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# Factors influencing digital literacy among university students in Beijing, China

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ABSTRACT

This study investigated the factors that affect digital literacy among university students in Beijing, focusing on how socioeconomic status, access to technology, educational programs, and the learning environment play a role. A quantitative method was used to collect data from 391 students at five universities through a structured questionnaire. The data were analyzed using structural equation modeling. The results show that although socioeconomic status and access to technology are important, educational programs have the most significant impact on improving digital literacy. Interestingly, the learning environment did not have a major direct effect on digital literacy, but the study found that simply providing digital tools is not enough without proper instructional support. This research points to key areas for policymakers and educators to focus on to improve digital literacy in higher education, highlighting the need for coordinated educational strategies that make full use of technology. The findings suggest further research is needed to understand how digital tools are used in learning environments and their long-term impact on students' digital skills, with the goal of improving educational practices and policies for the digital era.



## 1. Introduction

Digital literacy is a key part of modern education and is essential for success in today's job market. It includes the ability to find, evaluate, use, share, and create content through information technology and the internet, involving a variety of skills and abilities (Falloon, 2020). In China, where technological advancements are swift and considerable, the varying degrees of digital literacy among the young population, especially college students, prompt the need for significant reforms in educational policy and practice (List, 2019). Some studies have shown that digital literacy encompasses more than just basic internet navigation and software proficiency; it primarily involves critical thinking, problem-solving, and active engagement in a digital society (Kong, 2014). For Beijing, which has a culturally diverse student population and varying levels of access to digital resources, it is crucial to identify the factors that impact digital literacy. Thus, we believe that the selection of students from this area as a sample group is typically representative.

This study employed a quantitative approach to investigate the digital literacy characteristics of university students in Beijing, China. The main objective of this study was to examine the influence of several factors on the digital literacy of students at Beijing universities. The analysis considers factors such as socioeconomic status, access to digital devices and internet connections, the digital infrastructure of educational institutions, and the impact of both formal and informal digital literacy education (Tirado-Morueta et al., 2018; Nedungadi et al., 2018). In a broader sense, this study contributes to the ongoing conversation about digital literacy in China. This highlights the consequences of the digital divide and emphasizes the need to incorporate digital literacy into the main curriculum. Given the Chinese government's and educational stakeholders' recognition of the significance of this field for national progress, this study emphasizes the need for data-driven policies and interventions that can address disparities in digital literacy.

Overall, this study provides a quantitative analysis of the various elements that influence digital literacy among university students in Beijing. This study sheds light on the unique challenges and potential for growth in this particular location while also offering valuable insights for comparable

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initiatives aimed at enhancing digital literacy throughout China. In contemporary society, the prevalence of digital technology is on the rise. Consequently, it is imperative for young adults to acquire enhanced digital abilities to thrive academically, professionally, and in their future careers.

## 2. Literature review

### 2.1. Defining digital literacy

Digital literacy encompasses more than just proficiency with software and devices; it encompasses a broad spectrum of abilities necessary for efficiently accessing, analyzing, generating, and assessing digital content (Falloon, 2020). This concept has significantly evolved since the inception of computers and technology. Initially, the focus was solely on technical skills. However, over time, it has broadened to encompass interpretative and creative capabilities in various types of digital media. When discussing the act of reading and writing, we usually connect them with physical books or the use of pens and paper. Nevertheless, this aspect is truly a subordinate element of digital literacy. It also requires actively engaging with digital content in meaningful ways (Gamble and Easingwood, 2000).

The significance of digital literacy cannot be overemphasized. The advancement of human growth and social development is crucial, highlighting the necessity for policies that prioritize progress in many sectors. Put simply, digital literacy refers to the collection of abilities, understanding, and mindsets required to ethically and efficiently access, analyze, and use digital information (Julien, 2019). The word is frequently erroneously limited to technical talent, but in reality, it encompasses a range of diverse skill sets, including critical thinking and a comprehensive understanding of technology for efficient usage.

Digital literacy in the 21st century comprises a range of skills related to reading and writing in many forms of media (Osterman, 2012). Currently, the cognitive, social, and emotive elements of digital engagement are regarded as a significant necessity in education (Spires et al., 2019). This term has become so vague that it has no precise definition. Nevertheless, the demand for digital literacy remains constant globally. This emphasizes the significance of individuals possessing a thorough comprehension and practical implementation of the concept in the present-day situation (Biezā, 2020). Digital literacy is a comprehensive concept that includes a range of actions designed to educate individuals on the proper use of technology. By combining information and media literacy, we can provide a more accurate framework for defining digital literacy. Subsequently, we can rectify its shortcomings and significantly enhance the user experience (Leaning, 2019).

In our study, digital literacy is defined as the all-encompassing capability to access, interpret, create, and critically assess digital content (Wuyckens et al., 2022). It encompasses various cognitive, technical, and social skills that are crucial for effective engagement in the digital realm.

### 2.2. Socioeconomic determinants of digital literacy

Various socioeconomic factors influence an individual's ability to access and use digital technology effectively, thus impacting their level of digital literacy (Yu et al., 2017). These factors have a significant impact on the development of digital abilities and have wide-ranging implications for an individual's participation in a digital economy and society as a whole.

The global landscape is undergoing transformation. The advent of digital technology has propelled globalization to the forefront, resulting in fierce competition across all economic domains. Because of this alteration, it is crucial that we comprehend digital literacy to its utmost capacity. It is imperative to comprehend the potential of digital tools in empowering marginalized people and facilitating socio-economic liberation. Njenga (2018) proposed a revised definition of digital literacy that emphasizes the results and impacts related to socioeconomic progress.

Currently, there is a major emphasis on the pivotal role of digital technology in facilitating access to social determinants of health. This includes education, work, and housing. An investigation focusing on specific demographics concluded that those with little financial resources have significant challenges in terms of accessing and effectively utilizing digital technology. When individuals are unable to use it, it activates and intensifies all of their preexisting disadvantages. Typically, these drawbacks involve a lack of proficiency in reading and writing. In addition, individuals without internet connections may become trapped in a continuous loop where socioeconomic inequalities are intensified by the absence of digital accessibility (Baum et al., 2014).

Moreover, age, education, income, and household type are all variables that contribute to the digital divide. This division accounts for the various degrees of digital literacy observed among different demographic groups. Consequently, this results in societal-level digital division. A study conducted in Slovakia emphasized the influence of socioeconomic and demographic factors on an individual's level of digital literacy. This subsequently leads to a cascading impact on their digital well-being.

In addition, efforts to enhance digital literacy should prioritize the development of digital rights that foster community inclusion and engagement. When individuals possess the knowledge and skills to effectively interact with new forms of media and utilize the internet's potential, it fosters sustainable development and promotes growth in a society that values knowledge (Sharma et al., 2016).

Socioeconomic considerations significantly influence an individual's comprehension of digital

literacy. Specific interventions will be required to address inequalities and foster inclusiveness as we progress further into the era of digital technology. Previous efforts have been advantageous; however, they need to consider the complex nature of these factors to ensure that individuals from all backgrounds can actively engage with the world via the lens of technology.

### 2.3. Access to technologies and their impact on literacy

The swift transformation of higher education environments via digital technology vividly demonstrates the impact of reading and writing abilities on computers and the internet. Research indicates that the capacity to access information is a significant determinant of whether university faculty and students adopt new technologies (Maina and Nzuki, 2015). Additional studies have reached similar conclusions; however, in different terms, proficiency in computer usage is only partially influenced by one's aptitude towards computers. Effort and performance expectations have a significant impact (Nikou and Aavakare, 2021). A further investigation conducted between Korea and Finland delves into this concept, revealing that the manner in which individuals conduct research significantly influences their inclination to explore novel experiences. The level of familiarity an individual has with technology indirectly influences their willingness through the formation of habits and expectations (Jang et al., 2021).

The use of technology in education extends beyond being a tool for traditional literacy, and teachers need to adapt and incorporate technologies into the curriculum. This transformation necessitates a certain form of technological proficiency that examines its effects on relationships, identities, and power dynamics (Hasse, 2017). The global adoption of information and communication technologies in the 21st century is reshaping the concept of literacy. It compels educators to include digital resources to ensure that learning stays up-to-date with the expectations of society. However, access to technology alone does not suffice for an individual to possess literacy. A comprehensive perspective involves comprehending the process of technology development and its utilization within society. A lack of widespread technical literacy hinders our ability to effectively navigate the issues it presents (Bugliarello, 2000). The digital divide highlights the significant disparity in access and skills between students and teachers in terms of digital literacy and traditional educational techniques.

### 2.4. Pivotal role of educational institutions in cultivating digital literacy

In some studies, digital literacy goes beyond simply knowing how to use digital devices; it encompasses a wide range of cognitive, social, and technological abilities that individuals need to seek, evaluate, create, and share information from different digital platforms (Tsvetkova et al., 2021). The significance of this is not only pertinent to academic success but also intimately connected to employment prospects and broader engagement in digital culture. Recently, the importance of higher education institutions has increased significantly because of the rapid advancement of technology and the evident disparities in digital access.

Hence, it is imperative to enhance students' digital literacy. By doing so, the learning process will become more effective and efficient while also equipping individuals with the skills required for an ever-changing job market in the future. Shopova (2014) advocated the integration of digital literacy into university curricula to enhance academic achievements and equip students with the necessary skills for success in a technologically advanced society. Higher education institutions have increasingly utilized information and communication technologies to cultivate proficiency in students. An in-depth comprehension of how students use these resources can significantly influence the design of the curriculum for digital literacy courses. It also highlights the pressing necessity for students to have access to web resources and services that extend beyond personal usage (Parvathamma and Pattar, 2013).

In addition, proficiency in digital literacy is essential for individuals to adapt and meet the qualifications required in today's technology-driven societies (White, 2019). The focus has shifted from utilizing digital technologies to addressing real-world issues and comprehensively grasping the operational principles of digital technologies. The development of a comprehensive framework that encompasses various abilities, competencies, and awareness will ensure that college students meet their specific needs throughout this transition period (Wu, 2024). Furthermore, according to the research conducted by Tang et al. (2023), the utilization of multimedia can improve the efficacy of educators in their instructional practices. This study is also an empirical investigation in the realm of education that integrates digital technology.

Overall, we can easily find that educational institutions are recognized as crucial entities in fostering the development of digital skills that are required on a global scale (Sousa and Rocha, 2019). As society moves toward becoming a "Learning Society," it is important for educational systems to have a significant impact on developing these talents through training and learning methods (Milenkova et al., 2020).

### 2.5. Learning environments and their influence on digital literacy development

Learning environments have a substantial impact on the development of digital literacy, in contrast to conventional places (Liu et al., 2020). These include traditional educational institutions, such as colleges,

and informal learning environments, such as businesses or daily places. The concept of digital literacy is constantly changing due to the ongoing expansion of technology in different areas. Therefore, it is crucial to understand how learning settings impact digital literacy.

For formal educational settings, curriculum integration and pedagogical approaches to digital literacy are paramount. Such environments provide structured opportunities for students to use digital tools and resources (Cheung et al., 2021). However, the effectiveness of these opportunities is contingent on the curriculum's relevance to digital realities and the pedagogical strategies employed by educators. The challenge for formal education is to move beyond merely using digital tools for instruction to embed critical thinking, ethical considerations, and creative problem-solving into digital literacy learning (Falloon, 2020). Educational institutions must evolve to mirror the interconnected, multimedia-rich environment that defines the digital age, thereby preparing students not only to navigate but also to innovate within these spaces (Meyers et al., 2013).

Informal learning environments, usually including libraries, museums, and online communities, offer less structured but equally potent opportunities for digital literacy development (Martzoukou, 2021). These spaces often encourage exploration, self-directed learning, and peer-to-peer interaction, which are crucial for developing digital literacy. Informal settings can supplement formal education by providing diverse, real-world contexts in which digital tools are used to solve problems, create content, and communicate (Ramsurrun et al., 2024). Moreover, maximizing the potential of these environments requires intentional design and facilitation to ensure that learners can critically engage with digital technologies and media (Meyers et al., 2013).

Furthermore, home ambiance and educational settings significantly influence the development of early digital literacy abilities (Flewitt and Clark, 2020). The quantity and nature of a child's exposure to digital technology in his or her home environment greatly influence his or her level of proficiency and comprehension of these technologies. Parents and guardians play a crucial role in facilitating children's digital experiences by granting them access to digital devices and offering instruction on their proper usage. To foster effective digital literacy growth within the household, it is imperative for parents to strike a harmonious equilibrium between allowing children to explore diverse applications of technology while simultaneously ensuring their safe and appropriate usage. This dual strategy promotes an atmosphere in which children can cultivate their innate curiosity about digital technology while receiving appropriate supervision from adults.

In addition, blended learning environments, which integrate conventional in-person teaching with online learning, offer distinct opportunities for students to enhance their digital literacy abilities (Le et al., 2022). To thrive in integrated environments, students require more than mere rudimentary knowledge of technology. It is imperative for individuals to acquire the necessary skills to use these platforms proficiently for educational purposes. This includes tasks such as efficiently searching for material online, critically assessing its reliability, engaging in virtual collaboration with peers, and producing digital work that showcases knowledge and understanding. Teachers should strive to not only deliver this knowledge to students using digital platforms but also actively involve them in contemplating the consequences that these platforms have for the creation and dissemination of knowledge (Tang and Chaw, 2016).

Based on the above discussion, the development of digital literacy is a multifaceted process influenced by the interplay of various learning environments. Each environment contributes distinctively to the tapestry of skills that define digital literacy. As digital technologies continue to evolve, our understanding and enhancement of these learning environments must also foster a digitally literate society capable of navigating and shaping the future.

### 2.6. Research gap

After a thorough analysis of the literature on digital literacy, it is evident that certain areas in Beijing have not been thoroughly investigated despite the significant contributions made by numerous experts. This section attempts to fill the gaps in the literature by integrating the insights provided by authors such as Tsvetkova et al. (2021), Shopova (2014), and Liu et al. (2020) with the contexts and citations mentioned in the literature review.

First, Tsvetkova et al. (2021) redefined and expanded the concept and scope of digital literacy, highlighting its complex and diverse nature. Nevertheless, there is a lack of scholarly research on how cultural and geographical specificity within Beijing impacts these complex components. How does the local cultural, economic, and educational environment of Beijing align with the elements of digital literacy? This necessitates conducting more localized studies to enhance our comprehensive comprehension of digital literacy.

Furthermore, socioeconomic determinants of digital literacy highlight crucial elements that impact an individual's ability to use digital resources within a community. Yu et al. (2017) and Njenga (2018) conducted studies on this topic. However, there is currently a lack of relevant evidence regarding how these characteristics jointly affect various demographic categories in Beijing. This disparity indicates the need for more detailed research that examines how socioeconomic factors synergistically influence digital literacy in this region.

In addition, experts widely recognize that having access to technology is crucial for developing digital literacy. However, many experts fail to consider the specific type of technology being used or its quality,

as noted by Maina and Nzuki (2015) and Nikou and Aavakare (2021). However, what if the presence of high-speed internet or new equipment is crucial in the development of digitally savvy university students? This indicates a crucial domain that requires additional investigation. Furthermore, Shopova (2014) emphasized the significance of educational institutions in promoting digital literacy. What is the technique they use to achieve this? Do these initiatives provide favourable outcomes in the higher education setting of Beijing? This gap underscores the need for comprehensive research that explicitly investigates teaching methodologies and their influence on students' digital literacy in Beijing.

By conducting targeted research within Beijing, China, we may effectively address these gaps and make a substantial contribution to the existing body of information on digital literacy. It can create customized tactics that improve digital literacy skills among university students, considering the particular socioeconomic and educational characteristics of the region.

### 2.7. Conceptual frameworks and hypothesis development

This study establishes a conceptual framework for digital literacy by conducting a thorough evaluation of the literature on the subject. This approach is chosen to optimize efficiency and avoid unnecessary duplication of effort. The objective of this study was to identify and investigate all potential factors that influence digital literacy among university students in Beijing, China. This study employs variables obtained from academic sources such as Yu et al. (2017), Maina and Nzuki (2015), Shopova (2014), and Liu et al. (2020). These scientists examine fundamental assumptions such as socioeconomic issues, technology accessibility, educational interventions, and the characteristics of learning settings. From this point, we have developed hypotheses to guide future research on this topic. Several socioeconomic characteristics, including income, parental education, and urban or rural background, influenced digital literacy. It was suggested that students from wealthier socioeconomic backgrounds would either possess higher levels of early digital literacy or be more capable of acquiring this skill. Technology access, which encompasses the quality and availability of digital devices and internet usage, was found to have a favorable impact on digital literacy. The justification is that increased accessibility to technology offers greater possibilities for digital immersion and education. Furthermore, educational interventions, such as integrating digital literacy into university curricula and teaching methods, are recognized as crucial factors in improving digital literacy. Peer-reviewed sources, including digital literacy in the curriculum and the use of innovative teaching methods, have the potential to significantly enhance students' digital skills. The impact of the learning environment on digital literacy should not be underestimated. According to written sources, both formal and informal learning contexts, such as current blended learning, are thought to enhance students' digital literacy, thus expanding their opportunities for exploring digital literacy. Given the complex landscape of digital literacy, which is shaped by both individual and institutional factors, this study posits that a nuanced understanding of digital literacy within Beijing requires an examination of these variables in concert. Thus, the following hypotheses are proposed:

**H1:** Socioeconomic factors are positively correlated with digital literacy levels among university students in Beijing.
**H2:** Access to technology is positively associated with digital literacy levels among university students in Beijing.
**H3:** Educational interventions aimed at integrating digital literacy into the curriculum positively influence digital literacy levels among university students in Beijing.
**H4:** Learning environments, both formal and informal, positively impact the digital literacy levels of university students in Beijing.

## 3. Methodology

### 3.1. Research design

The research design in this study was well-planned. The objective was to examine the variables that impact the level of digital literacy among university students in Beijing, China. The formulation of research questions and hypotheses is the determining factor behind researchers' decision to adopt a quantitative approach. They determined that quantifying the impact of each element would facilitate the testing of ideas using statistical analysis. This was undoubtedly the logical choice for the specific information they were seeking.

This study used a cross-sectional survey design within a quantitative framework. This study aimed to assess the current digital literacy levels of university students and identify the factors that influence these levels at a particular moment. Given that we are merely conducting a brief examination, there is no requirement for extended monitoring or similar actions. To obtain the necessary data for this study, the researchers could generate a questionnaire. The survey comprised five Likert-scale questions in addition to demographic inquiries. These questions could provide insights into participants' socioeconomic status, their levels of access to digital technology, and other related factors.

### 3.2. Setting and participants

The study was conducted in Beijing, China. The educational system and technical development levels

vary between urban and rural areas. The presence of socioeconomic and technical differences creates a distinct setting for examining the digital literacy of university students. The province boasts numerous institutions and colleges that provide ideal settings for conducting this study.

This study was conducted on registered students enrolled in five universities and colleges in Beijing. A diverse group of students representing various socioeconomic backgrounds, fields, and urban-rural backgrounds were included in the study. The selection was based on the proportion of students with various background characteristics in the overall student population of the province.

According to Cochran's (1977) formula, using the estimated proportion, along with a confidence level of 95% (corresponding to a Z value of 1.96) and a margin of error of 5% (E), which is as follows:

$$n = \frac{Z^2 \times p \times (1 - p)}{E^2}$$

By feeding the values into the formula, we obtain:

$$n = \frac{1.96^2 \times 0.5 \times (1 - 0.5)}{0.05^2} = 384.16$$

This result is consistent with the research conducted by Smith et al. (2020) and Tang et al. (2023), who similarly recommend using a minimum of 384 samples to achieve sufficient statistical power for intricate analyses. Furthermore, Johnson et al. (2021) reinforced the adequacy of this sample size in their empirical research, highlighting its effectiveness in capturing diverse respondent perspectives and maintaining statistical validity. Hence, this study chose to implement the suggestions of the mentioned professionals about sample size, which should exceed 384 samples to be included.

### 3.3. Data collection methods and procedures

The data collection process for this study was conducted using the online questionnaire platform Wenjuanxing (wjx.cn), which is particularly popular and effective for research within China because of its user-friendly interface and broad reach. This platform was chosen for its ability to efficiently manage large volumes of responses and its extensive database, facilitating a detailed exploration of digital literacy among university students in Beijing.

The questionnaire, meticulously designed to probe the interconnected factors, was structured to elicit comprehensive information on each area. Each question was crafted to reflect the specific aspects of these domains and their impact on digital literacy.

To ensure a wide and diverse respondent base, the questionnaire was primarily distributed through social media channels, particularly via WeChat groups. WeChat, a dominant communication platform in China, provides access to a vast network of university students and enables the rapid distribution of survey links. By utilizing WeChat groups, especially those composed of university students and educational communities, the study leveraged an effective outreach strategy that not only facilitated easy access to the questionnaire but also encouraged a high participation rate among the target demographic groups. This approach allowed for efficient data collection while ensuring that the process was convenient for participants, thereby maximizing response rates and enhancing the reliability of the data gathered on digital literacy.

### 3.4. Variables and measurements

The study design enables a thorough examination of the factors that influence digital literacy among university students. It also involves defining and measuring independent variables using specific measurement items. Each question assesses a minimum of three factors using a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." The questionnaire extensively investigated the participants' perceptions and self-perceived abilities to identify and connect various socioeconomic factors, their level of access to different technological devices, educational advancements, the learning environment, and digital literacy. Therefore, the design of the scope items thoroughly examines and fully comprehends the impact of independent factors on digital literacy.

Table 1 is a refined summary of the variables, along with sample measurement items designed to fit the characteristics of the 5-point Likert scale and the references guiding their development.

**Table 1:** Measurement items

| Variables | Scale Items | References |
|---|---|---|
| Socio-economic factors | 1. My family's income level provides sufficient support for my digital learning needs<br>2. My parents' level of education has influenced my approach to digital technologies<br>3. Being from an urban/rural area has affected my exposure to digital literacy initiatives | Adapted from Yu et al. (2017) |
| Access to technology | 1. I have consistent access to a personal computer or laptop for my studies<br>2. The quality of my internet connection at home supports my online learning activities<br>3. I frequently encounter difficulties accessing digital platforms required for my coursework | Adapted from Maina and Nzuki (2015) |
| Educational interventions | 1. The digital literacy courses at my university equip me with practical skills for the digital world<br>2. My instructors effectively integrate digital tools into teaching and learning<br>3. The feedback I receive on digital assignments enhances my understanding of digital literacy | Inspired by Shopova (2014) |
| Learning environments | 1. I engage in online learning communities outside of my formal coursework to improve my digital skills<br>2. Physical learning spaces at my university are adequately equipped with technology for learning<br>3. Blended learning courses offer a more engaging learning experience than traditional formats | Based on Liu et al. (2020) |
| Digital literacy levels | 1. I am confident in my ability to locate information online effectively<br>2. I can critically evaluate the reliability of digital content<br>3. I possess the skills needed to create digital content (e.g., blogs, videos, and websites)<br>4. I effectively apply digital tools and resources to solve problems or accomplish tasks | Based on the DigComp framework and ISTE technology literacy standards |

### 3.5. Data analysis

The data collected through the online questionnaire underwent rigorous statistical analysis to uncover insights into the factors influencing digital literacy. This analysis was facilitated by SPSSPRO (Scientific Platform Serving for Statistics Professional Version 1.0.11), an online statistical analysis platform known for its extensive analytical capabilities and user-friendly interface.

The data analysis for this study primarily involved assessing the reliability, validity, and structural equation modeling (SEM) of the data. The main goal of the reliability analysis in the study was to assess the internal consistency of the constructs assessed using questionnaire items. The establishment of dependability ensured the degree to which the items accurately measured the specified variables. On the other hand, the validity analysis assessed whether the questionnaire items accurately measured the study constructs they were intended to evaluate. The robust reliability and validity of the study led to the utilization of SEM to examine the complex connections between various factors.

## 4. Results

The study collected a total of 391 samples. As shown in Fig. 1, demographic data offer a fundamental understanding of the factors influencing the measurement of digital literacy. The age group with the greatest number of participants was the 18-22 age cohort, which made up 39% of the total sample. The subsequent cohort, ranging in age from 23 to 27, is not markedly diminished and constitutes 30%. In addition, there is a subset of individuals aged 28-32, another subset over the age of 32, and a third subset under the age of 18. Hence, the sample exhibits a considerable range in age representation.

Regarding gender, the distribution is nearly balanced, with 52% of respondents identifying as male and 48% identifying as female. The majority of students, comprising 61% of the sample, were pursuing bachelor's degrees. A total of 30% of the students pursue master's degrees, while only 4% pursue PhD degrees. Moreover, a small proportion of pupils, namely 5%, are engaged in alternative academic pursuits. The areas of academic study are equally distributed across the disciplines of humanities and social sciences, each accounting for 22% of the sample. The remaining categories, namely STEM, business and economics, and arts and design, make up 21%, 15%, and 12% of the sample, respectively.

The reliability of the questionnaire items for all the constructs yielded good Cronbach's alpha coefficients, as shown in the outcomes above. The results exhibit robust internal consistency, as evidenced by the consistent reliability implications. This suggests that the scales used in the study are trustworthy measurements of the variables under examination.

As shown in Table 2, the socioeconomic factor scale demonstrated high internal consistency, with alpha values ranging from 0.956 to 0.957 after removing some items. The analysis of access to technology items resulted in alpha coefficients ranging from 0.954 to 0.955. The Educational Interventions and Learning Environments construct demonstrated high reliability, with alpha coefficients ranging from 0.949 to 0.950. The construct of Digital Literacy Levels exhibited a remarkably high alpha coefficient of 0.951, indicating the robustness of the items within this construct in assessing several aspects of digital literacy. Hence, the scales are deemed reliable, and the collected data can be further examined to determine the influence of the variables on the digital literacy of university students in Beijing.

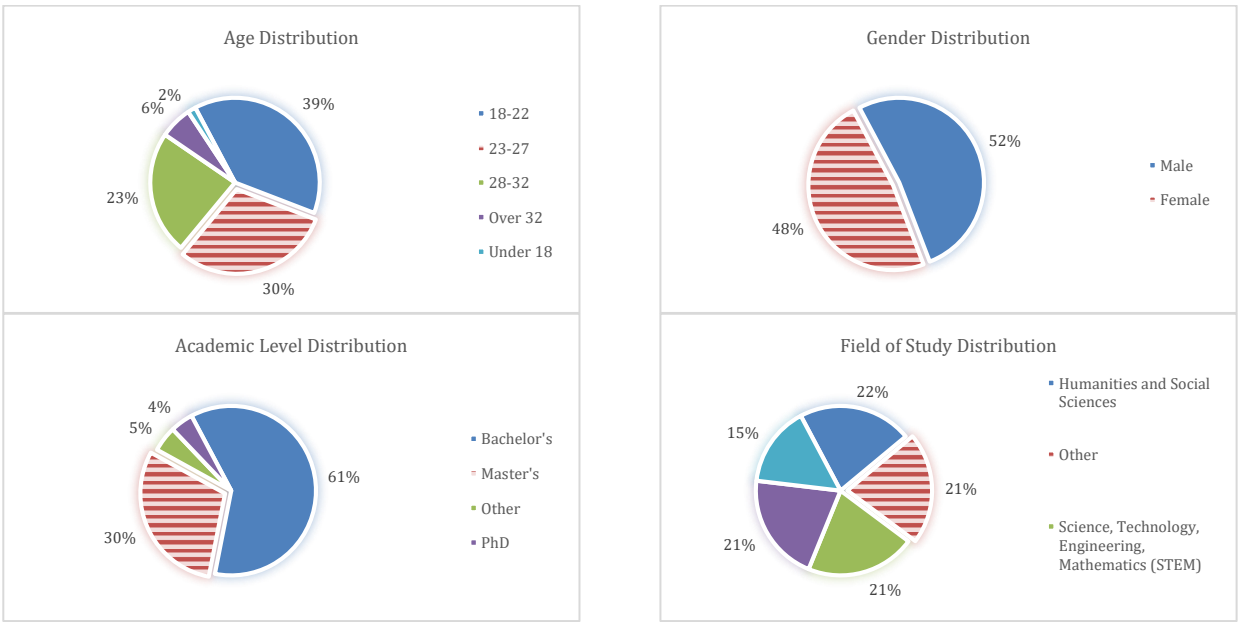


**Fig. 1:** Demographic summary

**Table 2:** Deletion of the statistical summaries of the analytical items

| | Average value after deletion of items | Variance after deletion of items | Correlation of deleted items with the total after deletion of items | Cronbach's α coefficient after deletion of items |
|---|---|---|---|---|
| Socio-economic_1 | 62.294 | 63.09 | 0.539 | 0.956 |
| Socio-economic_2 | 62.281 | 64.203 | 0.446 | 0.957 |
| Socio-economic_3 | 62.274 | 64.225 | 0.439 | 0.957 |
| Access to technology_1 | 62.24 | 63.522 | 0.585 | 0.955 |
| Access to technology_2 | 62.235 | 63.386 | 0.607 | 0.954 |
| Access to technology_3 | 62.253 | 62.728 | 0.652 | 0.954 |
| Educational interventions_1 | 62.765 | 58.796 | 0.868 | 0.949 |
| Educational interventions_2 | 62.754 | 58.611 | 0.867 | 0.949 |
| Educational interventions_3 | 62.78 | 58.367 | 0.889 | 0.949 |
| Learning environments_1 | 62.693 | 58.741 | 0.88 | 0.949 |
| Learning environments_2 | 62.657 | 58.887 | 0.867 | 0.949 |
| Learning environments_3 | 62.634 | 59.043 | 0.856 | 0.95 |
| Digital literacy levels_1 | 62.683 | 58.956 | 0.84 | 0.95 |
| Digital literacy levels_2 | 62.634 | 59.417 | 0.78 | 0.951 |
| Digital literacy levels_3 | 62.624 | 59.543 | 0.782 | 0.951 |
| Digital literacy levels_4 | 62.708 | 59.33 | 0.799 | 0.951 |

In this study, the Kaiser–Meyer–Olkin (KMO), as shown in Table 3 measure of sampling adequacy, yielded a value of 0.913, which is well above the commonly accepted threshold of 0.6, indicating that the data are indeed suitable for factor analysis. This high KMO value suggests that there are sufficient patterns in the responses that can be uncovered through factor analysis.

**Table 3:** The KMO test and Bartlett's test

| | | |
|---|---|---|
| KMO value | | 0.913 |
| Bartlett Sphericity test | Approximate chi-square | 7344.455 |
| | df | 120 |
| | P | 0.000*** |

***: represents a 1% level of significance

Bartlett's test of sphericity further supports this suitability, with a significant chi-square value of 7344.455 and 120 degrees of freedom, resulting in a p-value of 0.000, which is significant at the 1% level. This significance indicates that the correlation matrix is not an identity matrix and that there are relationships among the variables that factor analysis can further investigate.

The discriminant validity of the constructs in this study, assessed through Pearson correlations and the square root of average variance extracted (AVE), demonstrates that each construct is distinct and does not overlap excessively with others. As depicted in Table 4, the AVE square roots, which are the diagonal values, are 0.759 for socioeconomic factors, 0.878 for access to technology, 0.932 for educational interventions, 0.939 for learning environments, and 0.865 for digital literacy levels. The square roots consistently exceed the corresponding Pearson correlation coefficients for the constructs. For example, the correlation between socioeconomic factors and access to technology is 0.166, while the correlations between socioeconomic factors and educational interventions are 0.525 and 0.602, respectively. Similar significant relationships are observed for other pairs, all of which are significant at the 1% level ($p<0.001$***). This affirms strong discriminant validity, indicating that the constructs indeed measure distinct components of university students' digital literacy experience in Beijing.

**Table 4:** Distinguishing validity: Pearson's correlation vs. AVE root value

| | Socio-economic | Access to technology | Educational interventions | Learning environment | Digital literacy levels |
|---|---|---|---|---|---|
| Socio-economic | 0.759 | | | | |
| Access to technology | 0.166(0.001***) | 0.878 | | | |
| Educational interventions | 0.525(0.000***) | 0.602(0.000***) | 0.932 | | |
| Learning environment | 0.603(0.000***) | 0.608(0.000***) | 0.859(0.000***) | 0.939 | |
| Digital literacy levels | 0.48(0.000***) | 0.636(0.000***) | 0.859(0.000***) | 0.793(0.000***) | 0.865 |

***: represents a 1% level of significance; The diagonal number is the root value of the AVE for the factor

The correlation analysis conducted within the study underscores the complex interplay between the key variables influencing digital literacy among university students in Beijing. As shown in Table 5, the strong and significant correlations between Educational Interventions and Digital Literacy Levels, with coefficients such as r=0.883 for Educational Interventions_1 and Digital Literacy Levels_3 ($p<0.001$***), highlight how robust educational frameworks positively impact students' digital capabilities, suggesting that targeted teaching interventions are critical in advancing digital literacy skills. Access to Technology also has a notable influence, as evidenced by correlations such as r=0.822 between Access to Technology_1 and Digital Literacy Levels_1 ($p<0.001$***), indicating the pivotal role of technology access in enhancing students' ability to navigate digital environments effectively and emphasizing that quality technology access underpins the development of these essential skills. However, socioeconomic factors, while showing moderate correlations with digital literacy levels, such as r=0.414 for Socio-Economic_1 and Digital Literacy Levels_1 ($p<0.001$***), suggest that socioeconomic background provides foundational support but is less directly influential than educational interventions or technology access, implying that while socioeconomic status forms a baseline of support, access to resources and educational quality more strongly dictates digital literacy outcomes. Additionally, Learning Environments, despite their expected significance, displayed weaker correlations with Digital Literacy Levels, such as r=0.766 for Learning Environments_1

and Digital Literacy Levels_1 ($p<0.001$***), indicating that the mere presence of digital resources and conducive learning settings may not be sufficient without effective integration and utilization aimed at fostering digital engagement and skill development.

SEM analysis provides insight into the relationships between the independent variables (IVs) and the dependent variable (DV) of digital literacy levels. The results shown in Table 6 indicate that socioeconomic factors have a positive but relatively small effect on digital literacy levels, with a non-standardized coefficient of 0.216 (standardized coefficient=0.096), which is significant at the 5% level ($Z=2.001$, $p=0.045$**). Access to Technology has a stronger positive effect on Digital Literacy Levels, with a non-standardized coefficient of 0.304 (standardized coefficient=0.218), which is highly significant at the 1% level ($Z=4.344$, $p<0.001$***).

Educational interventions have the most substantial impact, with a large non-standardized coefficient of 0.773 (standardized coefficient=0.78), suggesting a very strong and highly significant influence on digital literacy levels ($Z=12.7$, $p<0.001$***). On the other hand, the learning environment has a negative effect on digital literacy levels, although this relationship is not statistically significant (non-standardized coefficient=-0.087, standardized coefficient=-0.078, $Z=-1.201$, $p=0.230$), indicating that within the context of this study, the learning environment does not significantly predict digital literacy levels among university students in Beijing.

## 5. Discussion

Socioeconomic factors have a small but considerable impact on digital literacy. Yu et al. (2017) found that socioeconomic background provides resources that might improve or hinder digital participation. Although the direct influence was less obvious than that of other factors in this study, this highlights the need for legislation to equalize digital opportunities across socioeconomic categories. Targeted support and resources for low-income children could help close the digital divide and give all pupils access to essential digital skills.

Thus, technology access had a stronger effect on digital literacy, supporting Maina and Nzuki's (2015) claim that technology access is crucial to digital competence. The substantial association in this study shows that providing pupils with reliable and modern equipment is essential to boosting digital literacy. Educational institutions should invest in technical infrastructure and offer students personal access to digital tools to promote digital learning.

Moreover, educational interventions predicted digital literacy best in this study. This conclusion supports Shopova (2014), who argued for digital literacy in curricula to improve academic performance and prepare students for a digitally evolved world. This shows that structured digital literacy programs work and support the idea of integrating digital literacy into university curricula. This finding suggests that digital skills should be taught as a separate subject and integrated across other disciplines to ensure that students develop the diverse digital abilities needed for academic and professional success.

The unexpected finding that the learning environment had no significant effect on digital literacy levels in this study deviates dramatically from previous research and our study's initial predictions. Based on the findings of the Pearson correlation test, there is a correlation between learning environment and digital literacy levels, although it is not very strong. Previous research, including that of Liu et al. (2020), has highlighted the importance of engaging and adaptive learning environments in enhancing digital literacy. This suggests that merely having access to digital technologies and mixed-learning settings is insufficient without effective implementation and active use. Our results indicate a need to reevaluate how digital tools are integrated and utilized within educational settings. Enhancing interactive elements and fostering active and collaborative learning could be crucial for transforming learning environments into effective platforms for developing digital literacy. This observation emphasizes the significance of educational institutions in addition to allocating resources to technology infrastructure and prioritizing pedagogical practices that maximize the utilization of these tools to enhance meaningful learning outcomes. Further extensive studies are required in the future to examine the influence of the learning environment on digital literacy levels.

This study confirms the importance of socioeconomic determinants and technological availability in digital literacy and emphasizes the transformative power of educational interventions. The findings suggest a strategic approach to digital literacy that includes broad access, curriculum integration, and learning environment optimization. This integrative approach could improve higher education digital literacy and better prepare students for the digital age. Researching effective educational practices and technical breakthroughs for digital literacy development could inform educational policy and practice.

## 6. Conclusion

This study comprehensively examines the factors influencing digital literacy among university students in Beijing, elucidating the roles of socioeconomic factors, access to technology, educational interventions, and the learning environment.

The analysis indicates that socioeconomic factors, though having a modest impact, significantly influence digital literacy. This underscores the importance of equitable access to digital resources across various socioeconomic groups, highlighting the need for initiatives that provide all students with the foundational tools required for digital learning.

**Table 5:** Pearson correlation analysis summary

| | Socio-Economic_1 | Socio-Economic_2 | Socio-Economic_3 | Access to Technology_1 | Access to Technology_2 | Access to Technology_3 | Educational Interventions_1 | Educational Interventions_2 | Educational Interventions_3 | Learning Environments_1 | Learning Environments_2 | Learning Environments_3 | Digital Literacy Levels_1 | Digital Literacy Levels_2 | Digital Literacy Levels_3 | Digital Literacy Levels_4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Socio-Economic_1 | 1(0.000***) | 0.428(0.000***) | 0.389(0.000***) | 0.326(0.000***) | 0.315(0.000***) | 0.372(0.000***) | 0.477(0.000***) | 0.469(0.000***) | 0.452(0.000***) | 0.513(0.000***) | 0.452(0.000***) | 0.456(0.000***) | 0.414(0.000***) | 0.392(0.000***) | 0.468(0.000***) | 0.395(0.000***) |
| Socio-Economic_2 | 0.428(0.000***) | 1(0.000***) | 0.769(0.000***) | -0.084(0.099*) | -0.067(0.186) | 0.15(0.003***) | 0.423(0.000***) | 0.375(0.000***) | 0.405(0.000***) | 0.494(0.000***) | 0.465(0.000***) | 0.444(0.000***) | 0.367(0.000***) | 0.315(0.000***) | 0.292(0.000***) | 0.361(0.000***) |
| Socio-Economic_3 | 0.389(0.000***) | 0.769(0.000***) | 1(0.000***) | -0.015(0.770) | 0.018(0.722) | 0.085(0.092*) | 0.361(0.000***) | 0.349(0.000***) | 0.414(0.000***) | 0.453(0.000***) | 0.514(0.000***) | 0.494(0.000***) | 0.346(0.000***) | 0.27(0.000***) | 0.271(0.000***) | 0.37(0.000***) |
| Access to Technology_1 | 0.326(0.000***) | -0.084(0.099*) | -0.015(0.770) | 1(0.000***) | 0.822(0.000***) | 0.725(0.000***) | 0.509(0.000***) | 0.552(0.000***) | 0.536(0.000***) | 0.473(0.000***) | 0.525(0.000***) | 0.52(0.000***) | 0.465(0.000***) | 0.523(0.000***) | 0.513(0.000***) | 0.466(0.000***) |
| Access to Technology_2 | 0.315(0.000***) | -0.067(0.186) | 0.018(0.722) | 0.822(0.000***) | 1(0.000***) | 0.766(0.000***) | 0.501(0.000***) | 0.511(0.000***) | 0.535(0.000***) | 0.497(0.000***) | 0.583(0.000***) | 0.584(0.000***) | 0.508(0.000***) | 0.52(0.000***) | 0.549(0.000***) | 0.464(0.000***) |
| Access to Technology_3 | 0.372(0.000***) | 0.15(0.003***) | 0.085(0.092*) | 0.725(0.000***) | 0.766(0.000***) | 1(0.000***) | 0.513(0.000***) | 0.554(0.000***) | 0.549(0.000***) | 0.551(0.000***) | 0.537(0.000***) | 0.54(0.000***) | 0.567(0.000***) | 0.616(0.000***) | 0.608(0.000***) | 0.485(0.000***) |
| Educational Interventions_1 | 0.477(0.000***) | 0.423(0.000***) | 0.361(0.000***) | 0.509(0.000***) | 0.501(0.000***) | 0.513(0.000***) | 1(0.000***) | 0.868(0.000***) | 0.883(0.000***) | 0.834(0.000***) | 0.774(0.000***) | 0.745(0.000***) | 0.779(0.000***) | 0.679(0.000***) | 0.681(0.000***) | 0.762(0.000***) |
| Educational Interventions_2 | 0.469(0.000***) | 0.375(0.000***) | 0.349(0.000***) | 0.552(0.000***) | 0.511(0.000***) | 0.554(0.000***) | 0.868(0.000***) | 1(0.000***) | 0.857(0.000***) | 0.816(0.000***) | 0.757(0.000***) | 0.743(0.000***) | 0.782(0.000***) | 0.687(0.000***) | 0.699(0.000***) | 0.761(0.000***) |
| Educational Interventions_3 | 0.452(0.000***) | 0.405(0.000***) | 0.414(0.000***) | 0.536(0.000***) | 0.535(0.000***) | 0.549(0.000***) | 0.883(0.000***) | 0.857(0.000***) | 1(0.000***) | 0.835(0.000***) | 0.793(0.000***) | 0.76(0.000***) | 0.786(0.000***) | 0.675(0.000***) | 0.663(0.000***) | 0.87(0.000***) |
| Learning Environments_1 | 0.513(0.000***) | 0.494(0.000***) | 0.453(0.000***) | 0.473(0.000***) | 0.497(0.000***) | 0.551(0.000***) | 0.834(0.000***) | 0.816(0.000***) | 0.835(0.000***) | 1(0.000***) | 0.828(0.000***) | 0.807(0.000***) | 0.766(0.000***) | 0.664(0.000***) | 0.66(0.000***) | 0.743(0.000***) |
| Learning Environments_2 | 0.452(0.000***) | 0.465(0.000***) | 0.514(0.000***) | 0.525(0.000***) | 0.583(0.000***) | 0.537(0.000***) | 0.774(0.000***) | 0.757(0.000***) | 0.793(0.000***) | 0.828(0.000***) | 1(0.000***) | 0.972(0.000***) | 0.697(0.000***) | 0.636(0.000***) | 0.616(0.000***) | 0.695(0.000***) |
| Learning Environments_3 | 0.456(0.000***) | 0.444(0.000***) | 0.494(0.000***) | 0.52(0.000***) | 0.584(0.000***) | 0.54(0.000***) | 0.745(0.000***) | 0.743(0.000***) | 0.76(0.000***) | 0.807(0.000***) | 0.972(0.000***) | 1(0.000***) | 0.689(0.000***) | 0.642(0.000***) | 0.63(0.000***) | 0.704(0.000***) |
| Digital Literacy Levels_1 | 0.414(0.000***) | 0.367(0.000***) | 0.346(0.000***) | 0.465(0.000***) | 0.508(0.000***) | 0.567(0.000***) | 0.779(0.000***) | 0.782(0.000***) | 0.786(0.000***) | 0.766(0.000***) | 0.697(0.000***) | 0.689(0.000***) | 1(0.000***) | 0.794(0.000***) | 0.801(0.000***) | 0.724(0.000***) |
| Digital Literacy Levels_2 | 0.392(0.000***) | 0.315(0.000***) | 0.27(0.000***) | 0.523(0.000***) | 0.52(0.000***) | 0.616(0.000***) | 0.679(0.000***) | 0.687(0.000***) | 0.675(0.000***) | 0.664(0.000***) | 0.636(0.000***) | 0.642(0.000***) | 0.794(0.000***) | 1(0.000***) | 0.847(0.000***) | 0.635(0.000***) |
| Digital Literacy Levels_3 | 0.468(0.000***) | 0.292(0.000***) | 0.271(0.000***) | 0.513(0.000***) | 0.549(0.000***) | 0.608(0.000***) | 0.681(0.000***) | 0.699(0.000***) | 0.663(0.000***) | 0.66(0.000***) | 0.616(0.000***) | 0.63(0.000***) | 0.801(0.000***) | 0.847(0.000***) | 1(0.000***) | 0.621(0.000***) |
| Digital Literacy Levels_4 | 0.395(0.000***) | 0.361(0.000***) | 0.37(0.000***) | 0.466(0.000***) | 0.464(0.000***) | 0.485(0.000***) | 0.762(0.000***) | 0.761(0.000***) | 0.87(0.000***) | 0.743(0.000***) | 0.695(0.000***) | 0.704(0.000***) | 0.724(0.000***) | 0.635(0.000***) | 0.621(0.000***) | 1(0.000***) |

Note: ***, ** represent 1% and 5% level of significance, respectively

**Table 6:** Model regression coefficients

| IV | → | DV | Non-standardized coefficients | Standardized coefficients | standard errors | Z | P |
|---|---|---|---|---|---|---|---|
| Socio-economic | → | Digital literacy levels | 0.216 | 0.096 | 0.108 | 2.001 | 0.045** |
| Access to technology | → | Digital literacy levels | 0.304 | 0.218 | 0.07 | 4.344 | 0.000*** |
| Educational interventions | → | Digital literacy levels | 0.773 | 0.78 | 0.061 | 12.7 | 0.000*** |
| Learning environment | → | Digital literacy levels | -0.087 | -0.078 | 0.073 | -1.201 | 0.230 |

*** and **: represent 1% and 5% significance levels, respectively

The study shows that access to technology is an important factor in digital literacy. The strong link found suggests that providing students with high-quality, immediate access to technology is necessary for building digital skills. Therefore, educational institutions should focus on creating a strong technological infrastructure and personal access to digital tools.

Additionally, educational programs were identified as the most impactful factor for improving digital literacy, showing the importance of well-designed educational programs. Including digital literacy within the curriculum greatly improves students' digital skills, suggesting that digital skills training should be integrated more systematically into education. In contrast to initial expectations, the study found that simply having digital resources or blended learning settings does not strongly affect digital literacy levels. This suggests that these resources need to be strategically applied to engage students and enhance learning.

The findings have three main implications. First, policymakers and educational leaders should ensure all students have access to technology, regardless of their economic background. Second, digital literacy should be included in all academic courses rather than taught separately. Third, educational policies should provide digital tools and monitor their use to create interactive, engaging learning environments.

Future research may focus on the quality of digital tools and learning environments to determine what makes digital literacy programs effective. Long-term studies could also explore how educational programs impact digital literacy over time to better understand its development and sustainability.

In summary, this study contributes to understanding the factors that shape digital literacy in higher education. Therefore, policies aimed at these areas can help students develop and maintain digital skills, supporting their ability to navigate the digital world.

## Compliance with ethical standards

## Ethical considerations

All participants provided informed consent, and their anonymity was ensured. The study adhered to ethical standards and institutional guidelines to protect participants' rights and confidentiality.

## Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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