adaptability. When students create digital products rather than merely consume information, they engage in higher-order thinking and demonstrate their understanding through authentic outputs.

Nevertheless, advanced digital production often remains less developed than basic access skills. Students may confidently search the internet or use social media but experience difficulty with spreadsheet formulas, document formatting, presentation design, file management, and online publishing. These gaps can restrict the use of ICT for scientific data handling and communication. Strengthening productivity-software competence and digital content creation is therefore essential for translating general technology familiarity into academic performance.

ICT Literacy and Academic Performance in Science

Academic performance reflects students' achievement of curricular goals as demonstrated through grades, assessments, and the application of knowledge and skills. In science, achievement depends on conceptual understanding, inquiry skills, critical thinking, and effective communication. Dulaney et al. (2023) noted that performance is influenced by students' strategic use of learning resources, motivation, and engagement. Digital tools can support these processes by providing timely feedback, varied representations, and opportunities for self-directed practice.

Empirical research generally reports positive associations between digital competence and academic outcomes. Guo et al. (2022) found that ICT access and use influence science literacy through students' digital engagement and learning conditions. Youssef et al. (2022) similarly reported that digital skills and educational ICT use were positively related to academic performance. Aesaert and van Braak (2015), however, showed that ICT competence can differ according to learner characteristics and socioeconomic context, reinforcing the need to examine profile-related differences rather than assuming uniform benefits.

The strength of the ICT-achievement relationship depends on the nature of technology use. Passive access, ownership of multiple devices, or long screen time may not independently improve learning. More meaningful predictors include positive technology acceptance, subject-specific application, information evaluation, and content creation. Limniou (2021) found that patterns of digital-device use were associated with academic outcomes, while Cabellos et al. (2024) emphasized the moderating role of facilitating conditions and attitudes. These findings support an analysis that considers both access variables and specific ICT literacy dimensions in predicting science achievement.

Conceptual Framework

The study was anchored on the Technology Acceptance Model, which explains technology use through perceived usefulness and perceived ease of use. Students' profile characteristics were treated as contextual variables that may shape access, exposure, and patterns of ICT engagement. ICT literacy was represented by eight dimensions: acceptance and availability of devices, willingness and opportunities for skills development, access to information, use of ICT for science learning, information management, and information creation.

The framework proposed that these profile variables and ICT literacy dimensions may be associated with science academic performance. It also recognized that the strongest effects may arise from active and purposeful use rather than access alone. The model therefore guided the descriptive, comparative, correlational, and predictive analyses undertaken in the study.

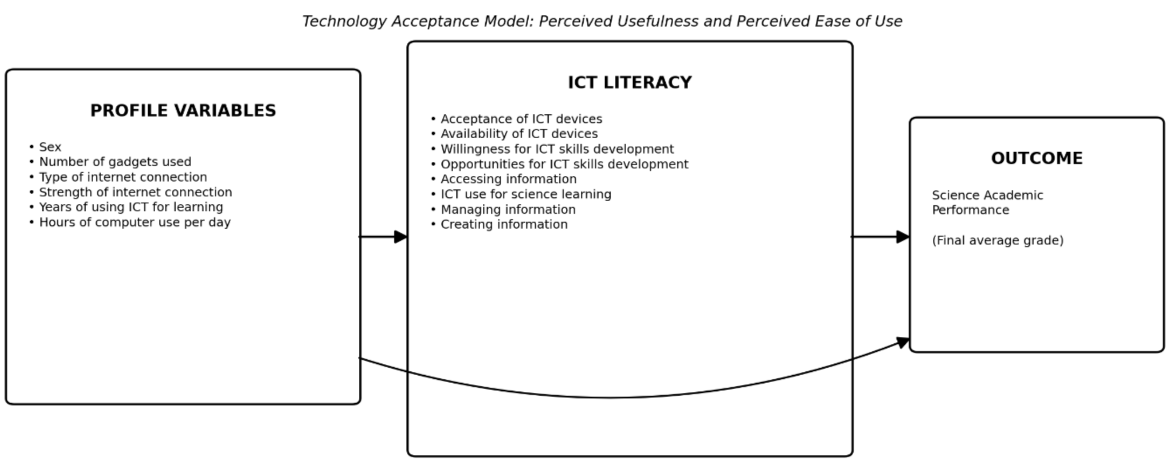

Figure 1. *Conceptual framework of the study.*

METHODS

Research Design

The study used a quantitative descriptive-predictive design through the survey technique. The descriptive component documented the demographic and technology-use profile of the respondents, their perceived ICT literacy, and their science academic performance. The comparative component examined differences in ICT literacy and science performance across profile groups, while the correlational component determined the association between ICT literacy and science achievement. The predictive component used multiple linear regression to identify the profile and ICT literacy variables that significantly explained science academic performance.

Research Locale

The study was conducted in eight selected media to very large public secondary schools in Northern Nueva Vizcaya: Bagabag National High School, Nueva Vizcaya General Comprehensive High School, Bonfal National High School, Diadi National High School, Quezon National High School, Solano High School, Uddiawan National High School, and Bintawan National High School. The schools represented municipalities with varying levels of urbanization, internet access, and technological infrastructure within the northern part of the province.

Participants and Sampling Technique

The participants were 300 Grade 10 science students enrolled during School Year 2024–2025. The target schools had a combined Grade 10 population of 2,828 students. G*Power 3.1 was used to establish an adequate sample, after which simple random sampling was implemented through random-number generation so that eligible students had an equal probability of selection. The final distribution included 40 students from Bagabag National High School, 75 from Nueva Vizcaya General Comprehensive High School, 19 from Bonfal National High School, 28 from Diadi National High School, 22 from Quezon National High School, 71 from Solano High School, 12 from Uddiawan National High School, and 33 from Bintawan National High School.

Research Instrument

The instrument had two parts. Part I obtained the respondents' sex, number of gadgets used, type and strength of internet connection, years of using ICT for learning, and daily hours of computer use. Part II was a researcher-made ICT literacy questionnaire patterned after Fekete (2020). It measured acceptance and availability of ICT devices, willingness and opportunities for ICT skills development, ability to access information, ICT use for science learning, information management, and information creation. Responses used a four-point scale from 1 (never true of me) to 4 (always true of me).

Three experts in science education and two experts in ICT evaluated the instrument for clarity, relevance, and alignment with the study objectives. Based on their recommendations, selected items were revised and the questionnaire was translated into Filipino to support comprehension. Pilot testing was conducted with 100 students who were not included in the final sample. The resulting Cronbach's alpha coefficient of .921 indicated excellent internal consistency. Science academic performance was measured through the students' recorded final average grade in science.

Data Gathering Procedure

The researcher secured permission from the Schools Division Superintendent and the principals of the participating schools. After approval, the questionnaires were personally administered to the selected respondents with the assistance of class advisers. Completed instruments were collected and checked for completeness. Science final grades were subsequently obtained from authorized school records through the registrar, advisers, and science teachers, then matched to de-identified survey data for analysis.

Data Analysis

Frequency counts and percentages described the respondents' profile and the distribution of science grades. Means and standard deviations summarized ICT literacy and science performance. An independent-samples t-test assessed differences by sex, while one-way analysis of variance tested differences according to number of gadgets, internet type, connection strength, years of internet use for learning, and daily computer-use duration. Tukey post hoc tests identified specific group differences when an analysis of variance was significant. Pearson's product-moment correlation determined the relationship between ICT literacy and science achievement. Multiple linear regression identified significant predictors from the profile and ICT literacy variables. All inferential tests used a .05 level of significance.

Ethical Consideration

Participation was voluntary, and the respondents were informed of the purpose of the study and the confidentiality of their responses. Survey records and academic grades were de-identified so that individual students could not be recognized in the dataset or report. Data were used only for academic purposes, stored securely, and reported in aggregate form. Respondents could decline participation without penalty.

RESULTS AND DISCUSSION

Profile of the Grade 10 Students

Table 1. *Profile of the respondents (N = 300)*

Profile variable	Category	f	%
Sex	Male	110	36.67
	Female	190	63.33
Gadgets used	1 unit	242	80.67
	2 units	53	17.67
	3 units	5	1.67
Internet connection	Wi-Fi	136	45.33
	Mobile data	113	37.67
	Cable	51	17.00
Connection strength	No internet	15	5.00
	Stable	252	84.00
	Unstable	33	11.00
Years using ICT for learning	Less than 2	22	7.33
	2–3 years	94	31.33
	4–5 years	184	61.33
Computer use per day	Less than 2 hours	173	57.67
	2–3 hours	97	32.33
	4 hours and above	30	10.00

The sample was predominantly female (63.33%). Most students used only one gadget (80.67%), usually a smartphone, while fewer used two or three devices. Wi-Fi was the most common internet connection, and 84.00% reported stable access. Most respondents had used the internet for learning for four to five years and spent less than two hours per day using a computer. These patterns show that digital exposure was common but often centered on a single mobile device rather than multiple productivity-oriented tools. The dominance of smartphones is consistent with findings that mobile devices are the most accessible learning technology among students, particularly where home computer ownership is limited (Asio et al., 2021).

The high proportion reporting stable internet suggests that most respondents had favorable conditions for digital learning. Nevertheless, 16% reported either unstable or no internet, indicating that a meaningful minority still faced connectivity constraints. The profile also suggests moderate daily computer exposure, which may protect against excessive use but can restrict practice with desktop applications used for document preparation, spreadsheets, and data analysis. Access and duration therefore needed to be interpreted together with the quality and purpose of technology use.

Level of ICT Literacy

Table 2. Summary of ICT literacy dimensions

ICT literacy dimension	M	SD	Interpretation
Acceptance of ICT devices	3.08	0.81	Very satisfactory
Availability of ICT devices	3.06	0.85	Very satisfactory
Willingness for ICT skills development	3.10	0.81	Very satisfactory
Opportunities for ICT skills development	2.89	0.85	Very satisfactory
Accessing information	2.86	0.88	Very satisfactory
Using ICT for science learning	3.09	0.83	Very satisfactory
Managing information	2.87	0.92	Very satisfactory
Creating information	2.65	1.01	Very satisfactory
Overall ICT literacy	2.95	0.87	Very satisfactory

The students demonstrated a very satisfactory overall level of ICT literacy (M = 2.95, SD = 0.87). Willingness for ICT skills development obtained the highest mean (M = 3.10), closely followed by the use of ICT for science learning (M = 3.09), acceptance of ICT devices (M = 3.08), and availability of ICT devices (M = 3.06). These results indicate a generally positive disposition toward technology and an awareness of its usefulness for academic work. The finding supports the Technology Acceptance Model, which proposes that favorable perceptions of usefulness and ease of use encourage technology adoption (Davis, 1989).

Information creation received the lowest mean (M = 2.65) and the largest variability (SD = 1.01). Within this dimension, students were less confident in applying spreadsheet formulas, creating charts, formatting professional documents, and publishing content online. Their access and willingness therefore exceeded their productive skills. This gap reflects the distinction between everyday device familiarity and higher-level digital competence described by Hero (2022). It also indicates that students need explicit instruction and repeated practice with word processing, spreadsheet analysis, presentation design, digital publishing, and ethical content production.

The relatively lower means for accessing and managing information suggest that students could conduct basic searches and downloads but were less confident in advanced searching, source evaluation, editing, file organization, and cloud-based management. These competencies are central to science learning because students must identify credible evidence, organize data, and communicate findings. The results support structured digital-literacy instruction that moves beyond access toward critical evaluation and creation.

Science Academic Performance

Table 3. *Distribution of science academic performance*

Grade range	Description	f	%
90–100	Outstanding	108	36.00
85–89	Very satisfactory	92	30.67
80–84	Satisfactory	53	17.67
75–79	Fairly satisfactory	47	15.66
Overall	M = 86.60; SD = 5.65	300	100.00

The students' mean science grade was 86.60 (SD = 5.65), interpreted as very satisfactory. More than one-third achieved outstanding performance, while 30.67% were very satisfactory. A smaller but substantial group remained in the satisfactory or fairly satisfactory categories. The overall result indicates commendable performance, although the distribution also shows that not all students benefited equally from available learning conditions and digital resources. Science performance is influenced by multiple academic and personal factors, including study habits, motivation, instructional quality, and the strategic use of learning resources (Dulaney et al., 2023). The very satisfactory mean suggests that most learners met curricular expectations, but the lower-performing group underscores the need for targeted support. Technology can contribute to this support when it is used to provide differentiated explanations, simulations, practice activities, and feedback rather than simply increasing screen exposure.

Differences According to Profile Variables

Table 4. *Summary of significant profile-based differences*

Outcome	Profile variable	Result	Significance
ICT literacy	Sex	No significant differences across dimensions	p > .05
ICT literacy	Number of gadgets	Availability, accessing, science use, managing, creating, overall ICT literacy	p < .01
ICT literacy	Internet type	Availability of ICT devices	p = .04
ICT literacy	Connection strength	Acceptance, availability, overall ICT literacy	p ≤ .01
ICT literacy	Years of internet use	Availability, managing, creating, overall ICT literacy	p = .03 or < .01
ICT literacy	Daily computer use	Availability, accessing, science use, managing, creating, overall ICT literacy	p < .01
Science performance	Sex	Female (87.13) > male (85.67)	p = .04
Science performance	Number of gadgets	Two gadgets (88.74) > one gadget (86.12)	p < .01
Science performance	Daily computer use	2–3 hours (88.45) and ≥4 hours (88.17) > <2 hours (85.28)	p < .01
Science performance	Internet type, strength, years of use	No significant differences	p > .05

ICT literacy did not significantly differ by sex, indicating that male and female respondents reported comparable digital competencies. Significant differences were more strongly associated with access and use conditions. Students using more gadgets reported higher availability, information access, science-related ICT use, information management, information creation, and overall ICT literacy. Stable connectivity was associated with higher acceptance, availability, and overall ICT literacy. Longer exposure to internet-based learning and more daily computer use were likewise associated with stronger productive and management skills. These results suggest that sustained opportunities for meaningful practice matter more than sex-based differences.

Science performance differed significantly by sex, number of gadgets, and daily computer-use duration. Female students obtained a higher mean grade than male students. Students using two gadgets performed better than those using one, suggesting that access to complementary devices—such as a smartphone and laptop—may support more flexible learning than dependence on a single device. Students using computers for two to three hours or at least four hours daily also outperformed those using computers for less than two hours. However, because the design was nonexperimental, these differences should not be interpreted as proof that longer computer use directly caused higher grades.

No significant performance differences were found by internet type, connection strength, or years of internet use for learning. This finding reinforces the idea that access alone is insufficient. The academic contribution of technology depends on what learners do with it. Similar conclusions have been reported in studies emphasizing that digital skill, learning purpose, and instructional integration are more consequential than mere ownership or connectivity (Limniou, 2021; Youssef et al., 2022).

Relationship between ICT Literacy and Science Performance

Table 5. *Correlations between ICT literacy and science academic performance*

ICT literacy dimension	r	p
Acceptance of ICT devices	.30	< .01
Availability of ICT devices	.27	< .01
Willingness for ICT skills development	.21	< .01
Opportunities for ICT skills development	.18	< .01
Accessing information	.27	< .01
Using ICT for science learning	.31	< .01

Managing information	.39	< .01
Creating information	.57	< .01
Overall ICT literacy	.44	< .01

All ICT literacy dimensions were positively and significantly related to science performance. The overall relationship was moderate ($r = .44$, $p < .01$), indicating that students with stronger ICT literacy tended to earn higher science grades. The strongest association was found for information creation ($r = .57$), followed by information management ($r = .39$) and ICT use for science learning ($r = .31$). Opportunities for skills development had the weakest, although still significant, association ($r = .18$).

The pattern shows that productive competence is more closely connected with science achievement than general access or willingness. Students who can create documents, presentations, spreadsheets, and other digital outputs are likely applying technology to organize evidence, explain concepts, and demonstrate understanding. This finding is consistent with research linking active digital engagement and content production with deeper learning and academic performance (Guo et al., 2022; Zizikova et al., 2023). It also suggests that school ICT programs should measure success through students demonstrated abilities rather than the number of devices distributed.

Predictors of Science Academic Performance

Table 6. *Multiple regression predictors of science academic performance*

Predictor	B	β	t	p	Decision
Sex	1.43	0.12	2.58	.01	Significant
Number of gadgets	-1.06	-0.08	-1.51	.13	Not significant
Internet type	0.68	0.05	0.91	.36	Not significant
Connection strength	-0.19	-0.01	-0.25	.80	Not significant
Years using internet	0.16	0.03	0.58	.57	Not significant
Hours using computer	0.42	0.10	1.79	.07	Not significant
Acceptance of ICT devices	1.65	0.16	2.62	.01	Significant
Availability of ICT devices	0.01	0.00	0.02	.99	Not significant
Willingness for skills development	-0.54	-0.06	-1.01	.32	Not significant
Opportunities for skills development	-0.65	-0.07	-1.16	.25	Not significant
Accessing information	-0.10	-0.01	-0.18	.86	Not significant
ICT use for science learning	1.26	0.14	2.18	.03	Significant
Managing information	-0.99	-0.10	-1.31	.19	Not significant
Creating information	4.11	0.57	8.40	< .01	Significant

Model summary: $R^2 = .38$; $F(14, 285) = 12.63$, $p < .001$.

The regression model explained 38% of the variance in science academic performance and was statistically significant. Four predictors made unique significant contributions: sex, acceptance of ICT devices, ICT use for science learning, and ability to create information. Information creation was the strongest predictor ($\beta = .57$, $p < .01$), substantially exceeding the effects of the other variables. Acceptance of devices ($\beta = .16$, $p = .01$) and subject-specific ICT use ($\beta = .14$, $p = .03$) also contributed positively. Female students maintained a small positive advantage after the other variables were considered ($\beta = .12$, $p = .01$).

The nonsignificance of device number, internet type, connection strength, and general availability in the multivariable model indicates that their bivariate advantages were largely accounted for by more direct learning behaviors and competencies. In other words, infrastructure enables participation, but students' acceptance and productive application of ICT explain more of the variation in achievement. This conclusion supports the OECD (2022) position that effective digital learning requires quality use, instructional purpose, and competence—not access alone.

The strong effect of information creation has practical implications for science instruction. Creating a spreadsheet, digital report, presentation, infographic, or multimedia explanation requires students to select evidence, organize ideas, analyze data, and communicate conclusions. These processes align closely with scientific inquiry and higher-order thinking. Strengthening such skills can therefore serve both digital-literacy and science-learning goals. The remaining unexplained variance also indicates that science achievement depends on other factors not included in the model, such as prior knowledge, motivation, teacher practices, and home learning support.

CONCLUSION

Grade 10 students in the selected Northern Nueva Vizcaya schools had generally favorable access to ICT and demonstrated very satisfactory ICT literacy and science academic performance. Their strongest digital characteristics were willingness to improve skills, acceptance of technology, and use of ICT for science learning. Their weakest area was the creation of information, particularly more advanced productivity-software tasks. The findings show that access, connectivity, and exposure create important conditions for digital learning, but these conditions do not independently guarantee stronger science achievement.

ICT literacy was positively associated with science performance, and the ability to create digital information emerged as the most influential predictor. Acceptance of technology and subject-specific ICT use also contributed significantly. The study therefore demonstrates that productive, purposeful, and academically relevant technology use matters more than ownership or connectivity alone. Its contribution lies in identifying the particular digital competencies that should be prioritized to strengthen science learning among junior high school students.

Recommendation

1. School administrators should sustain reliable internet connectivity and equitable access to appropriate devices, while prioritizing computer laboratories and productivity-oriented tools that allow students to complete complex academic tasks.
2. Science teachers should integrate ICT through inquiry activities, virtual simulations, data analysis, digital laboratory reports, multimedia explanations, collaborative research, and evidence-based presentations rather than relying mainly on information retrieval.
3. Schools should provide structured ICT skills sessions focused on Microsoft Word formatting, Excel formulas and charts, PowerPoint design, file organization, cloud-based collaboration, source evaluation, privacy, and responsible online publishing.
4. Targeted support should be provided to students who rely on a single smartphone, have unstable or no internet access, or use computers infrequently, so that differences in opportunity do not widen existing learning gaps.
5. ICT and science teachers should jointly design performance tasks that require students to create and communicate scientific information, because information creation was the strongest predictor of science achievement.
6. School monitoring should include demonstrated digital competencies and the quality of student-created outputs, not only device distribution, connection availability, or frequency of use.
7. Future researchers should examine additional predictors such as socioeconomic status, prior science achievement, teacher ICT competence, instructional strategies, motivation, and home learning support. Longitudinal or experimental designs may further clarify how specific digital-learning interventions influence science achievement.

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