**A Study on Extent of Utilization of Information and Communication Technology (Ict) Among Farmers in Tirupathur District, India**

**Abstract**

 The growing complexity of agrarian challenges in India has exceeded the capacity of traditional public extension services, challenging the integration of Information and Communication Technology (ICT) to ground the knowledge gap. This study explores the extent of utilization of ICT tools among farmers in Tirupathur district of Tamil Nadu. A study was conducted across 10 villages using a proportionate random sampling method, with data collected from 120 respondents through a structured interview schedule. Findings indicates that major ICT tools included Television, Mobile phones, Agrisnet, TNAU AGRITECH portal, Paddy expert system, IFFCO Kisan, YouTube and WhatsApp which exhibited high engagement. Conversely, minor tools such as e-agricultural magazines, e-Krishi Kendra, AGMARKNET, Telegram and Twitter showed minimal usage highlighting the need for improved digital literacy and targeted awareness campaigns to enhance the adoption of underutilized ICT tools for effective knowledge dissemination in rural communities. Analyzing 13 personal, socio-economic, cognitive, behavioral, and skill-related factors that revealed farm size, information seeking behaviour, ownership of ICT gadgets, social participation and social media usage exhibit very strong positive correlations with ICT adoption, while occupational status shows a strong negative correlation underscoring the need for targeted interventions to improve digital engagement in agriculture and Education showed a very weak and non-significant relationship with ICT usage, indicating that formal education alone does not significantly influence the extent of ICT utilization among respondents. This study sheds light on the transformative eventuality of ICT in ultramodern extension services and its critical part in strengthening pastoral agrarian knowledge dispersion.

**KEYWORDS**: ICT, Agriculture, Extent of utilization, Farmers, ICT Platforms.

**Introduction**

The agriculture is still the main stay of Indian economy with a share of about 17% in both National GDP and work force over half (World Bank, 2023). But even today, agriculture in India continues to suffer from innumerable problems like small and fragmented landholdings, lack of knowledge about modern agriculture technologies, poor market access and the like. These, in turn, have resulted in stagnating productivity and greater susceptibility, notably to smaller and marginal farmers. The growing importance of ICT for agricultural development with the advancement of digital technologies, the use of ICT has assumed a transformative role in agricultural development. ICTs—mobile phones, internet services, radio, television, and most recently artificial intelligence and data-empowered platforms—have the ability to transform information outreach, empower farmer choice making, and bridge the rural-urban divide.

ICT adoption and successful application in agriculture varies by location and community, despite its promise. Small and marginal farmers in India, who cultivate less than two hectares of land, own more than 81% of operational holdings (Government of India, 2021).

Determining the level of ICT use is crucial in areas like Tirupathur, where agriculture is a major source of rural livelihoods, in order to spot gaps and adjust extension tactics appropriately. This study examines the socioeconomic and behavioral aspects impacting adoption as well as the extent of ICT use among farmers in the Tirupathur district. It also seeks to clarify how beneficial ICTs are seen to be when making farming decisions. The research's conclusions will be useful to technology suppliers, agricultural extension programs, legislators and policy makers.

**Materials and methods**

**Study Area and Sample Selection**

 The purpose of this study is to evaluate how much farmers in Tamil Nadu's Tirupathur district use information and communication technology (ICT). Ten villages in the Tirupathur block are the subject of the study, these were chosen for their agricultural activities and ease of access to ICT services. To provide varied representation from a range of farm sizes and socioeconomic backgrounds, 120 respondents were chosen using the proportionate random sampling technique.

**Selection of Variables**

 The following factors were chosen to examine their effects on farmer’s use of ICT based on expert assessment and research relevance:

* **Personal and Socio-Economic Variables**: Age, educational status, occupational status, farm size, farming experience, and annual income.
* **Cognitive and Behavioral Variables**: Digital literacy, information-seeking behavior, ownership of ICT gadgets, social participation, innovativeness, and social media usage.
* **Skill and Knowledge Variables**: Training undergone on ICT.

**Data Collection**

 The chosen farmer’s primary data was gathered using a pre-tested interview schedule. The interview approach was chosen because it allowed for direct communication and guaranteed replies that were accurate and clear. Based on the multidimensional approach, questions were formulated.

**Data Processing and Analysis**

 Using the proper statistical methods, the gathered data was scored, tabulated, classified, and examined. Percentage analysis, frequency analysis, correlation, and multiple linear regression were used to evaluate the extent of utilization, enabling comparison of farmer’s extent of use. To determine the main elements impacting the integration of digital technologies in agriculture, relationships between the degree of ICT use and a few chosen variables were also investigated.

**Results and discussion**

**Distribution of respondents according to their Regressor variables**

**Age**

 The distribution of respondents by age revealed that a majority (65%) belonged to the middle-aged group (36-45 years), followed by older respondents (25%) and younger respondents (10%). This indicates that the primary decision-makers in farming activities were predominantly middle-aged individuals, likely contributing to their extensive experience and established practices.

**Educational Status**

 Educational attainment varied significantly, with the highest proportion (29.16%) having higher secondary education, while 24.19% had collegiate education. A notable portion (13.33%) were illiterate. This educational disparity may impact their capacity to adopt modern agricultural technologies and practices.

**Occupational Status**

 The data showed that 78.33% of respondents were engaged in agriculture as their primary occupation, reflecting the region's agrarian economy. The remaining 21.67% considered agriculture as their secondary occupation, possibly supplementing other income sources.

**Farm Size**

 The majority (65%) were small farmers, indicating the prevalence of small-scale farming systems. Marginal farmers constituted 11.66%, while 23.34% were big farmers, underscoring the challenges smaller landholders may face in resource mobilization and sustainability.

**Farming Experience**

 Most respondents had medium (45%) or low (40.83%) experience, while only 14.17% had extensive experience (>20 years). This suggests that a significant portion of the population may still be developing advanced farming skills.

**Digital Literacy**

 Digital literacy was moderate for 37.5% of respondents, while 35% reported low literacy and 27.5% had high literacy. This suggests a need for targeted digital training initiatives to enhance farmers' technological capabilities.

**Annual Income**

 Nearly half (46.66%) had low income, followed by 41.67% in the medium-income category and only 11.67% reporting high income. This income disparity highlights potential financial constraints in adopting advanced agricultural practices.

**Information Seeking Behaviour**

 A significant proportion (45%) exhibited medium information-seeking behavior, while 34.17% showed high engagement. This suggests a positive inclination towards exploring new agricultural methods.

**Ownership of ICT Gadgets**

 Mobile phones/smartphones were the most common ICT gadgets (35.83%), followed by televisions (27.5%). Limited ownership of computers/laptops (6.66%) suggests barriers to accessing advanced digital platforms.

**Social Participation**

 More than half (53.33%) exhibited medium social participation, while 25% had low participation. Enhanced social involvement could potentially improve knowledge exchange and adoption of new technologies.

**Innovativeness**

 Over half (54.16%) preferred adopting technologies after observing successful implementations, while 40% were early adopters. Only 5.84% delayed adoption, indicating a generally receptive attitude towards innovation.

**Social Media Usage**

 Medium social media usage dominated (71.67%), indicating that social platforms are emerging as key information channels for farmers.

**Training on ICT**

 A large proportion (70.83%) had no ICT training, underscoring the need for improved access to digital learning programs.

**Distribution of respondents according to their Regressed variables**

**Utilization of ICT Gadgets**

 Television (62.5%) and mobile phones (41.66%) were the most frequently used gadgets, highlighting their role in information dissemination. In contrast, tools like pendrives (20.83%) and e-agricultural magazines (16.67%) had lower adoption, indicating limited digital literacy.

**Utilization of Agricultural Portals**

 Portals such as **TNAU AGRITECH** (39.16%) and **AGRISNET** (40%) were widely used, while **e-Krishi Kendra** (56.66%) and **AGMARKNET** (63.33%) saw minimal engagement, reflecting awareness gaps.

**Utilization of VKCs and Telephony Services**

 Village Knowledge Centres (VKCs) had moderate usage (25%), while services like the **Farmers Call Centre** had low adoption (49.16% never), emphasizing the need for improved outreach.

**Utilization of Mobile Apps**

 Popular apps like the **Paddy Expert System** (40.83%) and **Uzhavan app** (37.5%) showed strong engagement. Conversely, crop-specific apps such as the **Sugarcane Expert System** (55% never) had low usage, indicating limited awareness.

**Utilization of Social Media**

 **YouTube** (41.67%) and **WhatsApp** (28.33%) were prominent, while platforms like **Twitter** (55.83% rarely) and **Instagram** (42.5% never) saw minimal engagement.

**Key findings**

 The findings highlight that while several socio-economic and behavioral factors correlate with ICT utilization, **social media usage** emerges as the most significant predictor. This emphasizes its crucial role in modern agricultural practices by enhancing information access, knowledge sharing, and technology adoption. Additionally, improving **digital literacy**, encouraging **social participation**, and expanding **ICT training** can further strengthen ICT adoption.

**1. Extent and Patterns of ICT Utilization**

The findings show that television (62.5%) and mobile phones (41.66%) remain the most frequently used ICT tools—reflecting their established relevance and accessibility in rural contexts. Similarly, studies like Shehrawat, Dahiya, and Nain (2024) found that mobile phones remain the most recognized tool (~68% awareness) among farmers in Haryana, while awareness of advanced tools like GPS and drones stayed low (~34–42%).

Modern digital tools such as the AGMARKNET portal (63.33% never used), e‑Krishi Kendra (56.66% never used), and specific mobile apps like the Banana Expert System and Crop Insurance App (50% non‑usage) exhibited minimal adoption. This pattern mirrors broader national trends where farmers face barriers like lack of training, awareness, and perceived complexity (Kumar & Alamgir, 2024).

Social media platforms—YouTube (41.67%) and WhatsApp (28.33%)—showed the highest frequent usage among respondents. In Uttarakhand, research found that younger and more educated farmers used social media more actively, whereas older farmers faced notable constraints such as low digital literacy and lack of awareness of useful platforms (Malik & Ansari, 2024). Similarly, a Telangana study reported that 78% of farmers used messaging platforms like WhatsApp and 61.7% accessed YouTube and Twitter for agriculture-related information (MadhuShekar, Bharat, & Jaganmohan, 2023).

**2. Determinants of ICT Utilization**

The correlation analysis identified social media usage (r = 0.946, R² = 0.895) as the strongest predictor of ICT engagement. Other strong correlates included social participation (r = 0.824), information-seeking behavior (r = 0.777), ICT gadget ownership (r = 0.771), digital literacy (r = 0.707), annual income (r = 0.727), and farming experience (r = 0.746).

These results align with findings from Telangana and Uttarakhand studies that confirm positive associations between education, digital literacy, social participation, and social media engagement (MadhuShekar et al., 2023; Malik & Ansari, 2024; Shehrawat et al., 2024). MadhuShekar et al. (2023) emphasized that education, income, and social orientation significantly influence social media use among farmers, although age and farming experience showed negative associations. In the Uttarakhand study, older farmers and those with lower digital literacy faced significant hurdles in adopting social media for agricultural information (Malik & Ansari, 2024).

**3. Predictive Power of Variables**

The multiple regression model—explaining 91.9% (R² = 0.919) of variance in ICT utilization—found social media usage (β = 0.743, p < 0.001) as the only statistically significant predictor. This reflects similar observations in global ICT-extension literature indicating social media as central to digital information pathways in rural agriculture (Mukherjee, Padaria, & Roy, 2025).

Other variables like education, income, occupation, and digital literacy lost statistical significance in the multivariate model, likely due to inter-relations among predictors or mediation by social media engagement—suggesting it functions as a gateway for using digital tools. The Uttarakhand study underlined the mediating role of digital literacy and information-seeking behavior in enabling social media adoption (Malik & Ansari, 2024).

**TABLE 1**

**(*Distribution of respondents according to their Regressor variables*)**

 **(N=120)**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Category** | **Number of respondents** | **Per cent** |
| **Distribution of respondents according to their age** |
| 1. | Young (Up to 35 years) | 12 | 10.00 |
| 2. | **Middle (36-45 years)** | **78** | **65.00** |
| 3. | Old (above 45 years) | 30 | 25.00 |
| **Distribution of respondents according to their educational status** |
| 1. | Illiterate | 16 | 13.33 |
| 2. | Primary education | 10 | 8.33 |
| 3. | Middle school education | 16 | 13.33 |
| 4. | Secondary school education | 14 | 11.66 |
| 5. | **Higher secondary school education** | **35** | **29.16** |
| 6. | Collegiate education | 29 | 24.19 |
| **Distribution of respondents according to their occupational status** |
| 1. | **Agriculture as primary occupation** | **94** | **78.33** |
| 2. | Agriculture as secondary occupation | 26 | 21.67 |
| **Distribution of respondents according to their farm size** |
| 1. | Marginal farmers(< 2.5 acres) | 14 | 11.66 |
| 2. | **Small farmers(2.51 to 5 acres)** | **78** | **65.00** |
| 3. | Big farmers(> 5 acres) | 28 | 23.34 |
| **Distribution of respondents according to their farming experience** |
| 1. | Low (<10 years) | 49 | 40.83 |
| 2. | **Medium (10-20 years)** | **54** | **45.00** |
| 3. | High (>20 years) | 17 | 14.17 |
| **Distribution of respondents according to their digital literacy** |
| 1. | Low  | 42 | 35.00 |
| 2. | **Medium**  | **45** | **37.50** |
| 3. | High  | 33 | 27.50 |
| **Distribution of respondents according to their annual income** |
| 1. | **Low** | **56** | **46.66** |
| 2. | Medium | 50 | 41.67 |
| 3. | High | 14 | 11.67 |
| **Distribution of respondents according to their information seeking behaviour** |
| 1. | Low | 25 | 20.83 |
| 2. | **Medium** | **54** | **45.00** |
| 3. | High | 41 | 34.17 |
| **Distribution of respondents according to Ownership of ICT gadgets** |
| 1. | Computer/Laptops | 08 | 6.66 |
| 2. | **Mobilephones/Smartphones** | **43** | **35.83** |
| 3. | Television | 33 | 27.50 |
| 4. | Radio | 25 | 20.83 |
| 5. | Pendrive | 11 | 9.18 |
| **Distribution of respondents according to their social participation** |
| 1. | Low | 30 | 25.00 |
| 2. | **Medium** | **64** | **53.33** |
| 3. | High | 26 | 21.67 |
| **Distribution of respondents according to their innovativeness** |
| 1. | As soon as a new technology is introduced | 48 | 40.00 |
| 2. | **After seeing the farmers have done it successfully** | **65** | **54.16** |
| 3. | I prefer to wait and take my own time | 7 | 5.84 |
| **Distribution of respondents according to their social media usage** |
| 1. | Low | 18 | 15.00 |
| 2. | **Medium** | **86** | **71.67** |
| 3. | High | 16 | 13.33 |
| **Distribution of respondents according to their training undergone on ICT** |
| 1. | **No training** | **85** | **70.83** |
| 2. | Attended one training | 20 | 16.67 |
| 3. | Attended two training or more | 15 | 12.50 |
|  | **Total** | **120** | **100.00** |

**TABLE 2**

**(*Distribution of respondents according to their Regressed variables*)**

 **(N=120)**

|  |
| --- |
| **Distribution of respondents according to their Extent of utilization of ICT gadgets** |
| **S. No** | **Services** | **Frequently** | **Sometimes** | **Rarely** | **Never** |
|  |  | **No** | **%** | **No** | **%** | **No** | **%** | **No** | **%** |
| 1 | Radio |  42 | 35.00 | 45 | 37.50 | 21 | 17.5 | 17 | 14.16 |
| 2 | Television | 75 | **62.50** | 45 | 37.50 | 0 | 0.00 | 0 | 0.00 |
| 3 | Mobile phone | 50 | **41.66** | 41 | 34.16 | 26 | 21.66 | 8 | 6.66 |
| 4 | Pendrive | 25 | 20.83 | 12 | 10.00 | 32 | 26.66 | 32 | 26.66 |
| 5 | e-Agriculturalmagazine | 20 | 16.67 | 18 | 15.00 | 30 | 25.00 | 37 | 30.83 |
| **Distribution of respondents according to their Extent of utilization of Agricultural portals** |
| 1 | TNAU AGRITECH portal | 47 | **39.16** | 31 | 25.83 | 41 | 34.16 | 22 | 18.33 |
| 2 | AGRISNET | 48 | **40.00** | 29 | 24.16 | 21 | 17.50 | 17 | 14.16 |
| 3 | e-Krishi Kendra | 0 | 0.00 | 0 | 0.00 | 48 | 40.00 | 68 | 56.66 |
| 4 | AGMARKNET | 0 | 0.00 | 0 | 0.00 | 39 | 32.50 | 76 | 63.33 |
| 5 | IFFCO Agri portal | 21 | 17.50 | 25 | 20.83 | 32 | 26.66 | 10 | 8.33 |
| **Distribution of respondents according to their Extent of utilization of VKC’s and Telephony**  |
| 1 | Village Knowledge Centres (VKCs) | 30 | **25.00** | 24 | 20.00 | 35 | 29.16 | 27 | 22.5 |
| 2 | Village Resource Centres (VRCs) – | 21 | 17.5 | 25 | 20.83 | 45 | 37.50 | 24 | 20.00 |
| 3 | Farmers Call Centre | 25 | **20.83** | 8 | 6.66 | 27 | 22.50 | 59 | 49.16 |
| 4 | Mobile Advisory Services by KVKs | 27 | 22.5 | 45 | 37.50 | 24 | 20.00 | 22 | 18.33 |
| **Distribution of respondents according to their Extent of utilization of Mobile apps**  |
| 1 | Paddy Expert System (TNAU) | 49 | **40.83** | 32 | 26.67 | 28 | 23.33 | 11 | 9.16 |
| 2 | SugarcaneExpert System Tamil (TNAU) | 0 | 0 | 0 | 0 | 54 | 45.00 | 66 | 55.00 |
| 3. | Banana Expert System Tamil (TNAU) | 0 | 0 | 13 | 10.83 | 47 | 39.17 | 60 | 50.00 |
| 4 | Uzhavan app | 47 | 37.50 | 31 | 25.83 | 23 | 19.17 | 19 | 15.83 |
| 5 | IFFCO Kisan | 45 | **36.67** | 31 | 26.67 | 26 | 21.66 | 18 | 15.00 |
| 6 | KisanSuvidha | 12 | 10.0 | 26 | 21.67 | 32 | 26.67 | 50 | 41.67 |
| 7. | TNAU app | 45 | 37.50 | 34 | 28.33 | 29 | 24.17 | 12 | 10.00 |
| 8. | M-Kisan | 12 | 10.0 | 26 | 21.67 | 51 | 42.50 | 31 | 25.83 |
| 9 | Crop Insurance app | 0 | 0.0 | 13 | 10.83 | 41 | 34.85 | 60 | 50.00 |
| 10 | AgriMarket | 18 | 15.00 | 11 | 9.17 | 40 | 33.33 | 51 | 42.50 |
| **Distribution of respondents according to their Extent of utilization of social media** |
| 1. | Youtube | 50 | **41.67** | 40 | 33.33 | 17 | 14.16 | 13 | 10.83 |
| 2. | Whatsapp | 34 | **28.33** | 40 | 33.33 | 32 | 26.67 | 14 | 11.67 |
| 3. | Telegram | 12 | 10.0 | 28 | 23.33 | 49 | 40.83 | 31 | 25.83 |
| 4. | Facebook | 27 | 22.50 | 44 | 36.67 | 24 | 20.00 | 25 | 20.83 |
| 5. | Twitter | 0 | 0.0 | 0 | 0.0 | 67 | 55.83 | 53 | 41.67 |
| 6. | Instagram | 20 | 16.67 | 11 | 9.17 | 38 | 31.67 | 51 | 42.50 |

**TABLE 3. Correlation of characteristics of the respondents with their extent of utilization of ICT services**

 **(N=120)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **-** | **p-** | **Pearson’s r** | **(R²)** | **Correlation strength** |
| Age | <0.001 | 0.589\*\*\* | 0.347 | Strong |
| Education | 0.191 | -0.120 | 0.014 | Very weak |
| Occupational Status | <0.001 | -0.663\*\*\* | 0.439 | Strong (Negative) |
| **Farm Size** | <0.001 | 0.809\*\*\* | 0.655 | **Very Strong** |
| Farming Experience | <0.001 | 0.746\*\*\* | 0.557 | Strong |
| Digital Literacy | <0.001 | 0.707\*\*\* | 0.500 | Strong |
| Annual Income | <0.001 | 0.727\*\*\* | 0.529 | Strong |
| **Information Seeking Behaviour** | <0.001 | 0.777\*\*\* | 0.604 | **Very Strong** |
| **Ownership of ICT Gadgets** | <0.001 | 0.771\*\*\* | 0.595 | **Very Strong** |
| **Social Participation** | <0.001 | 0.824\*\*\* | 0.679 | **Very Strong** |
| Innovativeness | <0.001 | 0.667\*\*\* | 0.445 | Strong |
| **Social Media Usage** | <0.001 | 0.946\*\*\* | 0.895 | **Very Strong** |
| Training Undergone on ICT | <0.001 | 0.714\*\*\* | 0.510 | Strong |

**\*** (Single asterisk) → **p < 0.05** (Significant)

**\*\*** (Double asterisk) → **p < 0.01** (Moderately significant)

**\*\*\*** (Triple asterisk) → **p < 0.001** (Highly significant)

**TABLE 4. Multiple regression analysis of contribution of characteristics towards their extent of utilization of ICT services**

| Model Fit Measures |
| --- |
|  | **Overall Model Test** |
| **Model** | **R** | **R²** | **Adjusted R²** | **F** | **df1** | **df2** | **p** |
| 1 | 0.958 | 0.919 | 0.909 | 92.1 | 13 | 106 | <.001 |
| Note: Models estimated using sample size of N=120 |

| **TABLE 5. Model Coefficients - EXTENT OF UTILIZATION OF ICT** |
| --- |
| **Predictor** | **Estimate** | **SE** | **t** | **p** | **Stand. Estimate** |
| Intercept | 0.45795 | 0.32573 | 1.4059 | 0.163 |   |
| Age | -0.00621 | 0.00345 | -1.7996 | 0.075 | -0.10577 |
| Education | -0.00905 | 0.02945 | -0.3072 | 0.759 | -0.02748 |
| Occupation status | -0.12622 | 0.12184 | -1.0360 | 0.303 | -0.09245 |
| Farm size | 0.08370 | 0.09054 | 0.9245 | 0.357 | 0.08790 |
| Farming experience | -0.01164 | 0.10817 | -0.1076 | 0.914 | -0.01373 |
| Digital literacy | -0.00332 | 0.07181 | -0.0462 | 0.963 | -0.00468 |
| Annual income | -0.01263 | 0.07441 | -0.1697 | 0.866 | -0.01524 |
| Information seeking behaviour | 0.10566 | 0.06831 | 1.5468 | 0.125 | 0.13704 |
| Ownership of ict gadgets | -0.01043 | 0.06077 | -0.1716 | 0.864 | -0.02023 |
| Social participation | 0.11328 | 0.07742 | 1.4632 | 0.146 | 0.13742 |
| Innovativeness | 0.01689 | 0.08387 | 0.2014 | 0.841 | 0.01755 |
| **Social media usage** | **0.78612** | **0.07953** | **9.8847** | **<.001** | **0.74356** |
| Training undergone on ICT | -0.05517 | 0.10511 | -0.5249 | 0.601 | -0.06888 |

**Conclusion**

 The study enhances the significant role of Information and Communication Technology (ICT) in enhancing agricultural extension services and improving farmer’s knowledge, decision-making, and productivity. The findings reveal that socio-economic variables such as education level, digital literacy, social participation, and information-seeking behaviour significantly influence ICT adoption among farmers. While platforms like YouTube, WhatsApp, and Facebook are widely used for agricultural information, the adoption of advanced digital tools such as e-agricultural magazines, crop insurance apps, and Kisan Suvidha remains limited, highlighting a crucial awareness gap. Key barriers to ICT adoption include limited access to digital gadgets like computers and low participation in ICT training programs. The prevalence of small-scale farming systems and financial constraints further impede farmer’s ability to leverage digital advancements effectively. To address these challenges, targeted interventions such as enhanced ICT training, improved digital infrastructure, and customized information services are essential. Policymakers, extension organizations, and agricultural stakeholders must collaborate to design inclusive and farmer-centric digital solutions that pave way to diverse socio-economic profiles.

 In conclusion, strengthening ICT integration in agriculture is vital for empowering farmers in Tirupathur district to overcome socio-economic challenges, increase productivity, and achieving integrated development and holistic approach.

**Disclaimer (Artificial intelligence)**

During the preparation of this work, the author used ChatGPT (developed by OpenAI), Scholarly AI, and Review Management AI in order to assist with formatting references, managing the review process, and improving language clarity. After using these tools, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

**References**

Akhter, A., Karim, M. M., & Islam, K. M. (2022). The impact of creativity and innovativeness on digital entrepreneurship: Empirical evidence from Bangladesh. The Journal of Asian Finance, Economics and Business, 9(3), 77–82.

Alkamel, M., & Chouthaiwale, S. S. (2020). ICT availability and uses among Yemeni university EFL students. TESOL and Technology Studies, 1(1), 1–9.

Amponsah, K. D. (2022). The impact of internet usage on students’ success in selected senior high schools in Cape Coast metropolis, Ghana. European Journal of Educational Sciences, 9(2), 1–18.

Apat, H. C. M., Sarias, K. J. M., Tomarong, M. T., & Bacatan, J. R. (2023). The influence of oral communication on the learning engagement of students. Canadian Journal of Language and Literature Studies, 3(4), 44–58.

Aziz, R. (2023). Creativity in higher education: The effect of personality on students’ creative thinking skills. Thinking Skills and Creativity Journal, 6(1), 44–51.

Bakare, O. D., & Solomon, A. O. (2022). Internet resources and academic performance of secondary school students in Nigeria. Global Scientific Journals, 10(6), 2082–2097.

Ballano, V. O., Mallari, N. T., & Sebastian, R. R. R. (2022). Understanding digital literacy, digital competence, and pedagogical digital competence: Implementing online teaching for Filipino tertiary educators during COVID-19. In Digital Literacy for Teachers (pp. 391–409). Singapore: Springer Nature Singapore.

Bandico-Brasileño, I., & Bidad, W. (2021). The state of ICT integration in the school learning system in junior high schools, General Santos – Philippines. International Journal of Interdisciplinary Studies, 2(3), 76–88.

Barbee, L. (2020). Teaching collaborative learning skills to students in a flipped statistics class: An action research study (Doctoral dissertation, Azusa Pacific University).

Barlow, E. K., & Barlow, A. T. (2020). What would mathematicians do? Providing opportunities for reasoning and sense making. Middle School Journal, 51(3), 5–10.

Basri, W. S., Alandejani, J., & Almadani, F. (2018). ICT adoption impact on students’ academic performance: Evidence from Saudi universities. Education Research International, 2018(1), 1–9.

Biletska, I. O., Paladieva, A. F., Avchinnikova, H. D., & Kazak, Y. Y. (2021). The use of modern technologies by foreign language teachers: Developing digital skills. Linguistics and Culture Review, 5(2), 16–27.

Bharuthram, S., & van Heerden, M. (2023). The affective effect: Exploring undergraduate students’ emotions in giving and receiving peer feedback. Innovations in Education and Teaching International, 60(3), 379–389.

Bhat, R. (2023). The impact of technology integration on student learning outcomes: A comparative study. International Journal of Social Science, Educational, Economics, Agriculture Research and Technology (IJSET), 2(9), 592–596.

Bhat, P. P., R., R. P., A., K., Jadhav, A., N. M., K., M. R., C., & Reddy, S. L. (2024). The role of information and communication technology in enhancing the effectiveness of agricultural extension programs worldwide: A review. *Journal of Scientific Research and Reports*, *30*(7), 963–976. <https://journaljsrr.com/index.php/JSRR/article/view/2206>

Carlisle, S., Ivanov, S., & Dijkmans, C. (2023). The digital skills divide: Evidence from the European tourism industry. Journal of Tourism Futures, 9(2), 240–266.

Chen, D., Zhang, Y., Luo, H., Li, J., & Lin, Y. (2023, July). From ICT utilization to student learning achievement: Mediation effects of digital literacy and problem-solving ability. In International Conference on Blended Learning (pp. 71–82). Cham: Springer Nature Switzerland.

Cukurova, M., & Luckin, R. (2018). Measuring the impact of emerging technologies in education: A pragmatic approach. In J. Voogt, G. Knezek, R. Christensen, & K. W. Lai (Eds.), Second handbook of information technology in primary and secondary education (pp. xx–xx). Springer, Cham, Switzerland.

Demirören, M., Turan, S., & Taşdelen Teker, G. (2020). Determinants of self-regulated learning skills: The roles of tutors and students. Advances in Physiology Education, 44(1), 93–98.

Department of Education (DepEd). (2007). DepEd Order No. 1 s. 2007: Strengthening the information communication technology (ICT) governance of the Department of Education.

Dublar, L. P. T. (2023). Assessing the impact of emerging technology integration on knowledge and skills acquisition of K12 students in the Philippines: A systematic literature review. SSRN. <https://doi.org/10.2139/ssrn.4355370>

Estriegana, R., Teixeira, A. M., Robina-Ramirez, R., Medina-Merodio, J. A., & Otón, S. (2024). Impact of communication and relationships on student satisfaction and acceptance of self- and peer-assessment. Education and Information Technologies, 1–17. <https://doi.org/10.1007/s10639-023-11700-x>

Gonzales, G. (2020, April 3). Big divide in internet use in Philippines by age, education level – report. Rappler. Retrieved September 8, 2022, from <https://www.rappler.com/>

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st century skills frameworks: Systematic review. Sustainability, 14(3), 1493. <https://doi.org/10.3390/su14031493>

González-Salamanca, J. C., Agudelo, O. L., & Salinas, J. (2020). Key competences, education for sustainable development and strategies for the development of 21st century skills: A systematic literature review. Sustainability, 12(24), 10366. <https://doi.org/10.3390/su122410366>

Government of India (2021). Agricultural Census 2015–16: All India Report on Number and Area of Operational Holdings. Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare.

Gürsoy, G. (2021). Digital storytelling: Developing 21st century skills in science education. European Journal of Educational Research, 10(1), 97–113.

Habiba, U., & Ahmed, S. Z. (2020). ICT infrastructure and access to online services: Determining the factors affecting faculty satisfaction with university-subscribed resources. International Information & Library Review, 53(2), 112–130. <https://doi.org/10.1080/10572317.2020.1718775>

Han, X., Xu, Q., Xiao, J., & Liu, Z. (2023). Academic atmosphere and graduate students’ innovation ability: The role of scientific research self-efficacy and scientific engagement. European Journal of Psychology of Education, 1–18. <https://doi.org/10.1007/s10212-023-00696-z>

Hani, A. (2021, June 23). Improving public awareness of ICT in the Philippines. OpenGovAsia. Retrieved January 5, 2023, from <https://opengovasia.com/>

Harefa, D., Sarumaha, M., Telaumbanua, K., Telaumbanua, T., Laia, B., & Hulu, F. (2023). Relationship student learning interest to the learning outcomes of natural sciences. International Journal of Educational Research and Social Sciences (IJERSC), 4(2), 240–246.

Hernando-Malipot, M. (2022, May 13). DepEd’s Digital Rise Program a key player to address challenges in education quality. Manila Bulletin. Retrieved November 29, 2022, from <https://www.mb.com.ph/>

Hori, R., & Fujii, M. (2021). Impact of using ICT for learning purposes on self-efficacy and persistence: Evidence from PISA 2018. Sustainability, 13(11), 6463. <https://doi.org/10.3390/su13116463>

Ivanova, T., Gubanova, N., Shakirova, I., & Masitoh, F. (2020). Educational technology as one of the terms for enhancing public speaking skills. Universidad y Sociedad, 12(2), 154–159.

Junaštíková, J. (2023). Self-regulation of learning in the context of modern technology: A review of empirical studies. Interactive Technology and Smart Education. Advance online publication. <https://doi.org/10.1108/ITSE-03-2023-0067>

Kennedy, T. J., & Sundberg, C. W. (2020). 21st century skills. In Science education in theory and practice: An introductory guide to learning theory (pp. 479–496). Springer.

Kholmuratovich, M. K., Mardanqulovich, A. S., Ravshanovich, J. R., Sharifovna, K. U., & Shodiyevna, B. O. (2020). Methodology of improving independent learning skills of future fine art teachers (on the example of still life in colorful paintings). *International Journal of Psychosocial Rehabilitation, 24*(05), 285–288.

Kozlova, D., & Pikhart, M. (2021). The use of ICT in higher education from the perspective of the university students. *Procedia Computer Science, 192*(1), 2309–2317.

Kumar, S., & Alamgir, A. (2024). Hurdles in the adoption of digital technologies in the agriculture sector of Bihar. Economics & Management Information, 3(3), 1–10.

Kwok, J. (2020, February 7). How education technology improves student engagement [Blog]. Australian Christian College. Retrieved October 9, 2022, from <https://www.acc.edu.au/>

Lewohl, J. M. (2023). Exploring student perceptions and use of face-to-face classes, technology-enhanced active learning, and online resources. *International Journal of Educational Technology in Higher Education, 20*(48), 1–17. https://doi.org/10.1186/s41239-023-00411-0

Livingstone, S., Mascheroni, G., & Stoilova, M. (2023). The outcomes of gaining digital skills for young people’s lives and wellbeing: A systematic evidence review. *New Media & Society, 25*(5), 1176–1202. https://doi.org/10.1177/14614448221090888

Ludvík, E., Łukasz, T., Milan, K., Mária, P., & Gabriela, P. (2020). How do first year university students use ICT in their leisure time and for learning purposes? *International Journal of Cognitive Research in Science, Engineering and Education, 8*(2), 35–52.

MadhuShekar, B. R., et al. (2023). Analysis of farmers’ perception and usage of social media in agriculture. International Journal of Bio‑resource & Stress Management, 14(12), 1646–1653

Mafang’ha, M. (2016). Teachers’ experience on the use of ICT to facilitate teaching: A case of Ilala District secondary schools [Master’s thesis, University of Tanzania].

Malik, A., & Ansari, M. A. (2024). Farmers’ use of social media and constraints faced: A study in Uttarakhand, India. Asian Journal of Agricultural Extension, Economics & Sociology, 42(8), 92–100.

Mapiye, O., Makombe, G., Molotsi, A., Dzama, K., & Mapiye, C. (2023). Information and communication technologies (ICTs): The potential for enhancing the dissemination of agricultural information and services to smallholder farmers in sub-Saharan Africa. Information Development, 39(3), 638–658.

Masadeh, T. S. (2021). Teaching practices of EFL teachers and the enhancement of creative thinking skills among learners. *International Journal of Asian Education, 2*(2), 153–166. https://doi.org/10.46966/ijae.v2i2.88

Mopara, R., & Sanrattana, W. (2023). Developing teachers to develop students' 21st century skills. *World Journal of Education, 13*(3), 94–104. https://doi.org/10.5430/wje.v13n3p94

Morsidi, S., Samah, N. A., Rahman, K. A. A., Ashari, Z. M., Jumaat, N. F., & Abdullah, A. H. (2021). WhatsApp and its potential to develop communication skills among university students. *International Journal of Interactive Mobile Technologies, 15*(23), Article 12. <https://doi.org/10.3991/ijim.v15i23.26115>

Mukherjee, S., Padaria, R. N., et al. (2025). Global trends in ICT‑based extension and advisory services in agriculture: A bibliometric analysis. Frontiers in Sustainable Food Systems, 9.

Munje, P. N., & Jita, T. (2020). The impact of the lack of ICT resources on teaching and learning in selected South African primary schools. *International Journal of Learning, Teaching and Educational Research, 19*(7), 263–279. https://doi.org/10.26803/ijlter.19.7.16

Nahar, S. (2022). Improving students' collaboration thinking skill under the implementation of the quantum teaching model. *International Journal of Instruction, 15*(3), 451–464. https://doi.org/10.29333/iji.2022.15325a

Nazhifah, N., Wiyono, K., & Azairok, M. (2023). Profile of physics creative thinking skills for high school students in the 21st century. *Jurnal Inovasi Pendidikan Fisika Dan Riset Ilmiah (JIPFRI), 7*(1), 1–11. https://doi.org/10.26740/jipfri.v7n1.p1-11

Osiesi, M. P., Yahya, O. A., Sanni, K. T., & Okorie, N. C. (2021). Assessment of undergraduates’ perception on ICT availability, accessibility and use in the Federal University Oye-Ekiti, Ekiti State, Nigeria. *Library Philosophy and Practice (E-journal)*, 6478. https://digitalcommons.unl.edu/libphilprac/6478/

Pachis, J., & Zonneveld, K. (2019). Comparison of prompting procedures to teach internet skills to older adults. *Journal of Applied Behavior Analysis, 52*(1), 173–187. https://doi.org/10.1002/jaba.517

Paje, Y., Rogayan, D. J., & Dantic, M. J. (2021). Teachers' utilization of computer-based technology in science instruction. *International Journal of Technology in Education and Science, 5*(3), 427–446. https://doi.org/10.46328/ijtes.v5i3.144

Patra, G., Datta, S., & Mukherjee, R. (2023). Students’ perception of ICT use in higher secondary school students: An exploratory factor analysis approach. In Digital technologies for smart business, economics and education: Towards a promising future (pp. 243–259). Cham: Springer International Publishing.

Pearce, A. (2022). The perceptions of students and teachers when using ICTs for educational practices matter: A systematic review. Advances in Science, Technology and Engineering Systems Journal, 7(6), 1–12.

Perez, K. Y. (2023). The impact of lack of internet and technology access on students’ academic achievement: An analysis of the United States (Doctoral dissertation, Georgetown University).

Priyambodo, P., & Wilujeng, I. (2023). Phenomenological studies: Strategies for improving Indonesian pre-service teacher collaboration skills. Pegem Journal of Education and Instruction, 13(3), 350–361.

Puscas, L., Kogan, J. R., & Holmboe, E. S. (2021). Assessing interpersonal and communication skills. Journal of Graduate Medical Education, 13(2S), 91–95. <https://doi.org/10.4300/JGME-D-20-01151.1>

Rana, K., & Rana, K. (2020). ICT integration in teaching and learning activities in higher education: A case study of Nepal's teacher education. Malaysian Online Journal of Educational Technology, 8(1), 36–47.

Ritter, S. M., Gu, X., Crijns, M., & Biekens, P. (2020). Fostering students’ creative thinking skills by means of a one-year creativity training program. PLoS ONE, 15(3), e0229773. <https://doi.org/10.1371/journal.pone.0229773>

Rubach, C., & Lazarides, R. (2021). Addressing 21st-century digital skills in schools–Development and validation of an instrument to measure teachers' basic ICT competence beliefs. Computers in Human Behavior, 118, 106636. <https://doi.org/10.1016/j.chb.2020.106636>

Sabbah, S., Hallabieh, F., & Hussein, O. (2020). Communication skills among undergraduate students at Al-Quds University. World Journal of Education, 10(6), 136–142. <https://doi.org/10.5430/wje.v10n6p136>

Serhan, D. (2020). Transitioning from face-to-face to remote learning: Students' attitudes and perceptions of using Zoom during COVID-19 pandemic. International Journal of Technology in Education and Science, 4(4), 335–342. <https://doi.org/10.46328/ijtes.v4i4.113>

Shchetynina, O., Kravchenko, N., Horbatiuk, L., Alieksieieva, H., & Mezhuyev, V. (2022). Trello as a tool for the development of lifelong learning skills of senior students. Postmodern Openings, 13(2), 143–167. <https://doi.org/10.18662/po/13.2/503>

Shehrawat, P. S., et al. (2024). Farmers’ awareness level and adoption regarding usage of ICT for crop production (Haryana, India). Int. Journal of Agriculture Extension & Social Development, 7(11), 167–173.

Shoaib, M., Abdullah, F., & Ali, N. (2021). A research visualization of academic learning skills among students in higher education institutions: A bibliometric evidence from 1981 to 2020. Library Philosophy and Practice, 5579, 1–34. <https://digitalcommons.unl.edu/libphilprac/5579/>

Shoaib, M., & Ullah, H. (2021). Classroom environment, teacher, and girl students’ learning skills. Education and Urban Society, 53(9), 1039–1063. <https://doi.org/10.1177/0013124520985570>

Siedlecki, S. L. (2020). Understanding descriptive research designs and methods. Clinical Nurse Specialist, 34(1), 8–12. <https://doi.org/10.1097/NUR.0000000000000504>

Singh, A., Ago, B. J., Cerillo, T., Laguna, D., & Ugto, A. (2020). Effectiveness of collaborative learning in enhancing academic performance in creative nonfiction literary essay subject of Grade 12 HUMSS students at Bestlink College of the Philippines. Ascendens Asia Singapore–Bestlink College of the Philippines Journal of Multidisciplinary Research, 2(1).

Sousa, A. E. (2019). High school students’ perception on the use of ICT in learning vocational courses: A survey. Proceeding of the 5th International Conference on Education, 5(1), 1–7.

Stein, S. J., & Sim, K. N. (2020). Enhancing the roles of information and communication technologies in doctoral research processes. International Journal of Educational Technology in Higher Education, 17(34), 1–15. <https://doi.org/10.1186/s41239-020-00196-9>

Sun, M., Wang, M., Wegerif, R., & Peng, J. (2022). How do students generate ideas together in scientific creativity tasks through computer-based mind mapping? Computers & Education, 176, 104359. <https://doi.org/10.1016/j.compedu.2021.104359>

Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., ... & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. Education and Information Technologies, 28(6), 6695–6726. <https://doi.org/10.1007/s10639-023-11984-3>

Toma, F., Ardelean, A., Grădinaru, C., Nedelea, A., & Diaconu, D. C. (2023). Effects of ICT integration in teaching using learning activities. Sustainability, 15(8), 6885. <https://doi.org/10.3390/su15086885>

Usman, S. A. (2020). Using the Pomodoro Technique® to help undergraduate students better manage technology-based multitasking during independent study: A design-based research investigation (Unpublished doctoral dissertation). Lancaster University, United Kingdom.

Utkerovna, B. S. (2023). Effective ways of improving language learners’ communication skills through story-based approach. American Journal of Language, Literacy and Learning in STEM Education, 1(9), 563–567.

Valtonen, T., Hoang, N., Sointu, E., Näykki, P., Virtanen, A., Pöysä-Tarhonen, J., ... & Kukkonen, J. (2021). How pre-service teachers perceive their 21st-century skills and dispositions: A longitudinal perspective. Computers in Human Behavior, 116, 106643. <https://doi.org/10.1016/j.chb.2020.106643>

Van Laar, E., Van Deursen, A. J., Van Dijk, J. A., & de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. SAGE Open, 10(1), 2158244019900176. <https://doi.org/10.1177/2158244019900176>

Warsah, I., Morganna, R., Uyun, M., Afandi, M., & Hamengkubuwono, H. (2021). The impact of collaborative learning on learners’ critical thinking skills. International Journal of Instruction, 14(2), 443–460. <https://doi.org/10.29333/iji.2021.14226a>

Weber, A. M., & Greiff, S. (2023). ICT skills in the deployment of 21st century skills: A (cognitive) developmental perspective through early childhood. Applied Sciences, 13(7), 4615. <https://doi.org/10.3390/app13074615>

Wordu, H., Victor-Asia, A., & Ukwe, A. (2021). Perceived impact of information and communication technology (ICT) on academic performance of students in senior secondary schools in Rivers State, Nigeria. International Journal of Advanced Educational Research, 6(4), 22–28.

Youssef, A. B., Dahmani, M., & Ragni, L. (2022). ICT use, digital skills and students’ academic performance: Exploring the digital divide. Information, 13(3), 129. <https://doi.org/10.3390/info13030129>