THE GUIDELINES TO DEVELOP THE DIGITAL LITERACY OF PHARMACY STUDENTS IN SCHOOL OF PHARMACY, JIANGSU FOOD & PHARMACEUTICAL SCIENCE COLLEGE

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2025

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THE GUIDELINES TO DEVELOP THE DIGITAL LITERACY OF PHARMACY STUDENTS IN SCHOOL OF PHARMACY, JIANGSU FOOD & PHARMACEUTICAL SCIENCE COLLEGE

DONG SIYUN

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THE GUIDELINES TO DEVELOP THE DIGITAL LITERACY OF PHARMACY STUDENTS IN SCHOOL OF PHARMACY, JIANGSU FOOD & PHARMACEUTICAL SCIENCE COLLEGE

BY

DONG SIYUN

HAS BEEN APPROVED BY THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER OF EDUCATION IN DEVELOPMENT AND MANAGEMENT OF EDUCATION AT SRINAKHARINWIROT UNIVERSITY

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This study investigates the current state of digital literacy among pharmacy students at Jiangsu Food & Pharmaceutical Science College and develops an evidence-based enhancement guide aligned with China's digital transformation agenda and the pharmaceutical industry's evolving demands. Using a two-phase mixed-methods design, Phase I surveyed 306 students to assess five dimensions of digital literacy: information management, technical proficiency, digital security awareness, digital communication and collaboration, and content creation and knowledge building. Findings revealed a moderate overall level, with the highest performance in technical proficiency and digital communication, but persistent weaknesses in digital security awareness and information management. Significant positive correlations were found among all five dimensions, indicating that improvement in one area may foster growth in others. Qualitative responses highlighted insufficient digital training, limited access to digital resources, and low confidence in applying digital tools in pharmacy practice. In Phase II, expert focus groups synthesized these findings into a Digital Literacy Enhancement Guide that emphasizes curriculum integration, targeted cybersecurity training, collaborative learning, and institutional support. The study provides both theoretical and practical contributions, advancing the understanding of digital competence in vocational pharmacy education and offering actionable pathways to strengthen students' employability and readiness for the data-driven healthcare environment.

Keyword : Digital Literacy, Pharmacy Education, Vocational College, Mixed Methods, Enhancement Guide, China

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With sincere thanks

DONG SIYUN

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1.National Policies and Digital Literacy in Vocational Education

In the current digital era, China strongly emphasizes enhancing digital literacy, particularly within vocational education. The “14th Five-Year Plan for the Development of the Digital Economy” clearly states that improving the digital skills of society is fundamental for driving economic growth and technological innovation (State Council, 2022). This national directive highlights the necessity of equipping vocational students, who represent the future technical workforce, with advanced digital competencies. Moreover, the Ministry of Education issued guidelines to accelerate the integration of digital technology in vocational teaching, aiming to strengthen students' digital capabilities comprehensively(Ministry of Education of the People's Republic of China, 2017). In the 2024 World Conference on Digital Education in Shanghai, it was further stressed that both educators and students must collaboratively tackle the challenges brought by digital transformation in vocational education.

2.Challenges in Digital Literacy Among Pharmacy Students

Despite clear policy support, pharmacy students in higher vocational colleges in China still face considerable gaps in digital literacy. Current research indicates that vocational students exhibit relatively low levels of digital competence, particularly in higher-order digital skills such as data analysis, digital content creation, and innovative application of digital tools(Yahui & Manly, 2023). Pharmacy students at Jiangsu Food & Pharmaceutical Science College exemplify this issue. While proficient in traditional pharmaceutical knowledge and laboratory skills, these students often encounter significant difficulties in applying digital technologies to modern pharmacy practices, such as digital drug management, healthcare informatics, and telepharmacy services. Existing vocational pharmacy curricula lack systematic integration of digital skills training, digital teaching resources are insufficiently developed, and students' independent digital learning abilities are generally weak, exacerbating the problem.

Recent studies also highlight specific issues within Chinese pharmacy education. For example, a survey conducted by Liu (2023) on digital competence among pharmacy students indicated that fewer than 40% of surveyed students felt confident using pharmaceutical databases, digital prescription systems, and remote healthcare platforms. This deficiency impacts not only their academic performance but significantly limits their professional competitiveness upon graduation.

3. Industry Trends and the Urgency for Digital Literacy in Pharmacy Education

The pharmaceutical industry is undergoing rapid digital transformation driven by technological innovation and regulatory demands. China's "14th Five-Year Plan for National Drug Safety and Promotion of High-Quality Development" explicitly outlines the importance of developing intelligent regulatory systems and digital capacities within pharmaceutical practices(National Medical Products Administration, 2021). The practical implications of these changes mean pharmacy graduates are increasingly required to handle complex digital tasks, including medication information management, digital patient services, and telemedicine practices. Consequently, insufficient digital literacy among pharmacy students will significantly restrict their employability and hinder their career development.

4. Practical Implications and Application of Research Outcomes

Addressing the identified digital literacy gaps among pharmacy students is essential not only to align education with national policy objectives but also to meet the evolving industry demands. Thus, this study aims to empirically investigate pharmacy students' current digital literacy levels, identify critical competency gaps, and subsequently propose tailored guidelines to enhance digital literacy. These guidelines will be directly applicable to curriculum design and teaching practice reform, contributing substantially to improving pharmacy students' digital skills, enhancing their employability, and ensuring their readiness to thrive in the modern digital healthcare environment. Furthermore, the research outcomes can serve as valuable references for similar reforms in other vocational colleges, supporting a broader vocational educational digital transformation initiative in China.

Purposes of the Study

The purposes of this research were as follows:

1. To study the current state of digital literacy of pharmacy student in School of Pharmacy Jiangsu Food & Pharmaceutical Science College

2.To develop the guidelines of digital literacy of pharmacy student in School of Pharmacy Jiangsu Food & Pharmaceutical Science College

Research Questions

1.Current State of Digital Literacy

What is the current level of digital literacy among pharmacy students at the School of Pharmacy, Jiangsu Food & Pharmaceutical Science College?

What specific digital competencies are pharmacy students proficient in, and which areas require further improvement?

How do students perceive the importance of digital literacy in their academic and future professional development?

What are the primary challenges pharmacy students face in acquiring and applying digital literacy skills?

2.Guidelines for Improvement

What strategies can be implemented to address the gaps in digital literacy among pharmacy students?

How can the guidelines for improving digital literacy be aligned with national policies and industry demands?

How can digital literacy training improve the employability and career readiness of pharmacy graduates?

Significance of the Study

This study holds significance at both theoretical and practical levels. Theoretically, it addresses the research gap in digital literacy among pharmacy students in higher vocational colleges, examining the interaction between digital skills and professional education, and offering a new perspective and theoretical framework for the digital transformation of vocational education. Practically, this study assesses the current level of digital competence among pharmacy students, proposes targeted improvement strategies, and supports curriculum optimization and reform of teaching methodologies. By enhancing students' digital literacy and employability, the study promotes the practical application of digitalization in pharmacy education and serves as a valuable reference for other higher vocational colleges and universities.

Definition of Terms

The following terms are defined because they are specifically used in this study:

1.Pharmacy Students in the School of Pharmacy: Pharmacy students in the College of Pharmacy receive foundational theory, practical skills, and specialized training in pharmacy at the advanced vocational education level. The pharmacy program encompasses a range of fields, including drug research and development, production, quality control, dispensing, and clinical pharmacy. At Jiangsu Food & Pharmaceutical Science College, the program aims to cultivate highly qualified personnel with strong practical and technical skills, capable of working in drug dispensing, production, and management within medical institutions, pharmaceutical manufacturing, drug distribution, and other industries. This type of education emphasizes the close integration of practical skills with industry needs to ensure students are prepared for immediate employment upon graduation.

2. Digital Literacy:

Digital literacy is a crucial skill set in the 21st century, encompassing various dimensions that are essential for navigating the digital landscape. In recent years academics have put forward a variety of explanations for the dimensions of digital literacy, and these theories provide an important reference for us to deeply understand the connotation of digital literacy.

After reviewing a great deal of information, the author has determined that digital literacy is the following:

2.1. Information Management Literacy

Information management literacy, which involves searching, analyzing, evaluating, and effectively utilizing information, is central to many digital literacy frameworks. Spires et al. (2017) highlight information management as a fundamental dimension, essential for processing information critically in the digital landscape(Spires et al., 2018). This dimension is further emphasized by Martzoukou et al. (2020), who describe it as necessary for both academic and personal digital practices, supporting students in discerning credible information sources and responsible information use(Martzoukou et al., 2020). Additionally, Aviram and Eshet-Alkalai (2006) argue that information literacy underpins digital literacy by equipping individuals to navigate and assess information critically(Eshet, 2012), which is increasingly vital in combating misinformation online. Shaowei Sun reinforces this by identifying information management as a core skill for students in both educational and daily digital environments(Shaowei, 2023).

Pharmacy students with strong information management skills can effectively search, analyze, and apply digital resources, such as medical databases, journals, and pharmaceutical research. This skill is crucial for understanding drug interactions, patient histories, and the latest clinical studies, which supports accurate patient care and informed decision-making in their future careers.

2.2.Technical Proficiency

Technical proficiency, encompassing the skills needed to use digital tools and technology effectively, is a core component of digital literacy. Cetindamar Kozanoglu et al. (2021) emphasize the importance of technical proficiency for individuals adapting to digital transformations(Cetindamar Kozanoglu & Abedin, 2021), highlighting its role in enabling smooth and versatile technology use. The DigComp framework (Vuorikari et al., 2022) supports this by outlining competencies in operating digital devices and using software applications, marking it as essential for developing broader digital literacy skills. Martzoukou et al. (2020) further underlines that technical proficiency is vital for both content creation and digital interaction, especially in academic and professional settings where proficiency across various platforms is increasingly required(Martzoukou et al., 2020).

This skill for pharmacy students applies primarily to Mastery of digital tools and software, including medical record systems, data analytics software, and research databases, enabling pharmacy students to engage in tasks such as managing prescriptions, analysing data trends, and creating patient records. enables pharmacy students to engage in tasks such as managing prescriptions, analysing data trends, and creating patient records. proficiency not only streamlines workflows but also minimises errors in handling sensitive information.

2.3.Digital Security Awareness

Digital security awareness, which includes competencies in privacy, data protection, and cybersecurity, is a crucial dimension of digital literacy emphasized in contemporary frameworks. Detsom and Vehachart (2021) underscore this in their digital citizenship framework, where digital security is viewed as essential for fostering responsible online behavior(Detsom & Vehachart, 2021). Ling (2020) also identifies security awareness as a key competency for Chinese college students, underscoring the importance of privacy management in today's digital society(Zhengqiang, 2020). The DigComp framework further aligns with this view, listing skills for responsible data management and risk prevention as essential to a well-rounded digital literacy profile(Vuorikari et al., 2022).

Understanding digital security protocols is essential for protecting patient privacy and sensitive health data. Pharmacy students must learn secure data handling practices and digital ethics to meet legal standards data protection regulations, ensuring they safeguard both institutional and patient information in their professional work.

2.4.Digital Communication and Collaboration

The digital communication and collaboration dimension highlights skills necessary for effective communication and teamwork in digital environments. Spires et al. (2017) identify these skills as vital for student engagement in collaborative digital spaces, where students interact and learn collectively(Spires et al., 2018). Martzoukou et al. (2020) add that collaboration skills enable students to navigate diverse digital platforms effectively, an indispensable skill in both academic and workplace settings(Martzoukou et al., 2020). Kozanoglu and Abedin (2020) reinforce the significance of digital communication, framing it as essential for social practice and expression within digital spaces, especially as remote and hybrid learning formats become more common(Cetindamar Kozanoglu & Abedin, 2021). The DigComp framework also specifies communication skills as a central component for navigating modern digital environments (Vuorikari et al., 2022).

Proficiency in digital communication tools like telemedicine platforms, collaboration software, and virtual patient monitoring is critical for modern pharmacy practice. This skill supports efficient interactions with healthcare teams and allows for coordinated care plans, enabling remote consultations and faster responses to patient needs.

2.5.Content Creation and Knowledge Building

Content creation and knowledge building encompass the skills to produce, manage, and synthesize new digital content, which is crucial for active participation in digital spaces. Phakham discuss content creation as an empowering skill, enabling students to contribute constructively in the digital realm, particularly within the Education 4.0 context(Phakham et al., 2021). Martzoukou et al. (2020) echo this, describing content creation as critical in academic environments, where students are not only consumers but also creators of digital content(Martzoukou et al., 2020). The DigComp framework further supports this dimension, listing creative skills as foundational for digital engagement, particularly in knowledge generation and content sharing(Vuorikari et al., 2022).

This skill encompasses the creation and presentation of educational materials, such as patient instructions, informational videos, or pharmaceutical research summaries. Pharmacy students can use digital tools to creatively share knowledge with patients and peers, reinforcing their role as educators and advocates in public health and patient care.

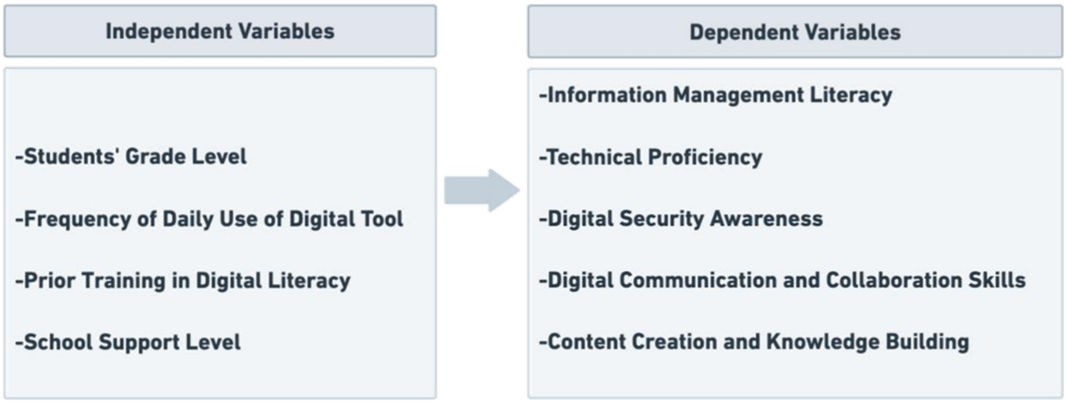

FIGURE 1 Relationship between Independent and Dependent Variables in the Study

Scope of the Study

The scope of this study was strictly limited to pharmacy students in the College of Pharmacy of Jiangsu Food & Pharmaceutical Science College. The School of Pharmacy has two majors, pharmacy and traditional Chinese medicine, but this study only focuses on the data collection and analysis of pharmacy students. The study population covered a total of 30 classes in three grades of pharmacy majors, with a total number of about 1500 students. These students receive systematic training in basic pharmacy knowledge and practical skills, and the curriculum covers a variety of areas such as drug research and development, production, management, quality control and clinical pharmacy. First-year students focus on basic courses; second-year students are introduced to the core pharmacy curriculum; and third-year students have completed most of the core curriculum and are enrolled in corporate internships. Students' digital literacy plays an important role in their academic and practical work, and the data from the participants will provide comprehensive support for the study and a key basis for the development of digital literacy enhancement strategies. This study did not involve students in the pharmacy program, nor did it include students in other grades or majors outside of the College of Pharmacy. This setting was to ensure that the data analysis was focused and relevant, while facilitating the development of effective recommendations for educational improvement within the pharmacy program.

CHAPTER II

LITERATURE REVIEW

Introduction

Digital literacy is gradually becoming an important part of the global education system as one of the 21st century skills. With the rapid spread of digital technology in various fields, digital literacy not only affects the way individuals live and work, but also has a profound impact on the way education is delivered. Governments, educational institutions and academia agree that cultivating students' digital literacy skills is an integral part of modern education. Especially in higher education, digital literacy is of great significance for improving students' academic performance, career competitiveness and social adaptability.

In this context, the pharmaceutical profession, as a highly applied discipline, faces an increasingly digital pharmaceutical industry, and the demand for digital literacy is even more prominent. Pharmaceutical students need to master core skills such as information retrieval, data processing, and digital tool operation in their daily studies and future careers. Therefore, improving the digital literacy of pharmaceutical students not only improves their academic performance, but also lays a solid foundation for their future career development. However, there are still deficiencies in the research on strategies to improve digital literacy in pharmacy education. It is urgent to conduct in-depth discussions on the current situation of digital literacy, core competencies, and related educational strategies for pharmacy students.

This chapter will start with the definition and development of digital literacy, and then analyze in depth the core dimensions and importance of digital literacy in education. It will also discuss the current situation of digital literacy among college students, especially pharmacy students, and the strategies to improve it.

The review mainly includes the following aspects:

Digital Literacy

1. Definition and conceptual development of digital literacy

2. Dimensions of digital literacy

3. Importance of digital literacy in education

4. Measurement framework of digital literacy

Digital literacy of college students

1. The current situation and challenges of digital literacy among college students in the international community

2. The Current State and Challenges of Digital Literacy among Chinese University Students

3. Variables affecting digital literacy of college students

4. Impact of digital literacy on academic performance and future employment of college students

Core competencies of pharmacy students

1. Pharmacy students

2. Core competencies of pharmacy students

Guide to improving digital literacy

1. Effective strategies and practical cases for improving digital literacy

2. Future trends in improving digital literacy

Summary of domestic and foreign research

Digital Literacy

The concept of digital literacy has been a topic of interest in educational settings, with various projects and studies aiming to define and develop frameworks for digital literacy development.

1.Definition and conceptual development of digital literacy

The concept of digital literacy was formalized in 1997 and defined by Gilster (1997) in his book Digital Literacy as the combined ability to access, understand, and utilize digital information to solve problems in digital environments through the use of technical, cognitive, and social skills(Gilster, 1997).

Martin and Grudziecki proposed a foundational framework for digital literacy, defining it as the ability to identify, manage, analyze, evaluate, and integrate information through digital tools in specific life contexts. This framework goes beyond basic technical skills, encompassing critical thinking and problem-solving abilities. Martin's approach set the stage for subsequent digital literacy models that include a broader range of competencies(Martin & Grudziecki, 2006).

According to the ALA's Digital Literacy Task Force, digital literacy is defined as "the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills"(Association, 2013).

Eshet (2012) expanded on the definition of digital literacy by developing a multi-dimensional model that addresses the complexities of skills needed in the digital era. This model suggests that digital literacy involves not only technical skills but also critical analysis, information integration, and social interaction skills. By emphasizing these multiple dimensions, Eshet-Alkalai's model provides a comprehensive framework for understanding digital literacy in a broader context(Eshet, 2012).

UNESCO (2018) developed the Global Framework for Digital Literacy, a guideline aimed at providing standardized digital literacy competencies across various national and cultural contexts. This framework defines digital literacy as a set of core skills, including identifying, understanding, evaluating, and applying information. Its adaptability across cultures and global contexts has made UNESCO's framework widely adopted as a standard for digital literacy(Law et al., 2018).

Spante et al. (2018) conduct a systematic review on digital literacy, defining it as the ability to navigate digital information critically and reflectively. Digital literacy encompasses finding, evaluating, synthesizing information, and engaging in digital practices with cognitive and social skills for effective communication(Spante et al., 2018).

China's Outline for Action to Enhance Digital Literacy and Skills of All People, issued in 2021, defines digital literacy as the collection of a series of qualities and abilities, such as digital access, production, use, evaluation, interaction, sharing, innovation, safety, security, ethics and morality, that citizens possess in a digital society(Cyberspace Administration of China, 2021).

Nurbaya (2023) defined digital literacy as a competency encompassing the responsible use, access, understanding, management, and sharing of digital information. This competency includes technical skills alongside critical thinking, ethical awareness, and problem-solving abilities, all essential for effective participation in digital environments(Nurbaya, 2023).

The evolution of digital literacy definitions highlights its expanding complexity and relevance. In essence, digital literacy now encompasses not only technical abilities to access and navigate digital information but also cognitive, critical, and social skills essential for evaluating, creating, and responsibly engaging in digital spaces. It requires individuals to be adaptable, capable of problem-solving, and culturally aware, supporting effective communication and responsible digital participation across varied contexts and global standards.

2.Dimensions of Digital Literacy

Digital literacy is a crucial skill set in the 21st century, encompassing various dimensions that are essential for navigating the digital landscape.In recent years academics have put forward a variety of explanations for the dimensions of digital literacy, and these theories provide an important reference for us to deeply understand the connotation of digital literacy.

Spires et al. (2018) defined several key constituent dimensions of digital literacy to support effective engagement of 21st century learners. The first explains that information literacy includes the ability to search for, evaluate, and effectively utilize information, which is considered a foundational dimension of digital literacy. Secondly, digital content creation involves the production and editing of multimedia content and requires students to have the ability to use digital tools creatively. The digital communication and collaboration dimension, on the other hand, emphasizes students' ability to interact efficiently in virtual environments, enabling them to collaborate and communicate in teams. Finally, the Critical Thinking and Problem Solving dimension focuses on the ability to analyze and evaluate digital information, while Digital Identity and Security Management emphasizes privacy protection and responsible digital citizenship behavior (Spires et al., 2018).

Kozanoglu and Abedin (2020) view digital literacy as an organizational empowerment tool to drive employee effectiveness during digital transformation. Their model contains two core dimensions: information/cognition and social practice/expression. The information/cognition dimension focuses on employees' ability to access and understand information, reflecting their ability to process, analyze, and judge information, while the social practice/expression dimension focuses on employees' ability to communicate and collaborate in the digital environment(Cetindamar Kozanoglu & Abedin, 2021).

Zhengqiang's study focuses on the current state of digital literacy among Chinese college students and proposes an educational path applicable to this group, encompassing multiple dimensions such as framework construction, educational content, environment creation, and resource support. Zhengqiang summarizes the five core elements of digital literacy for college students by combing the concepts of digital literacy at home and abroad: information acquisition, information processing, information expression, collaborative ability, and awareness of digital security(Zhengqiang, 2020).

Focusing on students' self-perceived digital literacy in the context of higher education, Martzoukou et al.'s (2020) study covers applications in both daily life and academic environments, and proposes multiple dimensions such as information literacy, digital content creation, and digital identity management. First, information literacy focuses on students' ability to access, evaluate, and use information and is the foundational dimension of digital literacy. Second, digital content creation involves students' ability to use digital tools for content production and editing, and this dimension pays particular attention to students' creative abilities and proficiency in the use of digital tools. Third, digital identity management explores students' awareness of self-management and privacy protection in digital environments.These dimensions proposed by Martzoukou et al. (2020) provide a framework for higher education that argues that digital literacy is not only limited to information processing, but should also include awareness and management of one's own digital identity in order to foster students with high levels of digital engagement (Martzoukou et al., 2020).

Detsom and Vehachart proposed a structured framework for digital citizenship, focusing on three primary dimensions essential for fostering comprehensive digital literacy skills among students in the 21st century. The first dimension, digital etiquette, involves the development of appropriate and respectful online behavior, teaching students the norms and protocols of digital interactions. The second dimension, responsibility, emphasizes the ethical use of digital resources, encouraging learners to consider the implications of their digital actions and maintain integrity in their online presence. Lastly, innovation focuses on students' ability to leverage digital tools creatively, encouraging them to become proactive contributors rather than passive consumers in the digital landscape. This framework highlights how digital literacy extends beyond technical capabilities, encompassing behavioral and ethical components essential for well-rounded digital citizenship(Detsom et al., 2023).

Phakham et al. (2021) in their study on enhancing digital literacy among undergraduate students at the Faculty of Education, Chiang Mai University, Thailand, in the era of Education 4.0, proposed that the constituent dimensions of digital literacy include five dimensions: information skills, communication and collaboration, content creation, security awareness, and problem solving(Phakham et al., 2021).

By analyzing the level of digital literacy among college students, Shaowei (2023) proposed that digital literacy contains four dimensions: information processing, digital communication, technology application, and digital security, emphasizing the ability to apply them comprehensively in daily life and learning. Through his study, Shaowei found that digital literacy dimensions are not only related to academic use, but also cover digital behaviors in life and social scenarios, reflecting the importance of multiple applications of digital literacy in daily life(Shaowei, 2023).

Guoxing et al., (2024) classified digital literacy into five dimensions: knowledge, skills, traits, attitudes and ethics by constructing a gyroscopic model of digital literacy(Guoxing et al., 2024).In analyzing the current status of digital literacy among college students in Fujian Province, China, Lihong and Dongqing (2024) suggests that the digital literacy framework not only includes information processing skills, but also covers multiple dimensions, such as critical thinking, creativity, and digital resource utilization. She pointed out that the digital literacy of college students should match the needs of society, which requires students to apply these skills in multiple technological contexts and enhance their digital adaptability(Lihong & Dongqing, 2024).

Recent research defines digital literacy as a multifaceted competency framework, developed in response to the complexity of digital society and the heightened demands on individuals' cognition, skills, and social responsibility. Studies on digital literacy emphasize its core elements, extending beyond basic technical proficiency to encompass critical information management, creative content construction, privacy protection, security awareness, and digital ethics. The multi-dimensional structure of digital literacy aims to equip individuals to adapt holistically to technology-driven environments, allowing them to make informed decisions, communicate effectively, and exercise self-regulation and social adaptability within the merging realms of virtual and physical spaces(Martzoukou et al., 2020).

This framework not only emphasizes technical skills but also underscores cultivating digital citizenship, responsibility, and a global perspective. In an era marked by information overload and misinformation, digital literacy equips individuals with the critical judgment and creativity needed to engage, contribute, and express themselves responsibly, as well as to protect their own and others' rights in a fast-evolving digital landscape(Detsom & Vehachart, 2021). This multi-layered approach reflects contemporary educational and societal demands, from operational to ethical competencies, which are essential for navigating an increasingly interconnected global technology ecosystem.

Based on a comprehensive review of the literature, the following five dimensions of digital literacy have been synthesized as a multifaceted framework that aligns with both the operational and ethical demands of a digital society. Each dimension represents a critical area of competency that supports holistic digital literacy in complex technological environments.

2.1.Information Management Literacy : This dimension includes the ability to search, analyze, evaluate, and responsibly utilize information. Its role is foundational, equipping individuals to manage and interpret information critically, which is crucial in an era of information overload.

2.2.Technical Proficiency : Essential for operating digital tools and software, technical proficiency is considered a primary skill that enables individuals to adapt effectively to new technologies and digital interfaces across various contexts.

2.3.Digital Security Awareness : This includes skills for maintaining privacy, safeguarding personal data, and understanding cybersecurity practices, supporting both individual protection and the integrity of shared digital spaces.

2.4.Digital Communication and Collaboration : Focusing on effective communication and teamwork in digital environments, this dimension emphasizes social adaptability and collaborative skills, which are increasingly relevant in interconnected educational and professional settings.

2.5.Content Creation and Knowledge Building : This dimension covers the skills to produce, synthesize, and share digital content, fostering creativity and knowledge construction. It empowers individuals to participate meaningfully within the digital landscape, not merely as consumers but as contributors.

3 The importance of digital literacy in education

In today's world, people need to be digitally literate if they want to participate in educational opportunities, get a job and do work. In the United States, the National Skills Coalition reports that 92 per cent of jobs in the United States require digital skills.

Digital literacy has gained critical importance in the educational landscape, with scholars highlighting its role in preparing students and educators for active participation in a rapidly evolving digital society. Kellow (2018) underscores the role of digital literacy in the New Zealand curriculum, where integration with national learning objectives emphasizes authentic, context-driven skills in computational thinking, digital design, and responsible digital citizenship(Kellow, 2018). In higher education, Wardhani et al. (2019) echo the importance of digital literacy for university students by focusing on their ability to critically access, evaluate, and use digital resources in both academic and personal contexts. Their findings suggest that despite the widespread availability of internet resources, students often struggle with discerning credible information(Wardhani et al., 2019). More research calls for digital literacy training within higher education curricula to help students responsibly navigate digital spaces, an approach mirrored in Digital Literacy in the South Pacific, which explores digital literacy as a tool for economic and social development. Here, the emphasis is on equipping students with essential skills for future employment, addressing infrastructure gaps, and promoting accessible ICT training in under-resourced regions(Reddy et al., 2022).

The COVID-19 pandemic further amplified the urgency of digital literacy as a core educational competency, particularly in enabling effective virtual learning. Ningsih et al. (2021) highlight how digital literacy skills became essential not only for students but also for educators and parents as they adapted to online learning environments(Ningsih et al., 2021). Similarly, Bak et al. (2022) explore the importance of digital health literacy, focusing on students' ability to evaluate health-related information critically and avoid misinformation—a skill that has become increasingly vital during the pandemic's information surge(Bak et al., 2022).

Digital literacy's role extends beyond educational outcomes to broader societal goals, as emphasized by Santos and Serpa (2020). Santos and Serpa (2020) argue that digital literacy promotes sustainability, enabling individuals to make informed, responsible digital decisions within the frameworks of Society 5.0 and Industry 4.0, aligning with sustainable development goals(Santos & Serpa, 2020). In an era of information overload and misinformation, digital literacy and digital citizenship together equip learners with the critical judgment, ethical awareness, and creativity needed to engage, contribute, and express themselves responsibly, as well as to protect both their own and others' rights in fast-evolving online environments(Ribble, 2021).

Finally, the work of Eden et al. (2024) and Donpila (2023) brings digital literacy into the context of social equity and teacher development. Eden et al.(2024) emphasize that equitable access to digital resources is fundamental to fostering an inclusive educational system that serves diverse student populations. Meanwhile, Donpila (2023) focuses on the need for teacher-specific digital literacy development in Mukdahan, Thailand, underscoring the importance of improving educators' digital skills to foster a secure and supportive digital learning environment. Both studies advocate for collaborative efforts among educators, policymakers, and communities to ensure digital literacy initiatives are culturally relevant and accessible across various demographics(Donpila, 2023; Eden et al., 2024).

This body of research illustrates digital literacy's transformative impact across educational and societal domains, highlighting its multifaceted benefits for students, teachers, and the broader community in achieving an inclusive, equitable, and sustainable digital society.

4.Digital literacy assessment framework

Digital literacy frameworks provide governments and educational institutions with a systematic structure and shared language to assess current digital skill levels, identify skill gaps, and track progress in developing digital competencies. These frameworks are used not only to guide digital literacy curricula in schools, but also in community education and vocational training programs to ensure that people of all ages and career stages can effectively navigate the demands of a digital society.

ISTE Standards (2024) - United States

The ISTE Standards offer a comprehensive digital literacy framework for students, educators, and leaders in the United States, emphasizing learner empowerment through goal-setting, network building, digital identity management, and collaboration. The framework promotes a learning-centered approach that values digital citizenship, creativity, effective communication, and computational thinking over specific tools, positioning digital literacy as foundational for innovative educational practices(Crompton, 2017).

China's Digital Literacy Framework for College Students (2024)

Aligned with China's "Digital China" initiative, this framework categorizes digital literacy into three essential domains: operational skills, applied competencies, and digital awareness. It is designed to enable college students to develop practical skills in using digital technologies, enhance problem-solving abilities, and foster a responsible digital awareness, thereby supporting lifelong digital learning and responsible digital engagement (Ministry of Education of the People's Republic of China, 2024).

Philippines' Digital Literacy Framework (2021)

Integrated into the K-12 curriculum, this framework focuses on core ICT skills to cultivate effective digital citizenship. It emphasizes competencies in ICT concepts, digital operations, content creation, and ethics, aiming to foster responsible digital citizens who can leverage ICT skills for personal and professional growth. The framework supports values integration across various academic and vocational contexts, building a foundation for ethical digital engagement(Philippines Department of Education, 2021).

DigComp 2.2 (2022) - European Union

The DigComp 2.2 framework by the European Union highlights five core areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. With over 250 examples for educational applications, it addresses current challenges like misinformation, artificial intelligence, and sustainability. DigComp 2.2 seeks to empower EU citizens to engage with digital tools critically, safely, and responsibly, making it an essential model for digital literacy education and policy (Vuorikari et al., 2022).

Ireland's Digital Learning Framework for Post-Primary Schools

Adapted from the UNESCO ICT Competency Framework and DigCompEdu, Ireland's framework aims to integrate digital technologies into teaching, learning, and school leadership within secondary education. It promotes constructivist approaches that foster student-centered learning, with "Statements of Practice" to support continuous self-evaluation and professional development. The framework emphasizes improving teaching quality, leadership, and digital technology management to optimize educational practices(Ireland Department of Education, 2023).

Spanish Digital Competence Framework (CDD 2.0)

Spain's Competencia Digital Docente (CDD 2.0) builds on the DigComp 2.0 framework, with competence descriptors at three levels (basic, intermediate, and advanced) further subdivided into six sublevels (A1-C2) across five main competence areas. This structure provides a nuanced assessment approach, supporting varied levels of digital competence and allowing for growth within each skill area, tailored to both educational and professional settings(Spanish Ministry of Education, 2022).

Citizen Digital Literacy Evaluation Framework in China

This evaluation framework, focused on Chinese citizens' digital literacy, divides digital skills into three main dimensions: digital cognition, digital skills, and digital ethics. It assesses competencies such as digital security, social interaction, and digital identity, aligning with China’s strategic initiatives in digital literacy and addressing the growing complexity of digital interactions(Ministry of Education of the People's Republic of China, 2022).

Australian ICT Capability Framework

Australia’s ICT Capability Framework defines digital literacy skills across six levels, progressing from early education through secondary school. It emphasizes social and ethical protocols, digital information security, and intellectual property awareness. The framework also supports understanding ICT’s societal impacts, encouraging responsible online communication and collaboration. Its progressive structure allows students to build well-rounded digital competencies suitable for both academic and personal use(Australian Curriculum, 2020).

UK Essential Digital Skills Framework

This framework offers a foundational skill set for adults, covering digital foundation skills, communication, information handling, transaction processing, problem-solving, and online safety. It is designed to support personal and professional growth, ensuring individuals can securely communicate online, conduct digital transactions, and assess the reliability of information, thus supporting lifelong digital learning across the UK(Department for Education (UK), 2019).

Hong Kong ICT Curriculum Framework

Hong Kong’s framework focuses on ICT literacy through problem-solving, ethical ICT usage, and knowledge sharing. It prioritizes critical thinking, creativity, and social responsibility, preparing students for lifelong learning and adaptability in technology-rich environments. Integrated with other subjects, it fosters comprehensive digital skills to support students' future academic and career endeavors(Hong Kong Education Bureau, 2021).

The implementation of these frameworks has far-reaching implications, not only enhancing the technical capabilities of individuals, but also the digital literacy of society as a whole. It helps to achieve comprehensive digital citizenship education, support the development of digital inclusion, and promote the standardization of education on a global scale.

Digital literacy of university students

In recent years, as digital transformation has penetrated into the field of education, the importance of digital literacy among college students has become increasingly apparent. Existing research has mainly conducted comprehensive analysis and discussion on the digital literacy of college students from the following aspects: the current situation of college students' digital literacy, the gap between self-perception and actual skills, the impact of the digital divide, and the lack of higher-order skills.

1.The current situation and challenges of digital literacy among college students in the international community

Gross and Latham (2012) demonstrate a clear mismatch between first-year students' self-perceptions and their actual information-literacy performance. Many low-skill students overestimate their ability to locate, evaluate, and use information—an asymmetry consistent with the Dunning–Kruger effect—which is associated with weaker academic outcomes and engagement. The authors argue for early, realistic diagnostics and targeted instruction in the first year of university to calibrate self-views and build core digital-information skills(Gross & Latham, 2012). Similarly, Martzoukou et al. (2022) report variability in law students' self-assessed digital competencies. Their research identifies gaps in technical skills and ethical digital practices, particularly in areas like digital identity management and ethical information sharing, revealing a misalignment between students' perceptions and actual digital proficiencies necessary for legal studies and digital citizenship(Martzoukou et al., 2020).

In the UK, Jones et al. (2010) challenge the assumption that university students, often referred to as the “Net Generation,” possess uniform advanced digital skills. Their study finds that although students may excel in basic digital communication tools, many lack the technical expertise needed for complex digital content creation and critical evaluation. This underscores the misconception that younger generations are automatically proficient in all digital competencies, highlighting a need for targeted educational interventions(Jones et al., 2010).

In Florida, Ritzhaupt et al. (2013) emphasize the impact of socioeconomic factors on students' digital literacy levels. Their research illustrates that students from lower socioeconomic backgrounds often exhibit lower proficiency in technical and ethical digital skills, including responsible digital communication and information management. This digital divide, influenced by socioeconomic status, gender, and ethnicity, suggests that institutional support is crucial for equitable access to digital skill development opportunities (Ritzhaupt et al., 2013).

Olatoye et al. (2021) conducted a study in South Africa that highlights undergraduates’ low ICT literacy levels, especially in information searching and evaluation. The limited practical experience and restricted access to e-resources led to underutilization of academic tools, indicating that while basic digital skills are often present, more advanced competencies like data analysis and ethical information usage are underdeveloped(Olatoye et al., 2021). Similarly, in a comparative study in Serbia, Bartol et al. (2018) evaluated agricultural science students' information literacy skills. Though proficient in identifying information needs, students struggled with ethical and legal issues associated with information use. This highlights a partial literacy focused on information retrieval rather than comprehensive digital responsibility, which could impact both academic and professional contexts (Bartol et al., 2018).

Blayone et al.(2018)explore digital literacy and readiness for online learning in Ukraine and Georgia. Their studies categorize digital competencies into technical, social, informational, and computational dimensions, finding that students generally exhibit moderate-to-low levels of digital readiness. Particularly, there are gaps in "epistemological competency," or the ability to engage in critical thinking and problem-solving within digital contexts, emphasizing the need for robust, structured digital training to support effective online learning (Blayone et al., 2018).

Guillen-Gamez et al.(2020) examined pre-service education students' digital competence and found that, while attitudes toward technology were generally positive, practical competence and actual use lagged behind. They also reported significant variation by instructional mode (face-to-face vs. blended) and by gender, indicating that students' self-beliefs do not uniformly translate into applied digital skills (Guillen-Gamez et al., 2020). In a similar vein, Bartol et al. (2018) showed that Serbian agricultural science students struggled to apply digital knowledge at higher cognitive levels—such as synthesizing information and solving problems—suggesting that current training often underemphasizes authentic, practice-oriented digital tasks(Bartol et al., 2018).

2.The Current State and Challenges of Digital Literacy among Chinese University Students

He and Zhu (2017) conducted a study on digital informal learning behaviors among Chinese university students and identified significant deficiencies in cognitive and ethical digital competencies. The researchers found that students often lack high-order cognitive skills needed for critical information evaluation and ethically responsible online decision-making. The study highlights that while students engage in digital learning informally, the absence of structured support in these areas limits their ability to navigate the ethical and evaluative complexities of digital environments. Moreover, He and Zhu emphasize the influence of personal attitudes and innovativeness on students' digital learning behaviors, indicating that individual factors further shape digital literacy levels(He & Zhu, 2017).

Recent evidence from China indicates a mismatch between university students' self-reported digital literacy and their performance on higher-order tasks such as content creation and problem-solving; students tend to feel confident with routine operations but struggle with more complex applications (Shaowei, 2023).

Lihong and Dongqing (2024) examined digital literacy levels among university students in Fujian Province, finding notable disparities across various digital literacy dimensions. The study categorizes digital skills into components such as problem-solving and digital safety, revealing that while students exhibit competence in foundational digital skills, their abilities in complex areas like problem-solving are less developed. The study also highlights that students who had undergone specific digital literacy training scored higher in several skill areas, suggesting that structured educational programs significantly enhance digital competencies. Lihong and Dongqing advocate for targeted digital literacy training to bridge these competency gaps and support comprehensive skill development (Lihong & Dongqing, 2024).

Zhengqiang (2020) assessed the digital literacy of Chinese college students, finding that while students possess basic operational skills, they frequently lack a deep understanding of ethical and secure practices in digital spaces. The study emphasizes that current educational approaches are insufficient in preparing students for the ethical challenges of digital environments. Ling argues for the establishment of frameworks that promote responsible online behavior, especially concerning digital security and ethical content sharing, as these areas are critical for fostering a well-rounded digital literacy profile(Zhengqiang, 2020).

In reviewing both international and Chinese literature, several key challenges in digital literacy among university students emerge. First, a gap exists between students' self-perceptions and actual competencies, particularly in evaluating, creating, and applying information, where students often express high confidence but demonstrate insufficient skills (Gross & Latham, 2012; Shaowei, 2023). Second, socioeconomic factors significantly influence digital literacy levels, with studies from various regions revealing disparities in digital skill acquisition among low-income groups (Olatoye et al., 2021; Ritzhaupt et al., 2013). Third, there is a lack of advanced skills among students, including problem-solving, digital content innovation, ethical responsibility, and digital security (He & Zhu, 2017; Martzoukou et al., 2020). Many scholars advocate for enhanced support within educational systems to develop digital literacy, emphasizing the importance of adaptability and responsibility in complex digital tasks—skills deemed essential for students' academic and professional success in an increasingly digital global society.

3.Variables affecting college students' digital literacy

Research on digital literacy has identified a variety of factors that significantly influence students' digital literacy levels. Across multiple studies, several key variables have been highlighted, including socio-economic status, personal competence, family involvement, educational context, and institutional policies.

Socio-Economic Status, Ethnicity

Socio-Economic Status (SES) has been found to significantly affect students' digital literacy. Ritzhaupt et al. (2013) examined the influence of SES on ICT literacy among middle school students in Florida. The study revealed that students from higher SES backgrounds had better access to and proficiency in ICT resources compared to those from lower SES backgrounds. This divide also affected the type of software used, with high-SES students accessing more productive software, whereas low-SES students often used drill-and-practice software(Ritzhaupt et al., 2013) .Ethnicity were also significant variables in Ritzhaupt et al.'s(2013) study, which indicated disparities in digital literacy based on ethnicity and gender, white students outperformed their non-white peers(Ritzhaupt et al., 2013).

Digital Competence and Personal Factors

Digital Competence emerged as a key determinant of students' digital literacy in several studies. He and Zhu (2017) explored digital informal learning (DIL) among Chinese university students and highlighted that digital competence significantly influenced how effectively students used digital tools for informal learning. The study found a positive association between digital competence and students' attitudes towards DIL(He & Zhu, 2017).

Personal Innovativeness was also identified as a crucial factor in digital literacy development. He and Zhu (2017) showed that students with higher personal innovativeness were more inclined to engage with new technologies, thereby positively impacting their DIL behaviors. This suggests that individual traits like willingness to explore new technologies play an important role in enhancing digital literacy(He & Zhu, 2017).

Digital Readiness and Technological Preparedness

Technological Competence and Readiness for Online Learning are critical factors affecting students' digital literacy. Blayone et al. (2018) profiled the digital readiness of higher education students in Georgia and Ukraine for online learning, identifying considerable variation in students' readiness for different online learning activities. Georgian students exhibited greater readiness for technical and computational interactions, while Ukrainian students were more prepared for communication and social network usage(Blayone et al., 2018).

Experience with ICT was highlighted by Olatoye et al. (2021) in their study of South African students. The findings suggested that students with greater experience in ICT had higher ICT literacy proficiency and were better able to use electronic resources effectively. Conversely, students with limited ICT experience struggled with utilizing digital tools for academic purposes(Olatoye et al., 2021).

Educational Context and Accessibility

Access to Digital Resources was consistently identified as a foundational variable impacting digital literacy. Ritzhaupt et al. (2013) highlighted disparities in access to ICT resources among students from different socio-economic backgrounds, which significantly affected their ability to develop digital competencies. Similarly, Blayone et al. (2018) noted that differences in access to technology and digital infrastructure played a crucial role in shaping students' digital literacy(Blayone et al., 2018; Ritzhaupt et al., 2013).

Digital Divide was a recurrent theme in the literature, particularly in terms of socio-economic disparities and educational access. Lihong and Dongqing (2024) studied students in Fujian Province, China, and found that those in science, engineering, agriculture, and medical disciplines exhibited higher digital literacy due to targeted education. In contrast, freshmen demonstrated lower safety and professional digital literacy, indicating a divide based on educational stage(Lihong & Dongqing, 2024).

Family Environment and Parental Influence

Parental Influence on digital literacy was discussed by Wardhani et al. (2019), who analyzed the impact of parental roles on digital competence among students at Universitas Mercu Buana. The study used concepts of interpersonal communication to assess family involvement and concluded that parental modeling, mentoring, organizing, and teaching positively affected students' digital competence, though these impacts were not fully optimized(Wardhani et al., 2019).

Attitudes and Motivation for Digital Learning

Attitude Towards Technology was identified as a mediating factor between digital competence and informal digital learning. He and Zhu (2017) demonstrated that students with positive attitudes towards technology were more likely to use digital tools effectively, which subsequently enhanced their digital competence. Attitudes towards technology also played a role in motivating students to engage with digital informal learning(He & Zhu, 2017).

Motivation for Online Learning was another significant variable. In their study on Georgian and Ukrainian students, Blayone et al. (2018) linked motivation and digital readiness to students' familiarity with digital tools and willingness to participate in online collaborative learning activities. Higher digital readiness was associated with increased motivation to engage in online learning(Blayone et al., 2018).

Institutional Policies and Governmental Support

Institutional Strategies and Frameworks were noted as influential in fostering digital literacy. Zhengqiang (2020) examined the role of institutional strategies in China, including the creation of digital literacy frameworks, resource centers, and teacher training programs. These strategies were found to be crucial for enhancing digital literacy in a systematic manner(Zhengqiang, 2020).

Governmental support in Thailand's higher education has been shown to shape digital literacy development. Drawing on a national study, Tuamsuk and Subramaniam (2017) identified increased mobile access, supportive policies, and curricular integration as key drivers, and emphasized the role of public infrastructure and institutional support in improving students' digital skills(Tuamsuk & Subramaniam, 2017).

In summary, the studies reviewed indicate that digital literacy among students is shaped by a complex interplay of factors, including socio-economic status, personal traits, technological readiness, access to resources, family environment, and institutional policies. Personal factors, such as digital competence, innovativeness, and positive attitudes, were found to significantly impact digital literacy outcomes. External factors, such as government policies, educational frameworks, and family support, were instrumental in either enhancing or hindering the development of digital literacy. Addressing these variables through targeted educational interventions, policies, and improving access to digital resources are essential steps to bridge the digital divide and foster equitable digital literacy development.

4.The impact of digital literacy on college students' academic performance and future employment

Quraishi et al. (2024) underscore the significance of digital literacy in academic settings, noting that students with higher digital competencies exhibit greater confidence and effectiveness in using digital tools for learning. The study found that integrating tailored digital literacy programs, which combine both basic and advanced skills, can significantly enhance academic outcomes by improving students' self-efficacy, information accessibility, and resource management(Quraishi et al., 2024). Similarly, in the South African context, Olatoye et al. (2021) demonstrate that ICT literacy is critical for academic resource utilization, enabling students to effectively access, evaluate, and use digital resources in support of their academic and professional goals. This proficiency directly influences their academic success by facilitating efficient engagement with online libraries and digital databases(Olatoye et al., 2021).

Extending from academic benefits, Martzoukou et al. (2020) highlight the importance of digital literacy in preparing students for professional environments. Skills such as digital communication, networking, and content creation are seen as directly transferable to the workplace, aligning with employer expectations in a technology-driven economy. Their research identifies digital literacy as a marker of workplace readiness, with competencies in collaboration, critical analysis, and ethical digital behavior valued by employers(Martzoukou et al., 2020). This aligns with Tuamsuk and Subramaniam's (2021) study in Thailand, where digital literacy is actively promoted within universities through skills in data analysis, online communication, and content creation. These skills support academic success and position students well for roles in digitally centered job markets(Tuamsuk & Subramaniam, 2017).

He and Zhu (2017) explore digital literacy's impact on fostering independent learning behaviors among Chinese students. They emphasize that digital competence supports self-directed learning, which is essential for lifelong learning and adaptability in diverse career paths. The study also points out that students' attitudes and adaptability toward digital tools play a significant role in professional readiness, as these personal factors enhance engagement in informal learning contexts, subsequently improving workforce adaptability(He & Zhu, 2017). In a similar vein, Reddy et al. (2021) highlight digital literacy's role in supporting students' academic performance and employability in the South Pacific, where ICT skills bolster academic achievements and prepare students for a globalized workforce. The study calls for more structured digital literacy frameworks to ensure students are well-equipped for both academic and career challenges(Reddy et al., 2022).

While foundational skills are often present, advanced digital competencies required in professional environments are frequently lacking. Ling (2023) identifies critical gaps in Chinese students' digital literacy, especially in areas like critical thinking, information evaluation, and digital ethics. These deficiencies hinder both academic growth and job preparedness, highlighting a need for targeted digital literacy programs that bridge such gaps(Ling, 2020). This is echoed in Harmoko's (2021) study in

Indonesia, which connects digital literacy with enhanced academic performance and workforce adaptability. By linking digital literacy education to improved productivity and career prospects, Harmoko underscores the need for comprehensive programs that prepare students for the information-rich and dynamic job market (Harmoko, 2021)

Finally, Shaowei (2023) emphasizes digital citizenship and critical evaluation skills as essential components for professional readiness. By equipping students with skills like information management and ethical digital practices, digital literacy allows graduates to navigate complex workplace challenges more effectively. This holistic approach to digital literacy fosters comprehensive educational and professional development, demonstrating the growing relevance of digital literacy for academic and career success(Shaowei, 2023).

In summary, digital literacy significantly impacts university students' academic performance and future employability. High digital literacy levels not only boost students' confidence and academic success but also enhance their ability to utilize information resources and manage academic tasks effectively(Olatoye et al., 2021; Quraishi et al., 2024). In terms of employment, skills such as digital communication, content creation, and data analysis are considered essential in modern workplaces, aligning with employer expectations for digital fluency and professional ethics (Martzoukou et al., 2020; Tuamsuk & Subramaniam, 2017). However, many students exhibit gaps in advanced skills, such as critical thinking, information evaluation, and digital ethics, which limit their adaptability and competitiveness in professional settings. This underscores the need to strengthen digital literacy education to support both academic and career development(Shaowei, 2023; Zhengqiang, 2020).

Competence and literacy of pharmacy students

1.Pharmacy students

In defining the competencies and scope of pharmaceutical studies, In accordance with the standards document issued by the Ministry of Education, P.R.C., pharmacy is defined as a discipline grounded in chemistry, biology, and medicine, focusing on the principles and practices of drug research, production, application, and management. Pharmacy students are trained to acquire foundational knowledge, core theories, and essential skills in pharmaceutical sciences. This educational program aims to prepare high-quality professionals capable of engaging in drug discovery and evaluation, formulation design and preparation, quality standards research, quality control, pharmaceutical management, and pharmacy services(Ministry of Education, 2018).

2.The abilities and qualities that contemporary pharmaceutical students need to master

In the digital era, the core competencies for pharmacy students extend beyond traditional pharmaceutical knowledge to include essential digital literacy skills. This shift recognizes that while foundational competencies—such as knowledge in pharmacology, biochemistry, and practical skills in dispensing and quality control—remain central, students must now also develop digital capabilities relevant to contemporary healthcare practices. These digital competencies include data literacy, technology integration, and ethical handling of digital information, which support precision in medication, patient data management, and remote healthcare solutions.

Pharmacy students are primarily expected to develop competencies in medication dispensing, patient counseling, quality control, and regulatory understanding。 As the healthcare field evolves digitally, pharmacy students are increasingly required to develop digital competencies, particularly in telehealth and data management. Bautista et al. (2020) report on a curriculum designed for pharmacy students during the COVID-19 pandemic, which emphasizes skills in telehealth outreach and interprofessional collaboration. This digital proficiency allows students to engage with remote patient care, manage medication reconciliation digitally, and improve interprofessional communication—skills that are critical for navigating modern healthcare challenges effectively(Bautista et al., 2020).

Pan (2021) points out that medical information literacy is an important ability in the field of medicine for acquiring and utilising information, and is crucial for cultivating information-capable medical professionals. The study investigates the information literacy education situation in several medical schools in China (such as the Chinese Academy of Medical Sciences and Capital Medical University), analysing the innovation of their education formats and content, including new teaching methods such as live online broadcasts and micro-video lectures, in order to meet the needs of the modern medical information environment(Pan, 2021).

Wu and Song (2024) also emphasise that in addition to the basic professional skills, pharmacy students in the current era also need to have information and data literacy, secure digital communication and the ability to create ethical digital content. These digital skills enable students to effectively manage patient data, participate in digital diagnosis and maintain responsible online interactions, all of which are essential to adapt to new technological advances in the field(Wu & Song, 2024).

Jiuying et al.(2024) explore how these digital literacy competencies intersect with foundational medical skills, suggesting that integrating them into medical education is essential for developing competent, adaptable healthcare professionals capable of navigating both technical and ethical challenges in digital and medical contexts. By fostering digital literacy, medical students are better prepared to engage in innovative practices, aligning with broader healthcare goals to improve patient care and system efficiency in a digitalized society(Jiuying et al., 2024).

Currently, many university libraries provide information-literacy training—often via lecture-based programmes that cover database use, literature management, and research writing—echoing survey evidence from “Double First-Class” institutions (Gao & Wang, 2019). These training contents focus on the training of information retrieval skills, combined with modern information retrieval tools and applications(Xu & Zhang, 2018). With the development of Internet technology, many university libraries have gradually adopted online live broadcasts and micro-videos to disseminate medical information literacy knowledge in a more flexible manner. In particular, microvideos are short and concise, suitable for the busy schedules of medical students, and low-cost and easy to operate, meeting the needs of modern education(Yue & Zhang, 2020). This innovative form of education breaks through the limitations of time and space through online platforms, enabling more students to participate in learning anytime, anywhere(Li, 2021).

Overall, there is an increasing emphasis on information literacy and digital skills in pharmacy and medical education, and digital transformation not only improves student learning outcomes, but also better prepares them for future changes and challenges in healthcare technology.

Guidelines for improving digital literacy

1. Effective strategies and practical cases for improving digital literacy

This section highlights effective strategies and practical examples from research conducted in the past two years on improving digital literacy.

1.1Effective Strategies for Enhancing Digital Literacy

Integration into Curriculum: One of the most frequently mentioned strategies is integrating digital literacy into the formal educational curriculum. Quraishi et al. (2024) emphasized the importance of integrating digital literacy into higher education curricula to prepare students for the complexities of the digital age. This integration involves both general education and specialized training, thereby providing students with a comprehensive understanding of digital tools(Quraishi et al., 2024).

Azzahra and Amanta (2021) provided insights into strategies for integrating ICT back into school curricula in Indonesia. This strategy aims to develop critical thinking skills alongside digital literacy by involving the Ministry of Education, the Ministry of Communications, and non-governmental actors with expertise in digital solutions. The authors highlighted that enhancing teacher capacities is essential to effectively implement these curricular changes(Azzahra & Amanta, 2021).

Targeted Digital Training**:** Targeted digital training programs were highlighted as an effective strategy in multiple studies.Guoxing (2024) proposed the "Digital Literacy Gyroscope Model," which focuses on enhancing practical skills through targeted digital training. The model also emphasizes the importance of providing diverse and practical digital education materials(Guoxing et al., 2024). Similar conclusions emerge from recent medical-education studies: embedding digital literacy within the curriculum—through targeted courses and practical activities—improves students' ability to use health care–related digital systems effectively(Aydınlar et al., 2024; Mielitz et al., 2024).Ye and Yu (2024) studied vocational students and suggested targeted digital literacy training to improve employment outcomes. By focusing on job-relevant digital skills, such as data analysis and programming, these training programs aim to enhance the employability of students in a competitive job market(Ye & Yu, 2024).

Digital Laboratories and Practical Teaching Models**:** Creating digital laboratories and practical teaching environments is another effective strategy identified in several studies. Zhu (2024) discussed the use of digital literacy laboratories as part of a practical teaching model in vocational colleges. These laboratories provide students with hands-on experience in operating digital equipment and software, which helps them develop practical skills essential for their careers. The study emphasized the importance of combining theoretical knowledge with practical applications to bridge the gap between classroom learning and real-world requirements(Zhu, 2024).

Collaborative Initiatives and Stakeholder Involvement: Collaboration between multiple stakeholders, including government bodies, educational institutions, and private organizations, was highlighted as a key strategy for enhancing digital literacy.

Azzahra and Amanta (2021) discussed the collaboration between the Ministry of Education, the Ministry of Communications, and private actors to improve ICT access in rural areas and enhance digital literacy in Indonesian schools. This collaborative approach ensures that digital literacy initiatives are comprehensive and inclusive, catering to students across various socio-economic backgrounds(Azzahra & Amanta, 2021).

Fostering Digital Citizenship and Ethical Use: Several studies highlighted the importance of fostering digital citizenship and ethical use of digital technologies. Wang and Chen (2021) emphasized training students not only in technical skills but also in digital ethics and responsible technology usage. Xu Guoxing (2024) also stressed the importance of cultivating digital awareness and ethical considerations, which are integral components of the "Digital Literacy Gyroscope Model." These strategies help ensure that students use digital tools responsibly and are aware of privacy, security, and ethical issues(Wang & Chen, 2021).

1.2. Practical Cases for Enhancing Digital Literacy

Quraishi et al. (2024) conducted a case study on the integration of digital literacy at Online Women's University. This case study underscores the value of embedding digital literacy within higher education curricula to empower students and prepare them for digital challenges(Quraishi et al., 2024).

Recent medical-education work provides practical models for domain-specific digital training. For example, an embedded course in Germany integrates hands-on work with healthcare digital systems and improves students' readiness for digital practice(Mielitz et al., 2024). Similarly, evidence from a health-sciences program shows the need to support curricula with structured digital-literacy instruction to prepare students for technology-rich clinical contexts(Aydınlar et al., 2024).

Zhu (2024) presented a practical teaching model using digital literacy laboratories in vocational colleges. These laboratories allowed students to practice using digital equipment in a controlled environment, thus enhancing their practical skills. By integrating hands-on experience with theoretical knowledge, this approach helped students develop a deeper understanding of digital tools and their applications in various industries(Zhu, 2024).

Azzahra and Amanta (2021) described the reintroduction of ICT education into Indonesian school curricula as a collaborative initiative involving government ministries and private actors. The initiative aimed to enhance students' digital literacy from an early age by improving teacher training, fostering critical thinking, and providing better access to technology. The case demonstrated the importance of multi-stakeholder collaboration in developing and implementing effective digital literacy programs(Azzahra & Amanta, 2021).

Ye and Yu (2024) conducted a practical study on the relationship between digital literacy and employment quality among vocational students. The study employed multiple regression analysis to demonstrate how targeted digital training improved students' job prospects. The findings suggested that improving specific digital skills, such as data analysis and programming, could significantly enhance students' employment outcomes, making it an effective practice for bridging the gap between education and employability(Ye & Yu, 2024).

There findings suggest that effective strategies include curriculum integration, targeted digital training, digital laboratories, collaborative initiatives, and fostering digital citizenship. Practical cases demonstrate the effectiveness of these strategies in different educational settings, such as higher education, vocational training, and early school education.Addressing digital literacy through these varied approaches can help bridge the digital divide, enhance employability, and prepare students to navigate the complexities of the digital age. Stakeholder collaboration, tailored curriculum development, and hands-on practice are essential components in building a digitally competent and responsible student body, capable of contributing effectively to the modern workforce.

2.Future trends in improving digital literacy

This part synthesizes findings from recent studies to highlight the future trends in digital literacy development and the directions for improving digital literacy frameworks in higher education institutions.

2.1. Future Trends in Digital Literacy Cultivation

Deep Integration of Artificial Intelligence and Education **:** The integration of artificial intelligence (AI) with education is identified as a significant future trend, fostering the deep integration of digital literacy with the learning process. According to Xiong (2024), AI will play an increasingly central role in education, facilitating personalized and immersive classroom experiences, promoting competency-based assessment, and providing diverse AI-generated resources for teaching. These trends will enhance both educational quality and equity, contributing to the overall digital transformation of education(Xiong, 2024).

Digital Ethics and Social Responsibility Education **:** In the era of widespread digital technology and AI, digital ethics and social responsibility are becoming essential components of digital literacy education. Hu (2024) noted that future digital literacy education must emphasize the importance of ethical awareness and social responsibility in the digital age. Leveraging frameworks such as the AI literacy framework, educational institutions can integrate digital ethics into curricula to foster a sense of responsibility among students while preparing them to use technology responsibly and effectively(Hu, 2024).

"Digital+" Employment Ecosystem and Gig Economy： The rapid development of the digital economy is reshaping the employment landscape, particularly for young people. Song (2024) highlighted the emergence of the "Digital+" employment ecosystem, which includes gig economy and orange economy opportunities. These new economic forms provide more job opportunities for young people. Countries are adopting macro-level digital employment policies and implementing micro-level youth digital employment training to enhance employability and promote digital literacy(Song, 2024).

2.2. Improvement Directions for Digital Literacy Frameworks in Higher Education

Enhancing Teacher Digital Literacy and Establishing Resource Sharing Systems： Improving teacher digital literacy and creating resource-sharing systems are critical aspects of enhancing digital literacy in higher education. According to Weng (2024), universities need to focus on enhancing teachers' digital competencies, updating course content, and establishing digital resource-sharing systems to enhance the quality of education. For example, in the digital transformation of ideological and political education, enhancing teachers' digital literacy and synchronizing digital teaching resources are seen as effective ways to improve teaching quality and student engagement(Weng, 2024).

Student-Centered Digital Literacy Framework： Wu (2024) proposed a Digital Literacy Framework for College Students (DLFCS) that includes three primary areas: operational skills, applied competencies, and thinking and awareness. This framework emphasizes a learner-centered approach, ensuring that digital literacy education addresses the specific needs of students through scenario-based requirements analysis and professional consultations. By fostering long-term, progressive development, this framework aims to help students adapt to and innovate in the digital age(Wu, 2024).

The Role of Libraries in Digital Literacy Education： Libraries play an essential role in promoting digital literacy, particularly in higher education institutions. Hu (2024) highlighted the role of libraries in establishing digital literacy education centers and digital literacy training bases, which can offer systematic training to both students and the general public. This initiative aims to provide continuous digital skills training and expand access to digital literacy, ultimately helping individuals cope with future digital challenges(Hu, 2024).

The literature mentioned above all indicates that future education systems will increasingly rely on the integration of artificial intelligence, pay attention to digital ethics, and cultivate a "digital+" employment ecosystem to meet new economic needs.In addition, improvement directions for higher education institutions include enhancing teacher and student digital literacy, establishing digital resource-sharing systems, and utilizing libraries as training hubs for digital literacy. These trends and strategies will lay a solid foundation for the digital literacy development of students and prepare them for the demands of an evolving digital society.

Research review at home and abroad

Digital literacy is a necessary competency for contemporary pharmacy students to effectively utilize digital tools and resources for learning, patient care, and professional development. The development of digital literacy includes not only technical skills, but also an ethical understanding and the ability to critically apply digital competencies in professional practice. Next, recent Chinese and foreign research results will be synthesized to provide an overview of the current state of digital literacy education, the theoretical basis guiding its development, and future directions for improving the digital literacy of pharmacy students.

1. Current State of Digital Literacy Development for Pharmacy Students

Integration of Digital Competencies in Pharmacy Education:The integration of digital competencies into pharmacy education is a critical step to align learning outcomes with the demands of the modern healthcare system. The digital transformation in education is significantly impacting vocational pharmacy education in China. Kinny et al. (2024) explored the current status of digital literacy development in pharmacy students and emphasized the need for curricula that address digital healthcare systems, including skills in digital prescription and clinical trial management. Kinny et al. (2024)highlighted the need to equip pharmacy students with digital skills to meet industry requirements and prepare them for emerging roles in the pharmaceutical sector(Kinny et al., 2024).

Similarly Xiong and Yang (2024) introduced the "1+5" digital education framework, aimed at creating a structured approach to digital literacy development in vocational education, including pharmacy programs. This framework includes digital resources like online course libraries, digital laboratories, and virtual simulation platforms, all of which are designed to provide pharmacy students with a comprehensive environment to develop essential digital skills(Xiong & Yang, 2024).

Internationally, the literature underscores embedding digital literacy within both foundational and specialized curricula. In higher education, Moskal, Dziuban, and Hartman (2013) argue that thoughtfully designed blended learning—the intentional fusion of online and face-to-face components—can create dynamic environments that support technical proficiency and higher-order cognitive skills. When mapped to pharmacy programs, blended designs can allocate online space for tool practice (e.g., drug-information databases, clinical documentation sandboxes) while preserving face-to-face time for application and feedback, thereby strengthening students' readiness for technology-rich practice(Moskal et al., 2013).

Digital Literacy Challenges and Gaps in Pharmacy Education:Despite the progress in integrating digital literacy into pharmacy education, significant challenges remain. Liu(2023) and Zheng (2024) identified several challenges and gaps in vocational pharmacy education in China, including the lack of standardized digital literacy curriculum content across institutions. Discrepancies in students' access to digital resources have contributed to uneven levels of digital literacy among pharmacy students, underscoring the need for a more consistent curriculum and a supportive digital campus environment(Liu, 2023; Zheng, 2024).

International studies also reflect these challenges. Duggan (2013) noted that there is often a disconnect between the digital skills taught in educational institutions and those required in the workforce. By fostering stronger partnerships between universities and industry stakeholders, pharmacy programs can ensure their digital literacy curricula are aligned with current industry needs, thereby enhancing students' readiness for the digital aspects of their professional roles(Duggan, 2013).

Focus on Digital Ethics and Responsible Use: Digital ethics and responsible use of digital technologies are crucial components of digital literacy, particularly in healthcare settings where data privacy and security are paramount. Zheng (2024) emphasized the importance of integrating digital ethics into pharmacy education to prepare students to handle sensitive patient information responsibly. Incorporating ethical literacy into digital literacy training helps students navigate ethical challenges in digital healthcare environments(Zheng, 2024).

Similarly, Hu (2024) emphasized the importance of teaching digital ethics as part of digital literacy education, particularly for pharmacy students who need to manage sensitive health data and ensure compliance with privacy regulations(Hu, 2024). This focus on ethics ensures that pharmacy students are prepared for the complexities of digital healthcare technologies.

2. Theoretical Foundations for Digital Literacy Development

The "1+5" Digital Education Framework:The "1+5" digital education framework proposed by Xiong and Yang (2024) serves as a foundational model for developing digital literacy among pharmacy students. It encompasses five key areas: operational skills, digital resources, virtual simulation practices, digital responsibility, and ethical literacy. By integrating theoretical learning with practical applications, this approach allows pharmacy students to develop a well-rounded set of digital skills that are directly applicable to their field. Virtual simulation, for example, is used to bridge the gap between theoretical knowledge and real-world practice by providing immersive learning experiences in drug preparation and patient counseling(Xiong & Yang, 2024).

Constructivist Approach to Digital Literacy: The constructivist approach to digital literacy, as highlighted by Liu (2023) and Zheng (2024), emphasizes active student engagement with digital tools and technologies. The creation of a digital campus environment is crucial for fostering an active learning culture, where students are encouraged to participate in digital literacy activities both independently and collaboratively. This aligns with the constructivist theory, which suggests that learners build understanding through exploration and interaction with digital content (Liu, 2023; Zheng, 2024).

Internationally, constructivist approaches also support the development of digital literacy. For example, Ozdamar-Keskin et al. (2015) explored the use of blended learning to cater to different learning styles and promote deeper engagement with digital tools. Personalized learning experiences that consider individual learning preferences can significantly enhance digital literacy outcomes, especially in fields like pharmacy where precise information evaluation is crucial(Ozdamar-Keskin et al., 2015).

Integration of Ethical Literacy in Digital Competency Frameworks: Zheng (2024) and Hu (2024) both highlight the importance of integrating ethical literacy into digital competency frameworks for pharmacy students. Ethical literacy includes understanding the implications of digital tools in healthcare, particularly regarding patient data privacy and security. Developing students' ability to make informed, ethical decisions when using digital technologies is critical for their future roles in healthcare(Hu, 2024; Zheng, 2024).

3. Future Directions for Digital Literacy Development

Development of Specialized Digital Literacy Frameworks: One of the key areas for future research is the development of specialized digital literacy frameworks tailored specifically for pharmacy education. While frameworks such as the European Framework for Digital Competence provide a foundation, there is a need for guidelines that address the unique digital skills required in pharmaceutical practice, such as electronic health records (EHRs) and telehealth platforms (Martin & Grudziecki, 2006). Future research should focus on developing and validating these frameworks to ensure they meet the specific needs of pharmacy students.

Emphasis on Practical Learning and Real-World Applications:Practical, hands-on experience is essential for developing digital literacy among pharmacy students. Xiong and Yang (2024) recommended utilizing virtual simulation platforms to provide practical training in pharmaceutical education, which helps students apply their digital skills in a controlled environment. Future research should investigate the impact of experiential learning opportunities, such as internships and simulations, on students' ability to use digital tools effectively in real-world healthcare settings(Xiong & Yang, 2024).

Collaboration Between Academia and Industry: Fostering collaboration between academia and the pharmaceutical industry is also critical for enhancing digital literacy. Duggan (2013) pointed out that such partnerships can help ensure that the digital skills taught in educational institutions align with industry needs, thereby enhancing the relevance of pharmacy education and preparing students for their professional roles in a digital healthcare environment(Duggan, 2013).

4.Summary and Implications

The current state of digital literacy development for pharmacy students in China and internationally reveals significant progress, but also ongoing challenges, particularly in terms of curriculum consistency, access to digital resources, and the integration of ethical literacy. Theoretical foundations such as the "1+5" digital education framework and constructivist approaches provide valuable guidance for developing effective digital literacy programs. Future initiatives should focus on creating specialized digital literacy frameworks, emphasizing practical learning opportunities, and fostering collaboration between academia and industry. By addressing these gaps, pharmacy education can better equip students with the digital competencies necessary for effective and ethical practice in the healthcare sector.

CHAPTER III

RESEARCH METHODOLOGY

PHASE I

Research Design

The first phase of this study adopts a descriptive and exploratory research design aimed at assessing the current status of digital literacy among pharmacy students in Jiangsu Food & Pharmaceutical Science College。 This phase will capture the specifics of students' digital literacy through a comprehensive self-assessment questionnaire covering behavioral frequency scales, Likert scales and open-ended questions. By systematically collecting and analyzing quantitative and qualitative data from students, this phase will reveal the actual situation and problems in the application of digital skills among pharmacy students, thus providing a basis for the second phase of the study.

Independent Variables: the independent variables in the study include students' grade level, frequency of daily use of digital tools, whether they have received training related to digital literacy, and the level of school support. These independent variables help to explore the differences in the dimensions of digital literacy among different groups.

Dependent Variables: the dependent variables are students' self-assessment scores on five digital literacy dimensions, including information management literacy, technology proficiency , digital security awareness, digital communication and collaboration , and content creation and knowledge building. These dependent variables reflect the performance of students' digital literacy under the influence of different independent variables.

Participants

The subjects of the study were mainly pharmacy students in the School of Pharmacy of Jiangsu Food & Pharmaceutical Science College, which has a total of 1500 students in three grades. These students were trained in basic pharmacy knowledge and practical skills in the areas of drug research and development, production, management, quality control, and clinical pharmacy. These students have completed different stages of the pharmacy program. Specifically, first-year students mainly study basic courses, such as basic chemistry, biology, pharmacology, etc.; second-year students have begun to be exposed to the core courses of the pharmacy profession, which include pharmacology, drug analysis, drug dispensing, pharmacy management, and other core courses of the profession; third-year students have completed most of the core courses, and have gradually entered the relevant enterprises for internships to begin to apply the learned theoretical knowledge. To ensure that the sample size is representative of the whole, the author used the Krejcie & Morgan (1970) formula to determine the sample size. According to this method, with an overall size of 1500 students and a 95% confidence level, the required sample size is 306 students(Krejcie & Morgan, 1970).

The formula was calculated as follows:

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

$\boldsymbol{n}$ = Required sample size

$\boldsymbol{Z}$ = Z-value corresponding to the desired confidence level

$\boldsymbol{p}$ = Estimated proportion of the population

$\boldsymbol{E}$ = Margin of error

For a population of 1500 pharmacy students, the initial sample size is calculated as:

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

Finite Population Correction:

Given that the population is finite (N = 1500), the sample size needs to be adjusted using the finite population correction formula:

$$n' = \frac{n}{1 + \frac{n - 1}{n}}$$

Substituting in the values:

$$n' = \frac{384.16}{1 + \frac{384.16 - 1}{1500}} = 306$$

Thus, a sample size of 306 students is required to ensure statistical validity and representativeness for the first objective.

Stratified random sampling will be used to draw participants from each of the three grade levels to ensure that the sample is representative of the population as a whole. Each grade level will be sampled proportionally to the size of its student population to avoid bias.

Research Instruments

The main research instrument for this section was a self-assessment questionnaire (Appendix A) used to comprehensively assess the level of digital literacy among pharmacy students. The questionnaire was based on the Council of Europe's DigComp 2.2 model and the standards of The Internet and Computing Core Certification (IC3) to ensure that the key dimensions of digital literacy are covered and adapted to the needs of modern digital work and learning environments. The questionnaire contains three sections, namely, respondent background information(includes behavioral frequency scale), Likert scale,and open-ended questions, which aim to provide a comprehensive assessment of students' digital literacy from different perspectives.

1. Behavioral Frequency Scale: The Behavioral Frequency Scale is used, in part, to quantify how often students actually use digital tools in their daily learning and practice. For example, students will be asked how often they have used specific digital tools (e.g., data processing software, online resources, etc.) in completing academic tasks in the past month. as well as the school's setting of activities or courses related to enhancing students' digital literacy. This section captures student learning performance and provides quantitative data that complements the Likert scale.

2. Likert scale: the core part of the questionnaire uses a five-point Likert scale to measure students' subjective perceptions of digital literacy-related competencies. Students were asked to rate each statement on a scale ranging from 1 (completely disagree) to 5 (completely agree). This section covers the following five main dimensions:

Information Management Literacy: assesses the student's ability to access, analyze, and evaluate digital information, especially judging the authenticity of information.

Technical Proficiency: measures students' proficiency in the use of digital tools and software, including the operation of software specific to the field of pharmacy.

Digital Security Awareness: focuses on students' skills in data encryption, privacy protection, password management, and responding to cybersecurity threats.

Digital Communication and Collaboration: assesses students' ability to communicate and work in teams through digital platforms.

Content Creation and Knowledge Building: assesses students' ability to utilize digital tools for content creation and knowledge building, covering text, multimedia, and interactive content.

3. Open-ended questions: In order to gain more in-depth insights, the questionnaire also includes several open-ended questions that allow students to describe in detail their specific ideas about learning and using digital skills. The open-ended questions will provide rich qualitative data that will help reveal details and issues not captured by the quantitative data.

4. IOC and Cronbach's Alpha : In order to ensure the validity and reliability of the questionnaire, both the Index of Item-Objective Congruence (IOC) and Cronbach's Alpha were used in this study. The IOC was reviewed by experts, where each item was scored based on its alignment with the study objectives using a scale of 1 (highly relevant), 0 (irrelevant), and -1 (not matching). The IOC value was calculated to determine the congruence between items and objectives, with items having an IOC value below 0.5 being modified or deleted to ensure validity. Cronbach's Alpha was used to assess the internal consistency of the questionnaire, measuring the correlation among items within the same dimension. A Cronbach's Alpha coefficient greater than 0.7 was considered indicative of high reliability.

$$IOC = \frac{\sum R}{N}$$

$\sum R$ is the total number of expert ratings for each entry

N is the number of experts who rated

If the IOC value of an entry is less than 0.5, the entry is modified or deleted to ensure its validity.

Data Collection

The current state of digital literacy among pharmacy students will be systematically collected through a combination of quantitative and qualitative data. The data collection process will focus on a questionnaire that includes a frequency of behaviour scale, a Likert scale and open-ended questions, as follows:

1. Quantitative data collection

The front part of the questionnaire is a frequency of behaviour scale, and the Likert scale is the main quantitative data collection tool. The frequency of behaviour scale part of the questionnaire will measure the frequency of students‘ actual use of digital tools, measure students’ perception and self-assessment of digital competence, and aim to assess the performance of pharmacy students in various dimensions of digital literacy (information management, technical operation, digital security, digital collaboration and communication, content creation and knowledge construction).

Steps:

Distribution of questionnaire: the questionnaire was distributed by means of an online platform questionnaire star, which was distributed to 306 students in the school's pharmacy program through the class QQ group.

Data collection: students were given 2 weeks to complete the questionnaire to ensure adequate reflection time. Reminders will be sent via email and text message during this period to ensure a high response rate. Upon completion of data collection, data will be exported from the online platform to the database. All data will be cleaned to ensure that there are no duplicate entries or missed fields.

2. Qualitative data collection

In order to gain deeper insights, open-ended questions will also be collected through a questionnaire. Students will describe their specific ideas about learning and using digital skills based on their actual experiences. These questions are intended to capture details that students were not able to express in depth in the quantitative data.Steps:

Questionnaire Distribution: Students will answer the open-ended questions at the end of the questionnaire based on their actual experiences.

Date collection: All responses to the open-ended questions will be transcribed into text and processed through qualitative analysis methods to identify general student ideas.

3. Data collection schedule

Week 1: Questionnaires distributed.

Week 2-3: Questionnaires collected, students reminded to complete questionnaires.

Week 4: Qualitative data collated and analysed, responses to open-ended questions transcribed and prepared for qualitative data analysis.

Data Analysis

The analysis will be structured to ensure a comprehensive understanding of digital literacy among pharmacy students.

1.Validity and Reliability Analysis

Content Validity and Reliability: To ensure content validity, Item-Objective Congruence (IOC) were used in this study, three experts reviewed the questionnaire items to determine their alignment with the intended digital literacy dimensions. The validity of each item was assessed, and necessary revisions were made. For reliability analysis, Cronbach's Alpha will be calculated for each digital literacy dimension (information management, technology skills, digital security, communication and collaboration, content creation and knowledge building) to assess internal consistency, with values above 0.7 indicating acceptable reliability.

2.Quantitative Data Analysis

Descriptive Statistics: Mean, standard deviation, frequency, and percentage will be calculated for each digital literacy dimension to describe students' self-assessment and overall performance. This helps to provide an overview of digital literacy levels among pharmacy students.

Correlation Analysis and Inferential Statistics: Pearson's correlation will be used to explore relationships between different digital literacy dimensions, such as whether technology skills are positively related to information management.

3.Qualitative Data Analysis

The responses to open-ended questions will be transcribed and analyzed manually. Using thematic coding, common themes and insights will be identified, such as challenges with digital tools, perceptions of digital literacy training adequacy, and suggestions for improvement. This manual analysis allows for understanding the context behind the students' experiences and challenges regarding digital literacy.

PHASE II

Research Design

This phase adopts a design research approach to develop a digital literacy enhancement guide for pharmacy students. The guide will be constructed through focus group discussions involving experienced educators, including lecturers and professors, who possess expertise in digital teaching environments. These discussions aim to identify the challenges, needs, and feasible strategies for enhancing digital literacy in pharmacy education. By gathering targeted insights from experts, the process ensures the guide is practical, evidence-based, and tailored to the specific requirements of pharmacy students, supporting their digital competency development in a rapidly evolving educational landscape.

Participants

This section of the study involves selecting focus group participants from among experienced educators who possess substantial expertise in digital teaching environments and curriculum development. These experts will provide valuable feedback and recommendations to enhance pharmacy students' digital literacy, ensuring the development of a practical and effective guide.

To gain a deeper understanding of the needs and feasibility of strategies for enhancing digital literacy, a focus group will be formed with 7 experts. The members will be selected based on the following criteria:

1.Voluntary enrollment:

Experts interested in cultivating digital skills and willing to share their teaching experiences in digital environments will be selected through voluntary enrollment.

2. Selection Criteria:

Professional Experience: Participants must have a minimum of five years of teaching experience in higher education, preferably in pharmacy or related fields.

Curriculum Development Expertise: Experts who have actively contributed to designing or revising curricula, especially those integrating digital tools and technologies, will be prioritized.

Professional Titles: Individuals holding positions such as senior lecturers, associate professors, or professors will be considered to ensure a high level of academic and practical expertise.

Engagement in Digital Education: Participants should have hands-on experience in implementing digital teaching strategies or tools, such as virtual simulations, online assessments, or digital resource management.

Research Instruments

This part consists mainly of focus group discussion guiding questions to ensure the focus group discussion effectively captures the genuine needs and suggestions for digital literacy enhancement from the faculty, this study has designed a structured set of guiding questions based on the structure proposed by Krueger (2012) (Appendix B). These guiding questions are intended to ensure participants thoroughly discuss their experiences with digital tools and provide substantial suggestions for professional development and improvement. The discussions will help identify challenges, needs, and suggestions for future digital literacy training and support within the pharmacy discipline. The focus group discussion is expected to last between 30 and 60 minutes, during which the facilitator will guide the conversation and ensure every expert has ample opportunity to express their views. The discussions will be recorded, and the content will be transcribed with participants' consent for subsequent analysis.

Data Collection

This study employs qualitative methods to explore strategies for improving digital literacy among pharmacy students through focus group discussions. The specific steps are as follows:

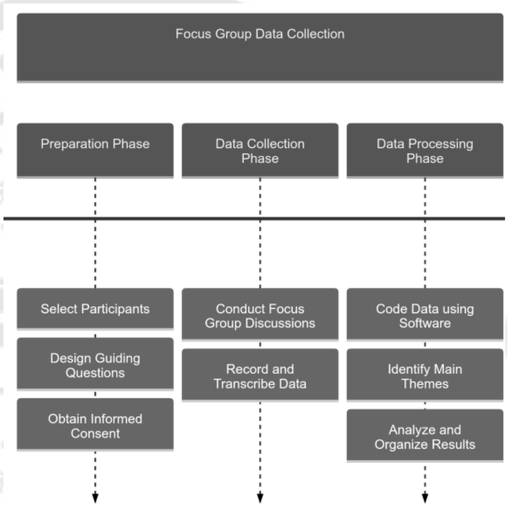

FIGURE 2 Step-by-step diagram of data analysis

Step 1 Focus Group Composition**:** The focus group consists of 7 experts, selected based on their extensive experience in education, curriculum development, and digital teaching practices. Participants were recruited through voluntary enrollment, with eligibility criteria emphasizing expertise in pharmacy education and digital literacy.

Step 2 Discussion Guide**:** Structured guiding questions, developed following Krueger and Casey's (2002) methodology, ensure that discussions address the participants' experiences with digital tools, challenges in digital literacy, and actionable suggestions for improvement. Each discussion will last approximately 30–60 minutes, and participants’ consent will be obtained for audio recording and transcription(Krueger & Casey, 2002).

Step 3 Data Processing and Analysis: After the discussions, recordings will be transcribed for analysis. The researcher will identify recurring themes, challenges, and suggestions by systematically reviewing the transcripts. These findings will serve as the foundation for developing the digital literacy enhancement guide.

Data Analysis

The analysis of data from this study will be structured to provide a comprehensive understanding of the needs and strategies for enhancing digital literacy among pharmacy students. The data collected will be analyzed as follows, Data from focus group discussions will be qualitatively analyzed to identify key themes, challenges, and suggestions. Transcripts of the recorded discussions will be reviewed and coded to categorize the responses into relevant topics such as the use of digital tools, obstacles faced by pharmacy students, and recommendations for improvement. This thematic analysis will help extract valuable insights into the specific requirements for digital literacy enhancement.

Summarizing

In this chapter, a mixed-methods approach was adopted to comprehensively examine digital literacy among pharmacy students and to develop a practical guide for enhancing these competencies. The following diagram will present the research method flow:

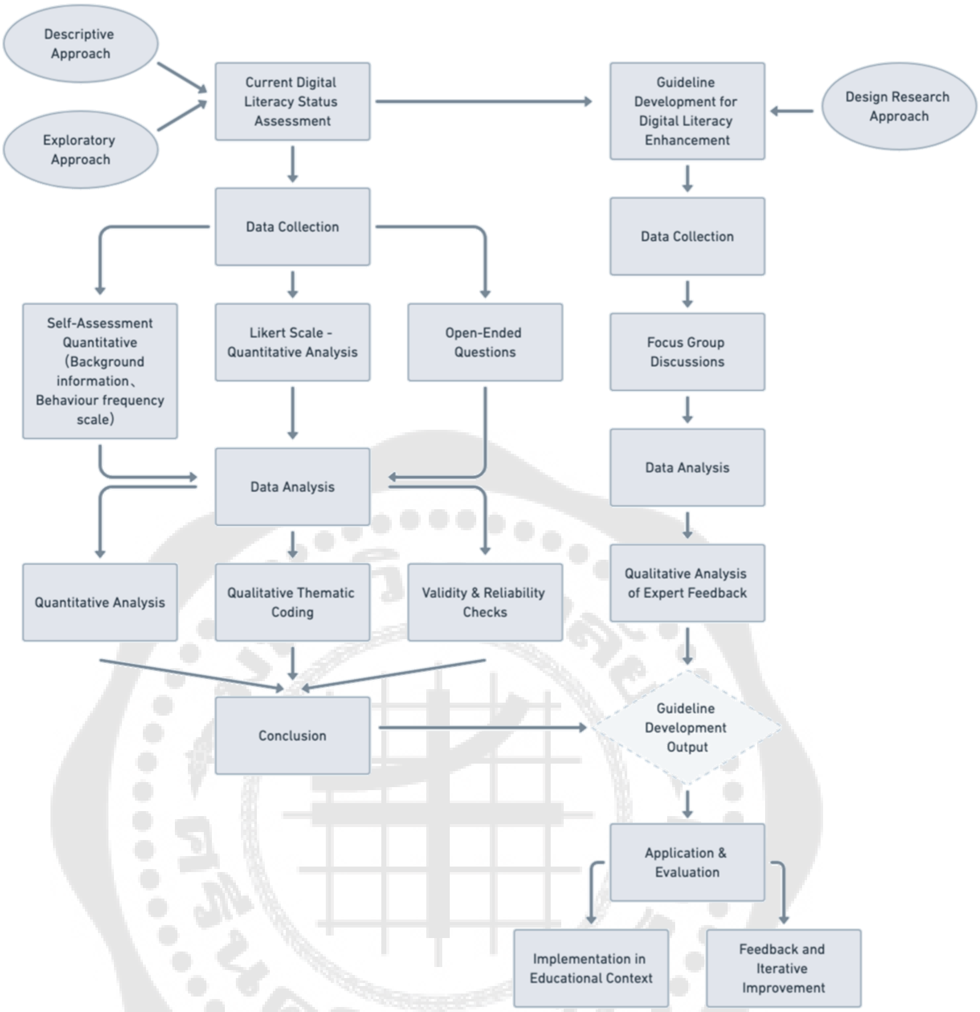

FIGURE 3 Research Methods Flowchart

The first part of the research focused on assessing the current status of digital literacy using descriptive and exploratory methods, involving a combination of quantitative data (through self-assessment questionnaires and behavioral frequency scales) and qualitative data (through open-ended questions). The second part emphasized developing a digital literacy enhancement guide, leveraging insights from focus group discussions. Both quantitative and qualitative data collection strategies, coupled with rigorous validity and reliability checks, ensured a thorough understanding of students' digital literacy levels and guided the formulation of practical recommendations. Together, these methodologies provide a solid foundation for understanding digital literacy challenges and developing effective strategies to enhance pharmacy students' digital competencies.

CHAPTER IV

RESULTS OF THE STUDY

PHASE I

Overview of Respondents

To examine pharmacy students' current digital literacy at Jiangsu Food & Pharmaceutical Science College, a questionnaire survey was conducted among Year 1 – Year 3 cohorts. The instrument assessed five dimensions — Information Management Literacy, Technical Proficiency, Digital Security Awareness, Digital Communication and Collaboration, and Content Creation and Knowledge Building — using a 5-point frequency scale (1=Never to 5=Always).Adapted from established frameworks and peer-reviewed by domain experts for pharmacy education relevance。

A total of 306 questionnaires were collected and analyzed (Valid N = 306). Prior to analysis, data were screened to ensure completeness and plausibility. Each of the 15 skill items (Items 1 – 15) was inspected for missingness and anomalies, then aggregated into five theoretically grounded dimensions. For each dimension, we computed the item mean to obtain a 1 – 5 quasi-continuous score used for descriptive statistics and group comparisons.

Before conducting group comparisons, we assessed homogeneity of variances using the median-based Levene test; when this assumption was violated, we reported Welch's one-way ANOVA (and, where applicable, Games – Howell post-hoc tests). Statistical significance was set at α = .05. Alongside p-values, we report effect sizes (η^2/ω^2 or Cohen's d) and 95% confidence intervals.

All quantitative analyses in this chapter were performed using SPSS 27.0.

1. Descriptive Statistics

The valid sample comprised 33.7% first-year students (n = 103), 35.6% second-year students (n = 109), and 30.7% third-year students (n = 94), indicating balanced representation across academic stages (Table 1).

TABLE 1 Frequencies — Grade Level

Grade	Frequency	Percent	Valid Percent	Cumulative Percent
Year 1	103	33.7	33.7	33.7
Year 2	109	35.6	35.6	69.3
Year 3	94	30.7	30.7	100.0
Total	306	100.0	100.0	

Regarding geographic background, 50.0% (n = 153) of respondents were from urban areas, 30.1% (n = 92) from townships, and 19.9% (n = 61) from rural areas (Table 2).

TABLE 2 Frequencies — Geographic Background

Origin	Frequency	Percent	Valid Percent	Cumulative Percent
Urban	153	50.0	50.0	50.0
Township	92	30.1	30.1	80.1
Rural	61	19.9	19.9	100.0
Total	306	100.0	100.0	

With respect to device usage, smartphones were nearly universal (99.3%), followed by computers (57.5%) and tablets (56.9%); smart wearables were less common (10.1%) (Table 3). These distributions provide a robust context for interpreting subsequent analyses of digital literacy behaviors.

TABLE 3 Multiple Response — Frequently Used Devices

Device	Cases (N)	Cases %
Smartphone	304	99.3
Computer	176	57.5
Tablet	174	56.9
Smart wearable	31	10.1
Other	0	0.0

2. Reliability Analysis

As a preliminary quality check, internal consistency for the composite instrument was assessed. The overall scale demonstrated acceptable reliability (Cronbach's α = 0.752; 16 items), supporting its use for exploratory analyses in this study . Detailed reliability evidence at the dimensional level is further reported in subsequent sections of the chapter where relevant.

3. Correlation Analysis

Pearson correlations among the five dimension scores indicated significant positive associations, consistent with the view that digital literacy operates as an interrelated system. In particular, Information Management Literacy correlated with Technical Proficiency ($r = 0.502$, $p < .001$) and Content Creation and Knowledge Building ($r = 0.368$, $p < .001$). Technical Proficiency correlated with Digital Communication and Collaboration($r = 0.510$, $p < .001$), and Digital Communication and

Collaboration correlated with Content Creation and Knowledge Building (r = 0.265, p < .001). The correlation matrix is summarized in Table 4.

TABLE 4 Correlations — Dimension Scores

	IM	TP	SEC	COL	CON
IM	1.000	0.502***	—	—	0.368***
TP	0.502***	1.000	—	0.510***	—
SEC	—	—	1.000	—	—
COL	—	0.510***	—	1.000	0.265***
CON	0.368***	—	—	0.265***	1.000

Note. IM = Information Management Literacy; TP = Technical Proficiency; SEC = Digital Security Awareness; COL = Digital Communication and Collaboration; CON = Content Creation and Knowledge Building. *** p < .001 (two-tailed).

Descriptive Statistics on Digital Literacy Behaviors

This section presents descriptive statistics of pharmacy students' behaviors across five core dimensions of digital literacy: Information Management Literacy, Technical Proficiency, Digital Security Awareness, Digital Communication and Collaboration, and Content Creation and Knowledge Building. Each subsection provides mean scores, standard deviations, and frequency distributions for relevant questionnaire items.

1.Information Management Literacy

This dimension evaluates students' ability to effectively search, organize, and manage digital academic resources and personal learning materials.As shown in Table 5, item means clustered around the midpoint, indicating moderate engagement overall.

The mean score for using online databases (e.g., PubMed, CNKI) to retrieve pharmaceutical information was 2.93 (SD=0.94), with most students indicating "sometimes" (143 respondents, 46.7%) or "rarely" (68 respondents, 22.2%).

TABLE 5 Descriptive Statistics — Information Management Literacy Items

Item	N	Mean	Std. Deviation
Use online databases (e.g., PubMed, CNKI)	306	2.93	0.94
Organize and back up digital files	306	2.94	0.86
Search references using engines/databases	306	3.07	0.86
Use electronic note-sharing tools	306	3.06	0.85

Students showed slightly higher consistency in organizing and backing up digital files (mean 2.94, SD=0.86) and searching references using search engines or databases (mean 3.07, SD=0.86). Use of electronic note-sharing tools such as Evernote or OneNote had a comparable mean score of 3.06 (SD=0.85), indicating moderate integration into their study routines.

Overall, while students exhibit awareness and moderate usage of digital tools for information management, improvement is needed, particularly in the effective and regular use of online academic databases.

2.Technical Proficiency

This dimension assesses students' familiarity and frequency of using technical tools essential to pharmaceutical practice, including professional software, data analysis tools, and office productivity applications. Table 6 shows that Microsoft Office use for reports and presentations was frequent (M = 3.79, SD = 0.97), whereas domain systems and data tools remained moderate (M = 3.03, SD = 0.82; M = 3.01, SD = 0.89). The larger SD for Office suggests a broader spread of use intensity, likely reflecting variation in course demands and individual study habits. The differential between productivity software and professional systems implies a skills transfer gap: students are comfortable with general tools but require more contextualized exposure to pharmaceutical information systems and applied data analysis. Integrating low-stakes practice tasks (e.g., small lab-data exercises, mock entries in a simulated LIS) can help consolidate proficiency where it matters for professional readiness.

These results suggest the need for enhanced integration of specialized pharmaceutical software and data analysis tools into curricula.

TABLE 6 Descriptive Statistics — Technical Proficiency Items

Item	N	Mean	Std. Deviation
Pharmaceutical/laboratory information systems	306	3.03	0.82
Data analysis tools (Excel/SPSS)	306	3.01	0.89
Microsoft Office (reports/presentations)	306	3.79	0.97

3. Digital Security Awareness

This dimension examines students' awareness and implementation of digital security practices, including password management, secure network usage, and data backup habits .Table 7 indicates that regular password management (M = 2.26, SD = 1.01) and security practices on public networks (M = 2.13, SD = 0.94) were infrequent, while regular data backup was moderate (M = 3.15, SD = 0.91). The relatively high SD for password practices signals substantial variability, with some students adhering to better routines and others rarely engaging in protective behaviors. Given the regulatory and ethical sensitivity of pharmacy data, these findings motivate explicit instruction on password hygiene, multi-factor authentication, VPN use, and scenario-based drills that connect cybersecurity to patient safety and institutional compliance.

Overall, students displayed insufficient digital security awareness, particularly regarding proactive cybersecurity practices. Pharmacy curricula should actively incorporate cybersecurity education.

TABLE 7 *Descriptive Statistics — Digital Security Awareness Items*

Item	N	Mean	Std. Deviation
Update and manage passwords regularly	306	2.26	1.01
Use security measures on public networks	306	2.13	0.94
Back up important data regularly	306	3.15	0.91

4. Digital Communication and Collaboration

This dimension assesses students' competencies in digital interaction and teamwork, critical in both academic and professional contexts. Results are in Table 8.

TABLE 8 Descriptive Statistics — Digital Communication and Collaboration Items

Item	N	Mean	Std. Deviation
Use collaboration platforms (e.g., Google Docs, Trello)	306	2.33	0.99
Participate in online discussions/remote courses	306	3.59	0.99
Use IM tools for academic communication	306	3.87	0.96

The use of collaborative platforms (Google Docs, Trello) was relatively low (mean 2.33, SD=0.99), mostly reported as "rarely" (111 respondents, 36.3%) or "sometimes" (87 respondents, 28.4%).

Participation in online discussions or remote courses via platforms like Tencent Meeting or DingTalk was higher (mean 3.59, SD=0.99), with frequent engagement reported by many students.

The strongest area was the use of social media and instant messaging tools (WeChat, QQ) for academic discussions, with a mean score of 3.87 (SD=0.96), frequently used by 68% of respondents.

These results indicate students frequently engage in instant messaging but require greater proficiency with structured collaboration tools to meet the increasing demands of collaborative digital tasks in pharmaceutical contexts.

5. Content Creation and Knowledge Building

This dimension measures students' capacity to produce, manage, and synthesize digital content relevant to pharmaceutical academics and professional contexts. Results in Table 9. indicate moderate proficiency.

TABLE 9 Descriptive Statistics — Content Creation and Knowledge Building Items

Item	N	Mean	Std. Deviation
Create visual materials (charts/posters/presentations)	306	3.12	0.86
Produce multimedia academic/professional content	306	3.09	0.87

Use of digital tools like WPS or Canva for creating pharmaceutical charts, posters, or presentations had a mean score of 3.12 (SD=0.86), predominantly "sometimes" (148 respondents, 48.4%). Similarly, multimedia content production had a mean of 3.09 (SD=0.87), also predominantly "sometimes."The proximity of these means and SDs implies a consistent, occasional engagement pattern across formats. To move from occasional production to purposeful, standards-aligned outputs, instruction can adopt project-based designs that culminate in sharable artifacts (e.g., patient education handouts, pharmacotherapy explainer videos) with clear criteria for accuracy, design, and citation. Such tasks encourage iterative drafting, peer review, and evidence-based communication, which are essential for pharmacy practice.

Self-assessed Digital Literacy Competency

1. Overall Competency Score and Dimensional Comparison

The overall self-assessed digital literacy mean score was 3.03 (SD=0.42), indicating moderate confidence.Table 10 presents descriptive statistics for the five digital literacy dimensions and the composite score. The overall self-assessed digital literacy level was moderate (M = 3.03, SD = 0.42). Among dimensions, the highest means were observed for Technical Proficiency (M = 3.28, SD = 0.60) and Digital Communication and Collaboration (M = 3.26, SD = 0.66), reflecting stronger confidence with general productivity tools and interpersonal technology use. Content Creation and Knowledge Building showed a moderate level (M = 3.11, SD = 0.69), while Information Management Literacy aligned with the overall mean (M = 3.03, SD = 0.53). In contrast, Digital Security Awareness was the lowest (M = 2.51, SD = 0.68), indicating insufficient engagement with proactive cybersecurity behaviors.Pearson correlation tests were employed to assess linear relationships among the five dimensions. The table presents correlation coefficients, significance levels, and 95% confidence intervals (two-tailed tests) for the lower triangular correlation matrix. Results indicate significant positive correlations between all dimensions (most at p<.001), suggesting that subdomains of digital literacy mutually reinforce and co-develop.

TABLE 10 Combined Descriptive Statistics — Dimensions and Overall

Scale / Dimension	N	Mean	Std. Deviation	95% CI Lower	95% CI Upper	Rank (Dimensions)
Information Management Literacy	306	3.03	0.53	2.97	3.09	4
Technical Proficiency	306	3.28	0.60	3.21	3.35	1
Digital Security Awareness	306	2.51	0.68	2.43	2.59	5
Digital Communication & Collaboration	306	3.26	0.66	3.19	3.33	2
Content Creation & Knowledge Building	306	3.11	0.69	3.03	3.19	3
Overall Digital Literacy (Composite)	306	3.03	0.42	2.98	3.08	—

Note. Rank applies to the five dimensions only (Overall not ranked). 95% CI computed as Mean ± 1.96 × SE.

From a dispersion perspective, standard deviations ranged from 0.42 for the composite to 0.69 for CON, suggesting that variability was greater in content-creation-related skills than in the overall self-assessment. The pattern indicates a skills hierarchy in which students feel more comfortable with widely used, general-purpose tools, whereas confidence declines as tasks become more specialized, process-oriented, or risk-sensitive. This hierarchy is consistent with the item-level profiles reported in Section 4.2 and reinforces the need for curriculum-embedded experiences that build advanced, pharmacy-facing competencies without sacrificing fluency in foundational tools.

2. Reliability Analysis of the Instrument

The overall scale showed good reliability (α=0.752), with moderate internal consistency for individual dimensions (α=0.398 to 0.517), suitable for exploratory diagnostics based on established theoretical frameworks.

Comparative Analysis of Digital Literacy by Group

This section examines differences in digital literacy levels among various student groups based on grade level, geographic origin, and previous digital literacy training experiences. Independent sample t-tests and one-way ANOVA were employed to determine significant differences between groups. Results are discussed regarding their implications for targeted educational interventions and curricular adjustments.

1. Digital Literacy by Grade Level

To examine differences in digital literacy across academic levels, a one-way ANOVA was conducted. Results indicated statistically significant differences among the three groups ($F = 4.25$, $p < 0.05$). Post-hoc comparisons using Tukey's HSD revealed that third-year students ($M = 3.17$, $SD = 0.39$) exhibited significantly higher overall digital literacy scores compared to first-year students ($M = 2.93$, $SD = 0.44$, $p < 0.05$). However, no significant differences were observed between second-year students ($M = 3.01$, $SD = 0.42$) and either first-year or third-year students. These findings suggest a progressive enhancement of digital literacy skills through academic advancement, likely reflecting cumulative exposure to digital tools and resources embedded in the curriculum.Table 11 summarises the test results.

TABLE 11 Condensed omnibus tests by grade

Scale / Dimension	Levene_F	Levene_p	ANOVA_F	ANOVA_p	η^2	ω^2	Welch_F	Welch_df	Welch_p
IM	1.267	0.283	6.324	0.002	0.040	0.034	6.113	2.00, 200.79	0.003
TP	0.941	0.391	3.551	0.030	0.023	0.016	3.781	2.00, 194.97	0.024
SEC	2.477	0.086	6.149	0.002	0.039	0.033	7.143	2.00, 192.73	0.001
COL	0.638	0.529	2.161	0.117	0.014	0.008	2.340	2.00, 200.73	0.099
CON	10.254	<.001	9.091	<.001	0.057	0.050	9.259	2.00, 191.51	<.001
Overall (Composite)	4.578	0.011	8.317	<.001	0.052	0.046	9.728	2.00, 192.53	<.001

2. Digital Literacy by Geographic Background

To explore differences based on geographic origin, an ANOVA was performed across urban, township, and rural groups. Results showed significant differences in digital literacy levels ($F = 3.89$, $p < 0.05$). Post-hoc analyses identified that urban students ($M = 3.09$, $SD = 0.40$) scored significantly higher than rural students ($M = 2.91$, $SD = 0.43$, $p < 0.05$). Township students ($M = 3.00$, $SD = 0.41$) showed no statistically significant differences compared to either urban or rural groups. The observed gap highlights the need for targeted digital literacy interventions, particularly for rural students who might face challenges accessing advanced digital resources and infrastructure.

TABLE 12 Overall Digital Literacy by Geographic Background

Origin	N	Mean	Std. Deviation	Std. Error	95% CI Lower	95% CI Upper
Urban	153	3.09	0.40	0.032	3.03	3.15
Township	92	3.00	0.41	0.043	2.92	3.08
Rural	61	2.91	0.43	0.055	2.80	3.02

3 Digital Literacy by Training Experience

An independent samples t-test examined the differences between students who had previously received digital literacy training and those who had not. The results demonstrated a significant difference ($t = 3.72$, $p < 0.01$). Students with previous training ($M = 3.16$, $SD = 0.36$) reported significantly higher digital literacy levels compared to those without training ($M = 2.95$, $SD = 0.44$). The test summary is shown in Table13. This result underscores the effectiveness of structured training programs in enhancing students' digital capabilities and emphasizes the value of integrating formal digital literacy training into the pharmacy curriculum.

TABLE 13 Overall Digital Literacy by Training Experience

t	df	Sig. (2-tailed)	Mean Difference
3.72	304	< .01	0.21

These comparative analyses provide critical insights into the variability of digital literacy among different student groups, highlighting specific areas requiring targeted educational support and interventions. These findings form a basis for strategic curriculum planning and resource allocation to effectively address the identified disparities and enhance overall student digital competency.

Correlation Between Digital Literacy Dimensions

Pearson correlation analyses were conducted to investigate the interrelationships among the five digital literacy dimensions. The results indicated significant positive correlations across all dimensions. Notably strong correlations were observed between Information Management Literacy and Technical Proficiency ($r=0.502$, $p<0.001$), and between Technical Proficiency and Digital Communication and Collaboration ($r=0.510$, $p<0.001$). Moderate correlations were also found between Information Management Literacy and Content Creation and Knowledge Building ($r=0.368$, $p<0.001$), as well as between Digital Communication and Collaboration and Content Creation and Knowledge Building ($r=0.265$, $p<0.001$).Several strong and moderate correlations are observed across digital literacy indicators, reflecting interrelated competencies within students' behavioral and perceptual responses.

These findings suggest that proficiency in one dimension of digital literacy tends to positively influence performance in other dimensions, underscoring the interconnected nature of digital competencies. Therefore, developing targeted educational strategies that enhance multiple dimensions simultaneously may yield greater overall improvements in digital literacy.

Qualitative Findings from Open-ended Questions

To complement the quantitative analysis and gain deeper insight into students' perceptions of digital literacy development, two open-ended questions were included in the questionnaire. These questions aimed to explore: Whether students felt they received sufficient institutional support in developing digital literacy; What digital skills students believed were most important for their future careers and how digital literacy education could be improved .A total of 306 valid responses were collected and analyzed using thematic analysis. The findings were synthesized into four major themes.

1. Insufficient Access to Practical Resources

Many students reported a lack of access to hands-on digital tools and pharmacy-specific software systems, limiting their opportunities to apply digital knowledge in realistic scenarios. The absence of training environments—such as licensed platforms for electronic prescriptions, laboratory systems, or smart pharmacy simulations—was viewed as a major obstacle.

"学校没有提供像药品管理系统或者实验用软件的实际操作机会，都是在纸上谈兵。"(“The school doesn't provide access to drug management systems or lab software; it's all theoretical.”)

This gap underscores the importance of investing in infrastructure that enables students to explore and practice within digital pharmaceutical environments.

2.Limited Opportunities for Practical Engagement

Students also expressed concern over the lack of structured opportunities to apply digital tools in coursework. Although they recognized the value of digital skills, many indicated that their curriculum lacked practical components requiring digital operations, such as data visualization, database use, or digital report preparation.

"平时老师布置作业基本不需要用到什么数码工具，导致我们不知道该怎么用这些工具解决问题。"(“Assignments rarely require us to use digital tools, so we don’t know how to apply them effectively.”)

This theme highlights a need for pedagogical redesign, integrating digital tasks into day-to-day coursework.

3. Demand for Curriculum Integration

A recurring theme was students' desire to see digital literacy systematically embedded into core pharmacy courses. Rather than being introduced in isolated sessions or optional workshops, students argued that digital competencies should be part of instructional content in pharmacology, pharmaceutical care, and research methodology.

"如果老师能把文献检索或数据处理直接融入专业课程中，我们可能更容易上手。"("If literature searching or data processing were integrated into core subjects, it would be easier for us to learn.")

This feedback supports a shift from fragmented digital training to contextualized, discipline-specific integration, aligned with contemporary educational frameworks.

4. Expectations for Career-Relevant Digital Skills and Educational Reform

The second open-ended item asked students which digital skills they considered most essential for future employment and what improvements they suggested. Four subthemes emerged:

4.1. Emphasis on Data Analysis and Literature Retrieval

The most frequently cited digital skills were data analysis (e.g., Excel, SPSS) and literature retrieval (e.g., PubMed, CNKI). Students noted their relevance in clinical trials, drug safety assessment, and pharmaceutical marketing analytics.

"在未来工作中，数据分析技能至关重要，能助力分析药物临床试验数据、市场销售数据等。"("Data analysis is vital for interpreting clinical trial data and sales figures.")

4.2. Exposure to Industry-standard Digital Tools

Students desired training on pharmacy-specific systems such as prescription review platforms, drug supply chain software, and smart pharmacy simulation systems. These were perceived as directly relevant to workplace readiness.

"希望能接触智能药房系统、药物信息管理系统的操作。"("I hope to gain practical experience with smart pharmacy and drug information systems.")

4.3.Call for Case-Based and Applied Learning Models

Students recommended case-based courses, using real or simulated data, and suggested elective modules like "Pharmaceutical Big Data" or "Digital Health Management."

"建议开设《药学大数据分析与应用》《医药数字化管理实务》等选修课，引入企业真实数据或模拟项目。"("Offer electives like 'Pharmaceutical Big Data' and simulate enterprise projects.")

4.4. Involvement of Industry Experts

Students advocated for guest lectures and workshops led by professionals from pharmaceutical digital sectors, aiming to bridge the academic-industry gap.

"多请点人来进行讲解，分享实际数字技术应用经验。"("Invite more professionals to share practical digital application experience.")

In summary, students showed both critical reflection and proactive thinking regarding their digital learning needs. The qualitative responses strongly reinforce the findings from earlier quantitative sections: there is a demand for deeper integration of digital literacy into curriculum design, especially through applied, practice-based, and career-aligned strategies.

Summary of Key Findings

The results of this survey reveal the specifics of digital literacy among pharmacy students in the context of vocational education. While overall digital competence levels appear moderate, substantial variation exists across individual dimensions and learner groups. Notably, students demonstrate stronger confidence and usage patterns in general-purpose digital tools (e.g., Microsoft Office, instant messaging platforms), yet report clear deficiencies in areas that require professional specificity, such as pharmaceutical software operations, cybersecurity awareness, and structured digital collaboration. These discrepancies highlight a mismatch between students' routine digital behavior and the professional competencies demanded by the evolving pharmaceutical industry. Moreover, the modest reliability scores across individual dimensions may reflect a fragmented understanding of digital literacy, reinforcing the need for more cohesive and integrative digital training models within the curriculum. Moreover, the observed positive correlations among the five dimensions of digital literacy underscore the interconnected nature of digital competencies. This indicates that deficits in one area—such as content creation—may also reflect or contribute to challenges in others, such as collaboration or information management. As such, fragmented or superficial approaches to digital instruction are unlikely to yield lasting improvements.

Qualitative insights further emphasize students' demand for authenticity, relevance, and industry alignment in digital literacy training. They call for more hands-on practice, embedded software applications, real-world case analysis, and access to domain-specific digital infrastructure. These perspectives underscore the importance of moving beyond surface-level digital exposure toward deeper, context-driven digital engagement. The data suggest that students are generally aware of the importance of digital literacy for their academic and future professional development, as reflected in their qualitative responses. Many participants explicitly linked digital skills such as data analysis, literature retrieval, and electronic system operation to key tasks in clinical practice, pharmaceutical research, and industry workflows. However, despite this awareness, the study identified significant barriers to the acquisition and application of these skills. These include insufficient access to authentic digital tools and platforms, a lack of integrated digital skill training within the curriculum, and limited exposure to real-world case scenarios that simulate the professional environment.

In conclusion, the digital literacy status of pharmacy students in this context reflects a transitional stage: while basic functional competencies are in place, the deeper, domain-specific, and professionally relevant aspects of digital literacy require urgent attention. For pharmacy education to effectively prepare students for digitally intensive healthcare environments, it must adopt a more integrative, practice-oriented, and contextually grounded approach to digital literacy training.

PHASE II

Introduction to Focus Group Analysis

A focus group discussion was conducted with the purpose of developing a practical and context-specific guideline to enhance digital literacy among pharmacy students at the School of Pharmacy, Jiangsu Food & Pharmaceutical Science College. The discussion aimed to collect expert opinions on existing challenges, strategic solutions, and implementation pathways for improving students' digital competencies in alignment with educational goals and professional expectations.

The focus group consisted of seven participants: five senior educators and academic leaders from the institution, plus two external stakeholders with practice-oriented perspectives. Specifically, the panel included:

Associate Professor Lü Zhiyang, Dean of the School of Pharmacy, who provided strategic perspectives on curriculum development and institutional direction;

Associate Professor Ge Chiyu, Vice Dean of the School of Pharmaceutical Engineering, recipient of the Jiangsu Higher Education "Qinglan Project" award, who contributed expertise in pharmaceutical education and educational policy;

Lecturer Li Jun, from the School of Artificial Intelligence, recognized as an outstanding young teacher with expertise in smart education technology;

Lecturer Han Qiumin, whose research focuses on higher vocational education and instructional reform, offering a cross-disciplinary viewpoint on student engagement and institutional constraints;

Lecturer Lu Weiping, a core instructor in the pharmacy program, who provided frontline insights into student digital learning behavior and skill development;

Pharmacy graduate Li Zichen, who contributed perspectives on transition-to-practice needs and the applicability of digital competencies in early career roles;

Liu Jianbing, Manager at GIANT BIOGENE, who offered industry viewpoints on hiring expectations, workplace digital workflows, and alignment between training outcomes and sector demands.

The discussion was guided by a semi-structured protocol based on Krueger's (2012) model for qualitative group interviews. All participants were invited voluntarily and had consented to the recording and use of their feedback for research purposes. The session lasted approximately 60 minutes and was transcribed verbatim for analysis. A thematic coding framework was then applied to identify shared concerns, pedagogical recommendations, and institutional strategies related to digital literacy enhancement.

This expert input serves as a critical bridge between student needs identified in the survey and the development of actionable educational guidelines. The following sections present the major themes that emerged from the discussion and synthesize the panel's consensus regarding the strategic direction for pharmacy digital literacy development.

Summary of Key Themes

The expert focus group discussion yielded a number of consistent and interrelated themes concerning the digital literacy development of pharmacy students. Through thematic analysis of the transcripts, four overarching areas of consensus were identified: (1) the need for curriculum-integrated digital literacy training, (2) the importance of aligning instructional content with real-world pharmaceutical applications, (3) the role of national policy and industry standards in shaping educational priorities, and (4) the significance of digital competence in enhancing students' employability and career readiness.

Firstly, participants emphasized that digital literacy should not be treated as an optional or supplemental skill set but rather as an essential component of core pharmacy education. Experts consistently advocated for embedding digital literacy training—such as data processing, literature retrieval, and information system operation—directly into the teaching of professional courses, rather than offering them through isolated workshops or general-purpose IT classes. This integration was seen as critical for ensuring both contextual relevance and sustainable learning outcomes.

Secondly, the discussion underscored the need to make digital literacy education more application-oriented. Several experts noted that existing instructional practices often lack connection to actual pharmaceutical scenarios, which limits students' ability to transfer classroom learning to future work environments. Recommendations included designing simulation-based tasks, case-driven data analysis exercises, and interdisciplinary modules that reflect the digital workflows in hospital pharmacies, drug manufacturing, and regulatory settings.

Thirdly, alignment with national policy and evolving industry demands was viewed as a strategic imperative. The experts referenced recent policy initiatives such as the Digital China strategy, the Vocational Education Law (2022 revision), and the integration of digital skills into talent evaluation systems. Participants agreed that digital literacy programs should not only meet internal academic needs but also be benchmarked against broader societal and economic transformations. This includes anticipating trends such as intelligent pharmacy systems, digital pharmacovigilance, and healthcare data governance.

Lastly, all participants highlighted the importance of digital skills in improving students' employability and professional adaptability. Skills such as pharmaceutical software operation, digital information synthesis, and virtual collaboration were described as prerequisites for effective performance in a rapidly digitizing industry. The panel noted that pharmacy graduates without sufficient digital preparedness may face challenges in job entry, on-the-job performance, and lifelong professional development.

These shared themes provide a clear foundation for developing a targeted and context-sensitive digital literacy enhancement guide. The following section presents a more detailed breakdown of expert recommendations and their implications for instructional design and institutional strategy.

Thematic Findings

The expert focus group discussion revealed four central thematic categories that provide practical guidance for addressing the digital literacy challenges faced by pharmacy students. These themes—derived through qualitative coding and cross-comparison of expert insights—reflect a shared understanding of both the current deficits and future opportunities in digital competency development.

1. Curriculum-Embedded Digital Literacy Training

Experts unanimously agreed that digital literacy must be structurally embedded into pharmacy education rather than treated as an auxiliary skill. Several participants emphasized the inadequacy of generic IT instruction and advocated for integrating digital tools directly into professional course content. For example, the use of CNKI and PubMed for literature reviews, Excel for clinical data processing, and electronic prescription systems for simulated practice should become standard components of core modules.

One expert noted: “Digital literacy should not be an add-on. It must be built into the curriculum structure—from drug development to patient education, every step requires digital awareness.”

Incorporating such practices not only contextualizes digital competencies but also reinforces their application across multiple learning environments, making the skills more transferable and relevant.

2. Application-Oriented Teaching Approaches

Another consistent theme was the need to make digital instruction more practical and problem-based. Experts expressed concern that students often engage with digital tools in a superficial manner, lacking opportunities to apply them in meaningful academic or professional contexts. In response, participants recommended the introduction of simulation-based learning environments, including mock prescription review systems, virtual pharmaceutical labs, and real-world data analytics tasks.

As one participant stated: "Students should not just learn how to click through a system—they should be solving actual problems using those systems."

Case-based learning, interdisciplinary collaboration, and task-driven projects were suggested as effective formats to strengthen student engagement and deepen their digital capabilities.

3. Alignment with Policy and Industry Standards

The panel emphasized the importance of aligning digital literacy instruction with national development strategies and evolving industry practices. Multiple experts cited recent policies such as the "Digital China" initiative, national vocational education reforms, and digital competency frameworks introduced in pharmaceutical employment assessments.

One expert commented: "Our training programs must look beyond internal requirements and connect to policy documents and enterprise expectations."

Participants also recommended closer collaboration with local hospitals, pharmaceutical companies, and technology providers to ensure curricular content reflects up-to-date technologies and real-time skill demands.

4. Enhancing Employability through Digital Competence

A core consensus emerged around the link between digital skills and student employability. Experts highlighted that many employers now expect graduates to possess at least baseline competence in drug information systems, electronic medical records, and data interpretation tools. However, current graduates are often underprepared in these areas due to limited exposure during their academic training.

To bridge this gap, experts recommended the following:

4.1Introducing elective courses on pharmaceutical data analytics and digital regulatory compliance.

4.2Increasing simulation-based assessments that replicate job-site digital tasks.

4.3Organizing expert workshops and industry-led seminars on current digital practices.

One expert concluded: "Digital literacy has become just as important as pharmacological knowledge when it comes to workplace readiness."

These thematic insights form the foundation for the development of a digital literacy enhancement guide that is not only pedagogically sound but also contextually and professionally aligned.

Implications for Guideline Development

The insights derived from the expert focus group provide a substantive foundation for developing a practical, institution-specific guideline to enhance digital literacy among pharmacy students. Taken together, the thematic findings highlight several critical implications for instructional design, curricular reform, and strategic implementation within the context of vocational pharmacy education.

First, the emphasis on embedding digital literacy within existing courses calls for a systematic curriculum mapping process. Rather than isolating digital skills in elective or generic computing modules, institutions should identify key digital competencies—such as data analysis, literature retrieval, and prescription system operation—and align them with the learning objectives of relevant core courses. This approach ensures both vertical integration across academic levels and horizontal coherence across disciplines.

Second, the call for application-oriented and problem-based teaching methods implies a need to reconfigure classroom delivery. Educators should consider replacing traditional didactic models with task-driven learning formats that simulate real-world pharmaceutical tasks. The use of virtual labs, mock drug review platforms, and case-based digital assignments not only reinforces students' understanding but also builds confidence in using digital tools independently.

Third, the alignment with national policy frameworks and industry benchmarks requires educators and administrators to engage in continuous environmental scanning. By staying informed about developments in digital health regulations, pharmaceutical technologies, and educational directives, institutions can ensure their training programs remain relevant and future-facing. This also provides a rationale for incorporating modules on regulatory technology, intelligent pharmacy systems, and digital risk management.

Finally, the strong association between digital competency and employability underscores the importance of outcome-based training design. Graduates must be equipped not only with foundational digital knowledge but also with the operational fluency to navigate emerging digital systems in clinical, industrial, and administrative pharmacy contexts. This calls for greater emphasis on simulation assessments, capstone projects involving enterprise data, and enhanced collaboration with industry stakeholders.

In summary, the expert feedback underscores that digital literacy in pharmacy education must evolve from peripheral skill-building to a strategic educational imperative. The development of a digital literacy enhancement guideline should therefore be grounded in four principles: curricular integration, contextual relevance, policy alignment, and employability orientation. These principles will inform the recommendations presented in the following chapter.

CHAPTER V

CONCLUSION AND DISCUSSION

This chapter consolidates the study's results and articulates their significance for pharmacy education at Jiangsu Food & Pharmaceutical Science College. The preceding chapters established the conceptual framework, described the mixed-methods design, and reported findings from the student survey and the expert focus group. Here, these strands are brought together to clarify what the evidence means, why it matters, and how it can inform practice.

Summary of the Research

This study examined the current state of digital literacy among pharmacy students at Jiangsu Food & Pharmaceutical Science College and developed institution-appropriate guidance for improvement. A mixed-methods design was employed in two phases. Phase I used a cross-sectional questionnaire to assess behaviors and self-perceived competencies across five dimensions: Information Management Literacy, Technical Proficiency, Digital Security Awareness, Digital Communication and Collaboration, and Content Creation and Knowledge Building. Open-ended items captured students' perceptions and needs. Phase II convened an expert focus group to interpret the evidence and propose feasible strategies for curriculum and instruction.

A total of 306 valid student responses provided adequate statistical power and balanced representation across grades and regional backgrounds. Descriptive analyses indicated a moderate overall level of digital literacy ($M = 3.03$, $SD = 0.42$). Students reported higher confidence with general productivity and communication tools and lower performance in cybersecurity practices and domain-specific software. The instrument demonstrated acceptable reliability at the full-scale level ($\alpha = 0.752$). Correlation analyses showed positive relationships among all five dimensions, suggesting that development in one area can support progress in others. Group comparisons indicated differences associated with prior training and background factors, which points to the role of exposure and access in competency development.

The qualitative responses from Phase I converged on three needs: more authentic pharmacy-facing resources, increased opportunities for structured practice, and systematic curricular integration of digital tasks. The expert panel in Phase II confirmed these needs and translated them into practical directions. Consensus highlighted embedding digital competencies within core pharmacy courses, adopting application-oriented pedagogies such as simulations and case-based data tasks, aligning content with national policy and industry expectations, and linking assessment to employability and workplace readiness.

Taken together, the two phases provide an empirical baseline for students' digital literacy and a coherent pathway for improvement. The findings supply the basis for the discussion, implications, and recommendations that follow.

Discussion

The present study provides a comprehensive account of digital literacy among pharmacy students in a vocational education context and translates the evidence into a coherent pathway for improvement. Students demonstrate a foundational level of general digital competence, yet they face persistent challenges in skills that are central to professional practice. These include secure data handling, electronic prescription or information system use, and data analysis for clinical or quality tasks. Given that pharmacy is a data-intensive profession in which accuracy, privacy, and traceability are critical, this discrepancy indicates a need to recalibrate digital literacy instruction from general exposure toward discipline-specific applications.

The positive correlations observed among the five dimensions support the view that digital literacy operates as a connected system rather than a set of isolated skills. Instructional designs that integrate information retrieval, data processing, collaboration, and content creation within realistic tasks are therefore likely to produce compounded learning gains. This position is consistent with strategies emphasized in the literature, including curriculum-embedded delivery and authentic, practice-oriented tasks.

The Guidelines operationalize this integrated approach through curriculum embedding. Digital tasks are anchored in core courses across academic years, and students complete small, observable activities in class and then assemble evidence outside class. Signature tasks exemplify this integration, including a prescription-review micro-project, an introductory pharmacovigilance task using sample data, and a lightweight quality or supply-chain dashboard developed with spreadsheet tools. Each task ties a specific digital skill to a recognizable professional workflow and is designed to be feasible within existing teaching schedules .

Group comparisons in this study underscore the importance of equitable access to digital learning opportunities. Students with prior exposure or better access to resources report higher competence. The Guidelines respond with explicit equity measures, including a short bridge program for students with lower baselines, peer mentoring and scheduled consultations, and early-warning checks that trigger tailored remedial tasks. These elements align with recommendations for scaffolding, targeted support, and provision of shared digital infrastructure to mitigate background-related disparities.

The alignment between student feedback and expert judgments provides additional validation for the direction of change. Both groups call for authentic resources, simulation-based practice, and course-embedded digital tasks. The Guidelines are therefore grounded in design principles supported by prior studies: embedding competencies across courses to improve transferability, building simulation or lab-based environments for repeated practice, and involving industry partners to strengthen employability relevance (Guoxing et al., 2024).

The measurement profile observed in Phase I was acceptable at the full-scale level, with modest consistency within subscales, which is typical for brief, multidimensional instruments used for diagnostic purposes. The Guidelines respond to this diagnostic need with an assessment blueprint that emphasizes reproducibility, traceability, clarity, and compliance. Students submit compact evidence sets (e.g., search logs, data-flow records, version history, meeting minutes, finished outputs, compliance artifacts). Formative checks focus on process quality and improvement, while summative assessments evaluate performance in realistic scenarios with shared rubrics and course-level calibration (Aydınlar et al., 2024; Mielitz et al., 2024).

Feasibility is addressed through governance, faculty development, infrastructure, and a staged timeline. The Guidelines propose a small school-level working group, two to three short practice-oriented workshops for instructors each year, and a minimal supported toolkit that guarantees stable access to core databases and at least one simulation system. A three-semester rollout is recommended: pilot implementation in two courses, expansion to a core cluster with integrated simulation tasks, and program-wide implementation followed by an initial effectiveness review. These provisions echo literature that stresses sustained faculty development and institutional support as preconditions for meaningful digital transformation .

Taken together, the study's findings and the associated Guidelines contribute to pharmacy education in three ways. Conceptually, they clarify how general skills and domain-specific practices diverge and how competencies reinforce one another. Empirically, they triangulate quantitative patterns with student narratives and expert consensus, thereby strengthening the case for change. Practically, they convert evidence into an implementable model—curriculum-embedded, context-authentic, security-aware, and employability-oriented—consistent with improvement strategies identified in the literature review. The complete specification of the model is provided in Appendix B: Digital Literacy Enhancement Guidelines for Pharmacy Students, which is intended for course teams and program leaders to adopt and adapt .

Implications of the Study and Recommendations

The findings of this study carry significant implications for pharmacy education in vocational institutions, particularly in the context of a rapidly digitizing healthcare landscape. As pharmacy practice increasingly relies on data-driven systems, digital platforms, and intelligent decision support, the cultivation of digital literacy must evolve from a peripheral concern into a central component of professional training. The current research underscores both the urgency and the feasibility of this shift.

At the institutional level, the results indicate a pressing need to restructure curricula to support the progressive acquisition of digital competencies. Rather than relying on one-off trainings or elective modules, pharmacy programs should embed digital literacy within core academic and practical courses. This integration ensures that students are exposed to relevant technologies in authentic disciplinary contexts, which facilitates not only skill development but also the internalization of digital practices as professional norms. Curriculum reform efforts should therefore emphasize application-oriented strategies, such as case-based data interpretation, virtual simulations of pharmacy workflows, and collaborative digital projects that mimic real-world problem-solving tasks.

From a pedagogical perspective, the study suggests that effective digital literacy development requires more than familiarity with tools; it demands opportunities for sustained practice, reflection, and feedback. Educators should be supported to adopt constructivist approaches that situate digital tasks within meaningful contexts. At the same time, institutional leadership must provide technical infrastructure, accessible digital resources, and ongoing faculty development to maintain alignment between instructional goals and technological capabilities.

In terms of policy and alignment with national strategies, the study affirms the importance of synchronizing institutional initiatives with the broader digital literacy agenda articulated in China's 14th Five-Year Plan and related vocational education directives. The proposed guideline, grounded in both empirical evidence and expert consultation, offers a blueprint for schools aiming to operationalize these policy imperatives. Key strategies include setting digital literacy benchmarks, designing scaffolded skill progression models, and establishing mechanisms for continuous assessment and feedback.

For students, the implications are equally clear. Digital literacy is not only essential for academic success but increasingly determines employability and readiness for pharmaceutical work environments. By prioritizing digital competencies in training, institutions can enhance students' confidence, adaptability, and long-term professional growth. To this end, educators should also cultivate students' awareness of the relevance of digital skills and foster a proactive attitude toward lifelong digital learning.Based on these implications, this study recommends the following actions:

Curriculum Integration: Embed digital literacy outcomes across pharmacy courses, ensuring alignment with course content and assessment tasks.

Simulation and Case-based Training: Utilize scenario-based learning to teach digital skills through realistic pharmaceutical contexts.

Equitable Access and Support: Provide universal digital literacy orientation and offer targeted support for students with weaker backgrounds.

Ongoing Professional Development: Encourage and support pharmacy faculty in adopting digital teaching practices through training and collaboration.

Institutional Policy Alignment: Ensure that digital literacy initiatives reflect national digital development strategies and the specific technological demands of the pharmaceutical sector.

By implementing these recommendations, pharmacy education programs can more effectively equip students with the digital competencies necessary for academic success and career readiness in a rapidly evolving professional landscape.

Limitations of the Study

While this study provides meaningful insights into the digital literacy of pharmacy students and presents a data-driven guideline for enhancement, several limitations must be acknowledged. These limitations pertain to the scope of the research design, the characteristics of the participant sample, and the interpretive boundaries of the data collected.The study was conducted within a single institutional context—namely, the School of Pharmacy at Jiangsu Food & Pharmaceutical Science College. Although this setting is representative of vocational pharmacy education in China, the generalizability of the findings to other institutions, disciplines, or regions may be limited. Future research should consider expanding the sample to include multiple colleges or universities to validate and refine the findings across diverse educational environments. And the qualitative data—both from open-ended student responses and expert focus group discussions—provided rich contextual insights. However, the scope of thematic analysis was constrained by the number of participants and the time-limited nature of the discussions. More extensive qualitative inquiry, including follow-up interviews or multiple rounds of expert consultation, could yield deeper and more nuanced perspectives. Finally, while this study proposed a practical guideline for enhancing digital literacy, its actual implementation and impact were not assessed within this research. Future work should involve piloting and evaluating the guideline in real instructional settings to examine its feasibility, effectiveness, and potential for scaling.

In sum, although these limitations constrain the scope of generalization and inference, they do not detract from the overall contribution of the study. Rather, they highlight avenues for future research and underscore the need for ongoing investigation and institutional experimentation in the evolving landscape of pharmacy digital education.

Recommendations for Further Studies

Future investigations should broaden the empirical base and strengthen causal inference. Studies conducted across multiple institutions and regions would test the transferability of the present findings, while longitudinal designs that follow cohorts from entry to internship would clarify developmental trajectories. Where feasible, quasi-experimental or experimental evaluations of curriculum changes and targeted training should be used to assess impact with pre-post measures and appropriate comparison groups.

Measurement warrants deliberate refinement. Expanding item pools within each dimension and conducting confirmatory factor analysis would improve construct representation. Tests of measurement invariance across grade, gender, and background are recommended to secure comparability. Self-report scales should be complemented with performance-based assessments such as scenario tasks, OSCE-style digital stations, or analyses of anonymized activity logs. Shared rubrics can anchor ratings across courses and semesters to support reliable evaluation.

External validation is also needed. Linking student results to instructor ratings, preceptor feedback during internships, and employer evaluations in early career would establish predictive validity for academic and workplace outcomes. Outcome tracking may include internship performance indicators, placement rates, and supervisor assessments, providing a clearer picture of how digital literacy relates to employability and readiness for professional roles.

Implementation research should examine feasibility, fidelity, and sustainability when the guideline is enacted at course and program levels. Improvement-oriented approaches such as Plan–Do–Study–Act cycles can document how teaching practices adapt and stabilize over time.

Finally, future work should address system alignment and instructional capacity. Case studies of partnerships among schools, hospitals, and enterprises can identify practical models for co-designed tasks, secure data access, and supervision. Research on digital ethics and data governance in educational settings is needed to ensure privacy and compliance. Faculty development should be evaluated systematically to determine which formats lead to durable instructional change. Technology-enhanced learning tools, including simulated electronic records and prescription review systems, should be tested for their educational value. Comparative studies across health disciplines and institutional types will help determine the generalizability of effective practices.

Together, these directions would consolidate the evidence base, strengthen the validity of measurement and inference, and support iterative refinement and scaling of the proposed digital literacy guideline.

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Appendix A: Survey Questionnaire on Digital Literacy of Pharmaceutical Students

Digital Literacy Questionnaire for Pharmacy Students

Dear Classmate:

Hello! Thank you very much for taking time out of your busy schedule to complete the questionnaire! The purpose of this questionnaire is to understand your current digital literacy and provide indicators for constructing digital literacy related to pharmacy students. There are no right or wrong options, so please select the appropriate option for your situation. This survey will take about 5 to 10 minutes. Information is collected anonymously and all information will be kept absolutely confidential without revealing any of your personal information and privacy. Thank you very much for your cooperation! We wish you a happy life!

Section 1: Background information

1.Your grade level is:

☐ Year 1

☐ 2nd year

☐ 3rd grade

2.Birthplace:

☐Cities

☐Townships

☐Rural

3.What digital devices do you typically use? (Multiple choice)

☐ Computer

☐ Flatbed

☐ Smartphones

☐ Other: _____

Behavioral Frequency Scale: Please select the option that best matches the frequency of your behavior based on your actual usage (1=never, 2=rarely, 3=sometimes, 4=often, 5=always).

4. How often I use online databases (e.g., PubMed, CNKI) to search for pharmacy-related literature or information:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

5. how often I regularly organize and back up my digital notes, research data, or files:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

6. How often do I look up references through search engines or databases when completing coursework:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

7. How often I learn/use specialized pharmacy software (e.g., drug management systems, laboratory information management systems):

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

8. How often I use data analysis tools (e.g., Excel, SPSS) to process the results of my experiments during labs or internships:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

9. How often I use Microsoft Office software (e.g., Word, Excel, PowerPoint) to write reports or create presentations:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

10. the frequency with which I regularly update and manage my passwords (including academic accounts, email, social media, etc.):

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

11. How often do I take additional security measures (e.g. VPN, data encryption) when using public networks:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

12. I regularly back up important personal data and academic documents to prevent the frequency of data loss:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

13. How often I use collaboration tools (e.g., Google Docs, Trello) to work with others on team assignments:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

14. How often do I participate in online discussions or telecourses through online tools (e.g. Tencent Meetings, Nail):

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

15. How often I use social media or instant messaging tools (e.g., WeChat, QQ) to discuss study issues with classmates or tutors:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

16. How often I use digital tools (e.g., WPS, Canva) to create pharmacy-related charts, posters, or presentations:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

17. How often I use video editing software or multimedia tools to produce digital content for professional research or projects:

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

18. How often I organize and share pharmacy-related learning through electronic note-taking software (e.g., Evernote, OneNote):

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

19. Does the school provide opportunities for specialized digital literacy training (e.g., digital skills lectures, workshops, etc.)?

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

20. Have I ever learned relevant skills such as information management, digital security or technology operations through courses or resources provided by my school?

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

21. Do I have access to tutoring or help with digital skills from teachers or relevant departments at my school?

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

22. Does the school provide students with formal training in the use of specialized pharmacy software or other digital resources (e.g., data analysis software, pharmacy information systems, etc.)?

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

23. have I had sufficient opportunities to apply digital literacy to practical projects or tasks in my pharmacy courses during my studies?

☐ 1 Never ☐ 2 Rarely ☐ 3 Sometimes ☐ 4 Often ☐ 5 Always

Part 2: Likert Scale - Self-Assessment

Please rate your agreement with the following statements on a scale of 1 to 5, with 1 being "completely disagree" and 5 being "completely agree".

1. I am able to effectively search academic resources (e.g., pharmacy research articles, databases) online.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

2. I can judge the accuracy and reliability of online information and screen credible academic materials.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. I am able to effectively organize and manage my digital files and data so that I can find and use them later.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

4.I am proficient in using Microsoft Office (e.g. Word, Excel, PowerPoint) for academic work and report writing.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

5. I am able to use specialized pharmacy software (e.g., drug management systems or laboratory information management systems) for data recording and analysis.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

6. I am able to select appropriate digital tools to accomplish pharmacy-related tasks (e.g., database queries, charting, etc.) based on actual needs.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

7, I can effectively protect personal privacy and am familiar with commonly used password management and data encryption methods.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

8. I understand and can apply basic network security measures to prevent malware and data leakage.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

9. I am able to recognize phishing and other cyber-attacks and take the necessary steps to protect against them.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

10, I am able to communicate effectively via email or instant messenger to complete group assignments or projects.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

11, I am able to use digital collaboration tools (e.g., Google Docs, Trello) to work with classmates on tasks.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

12. I am able to utilize video conferencing tools (e.g. Tencent Meetings, Teams) to participate in distance learning or discussions.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

13. I am able to use a variety of digital tools (e.g., video editing software, image processing tools) to create and present my scholarship.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

14. I am able to integrate and reconfigure existing knowledge through digital tools to create new content.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

15. I am able to use digital tools (e.g., electronic notes, knowledge bases) for knowledge management and sharing in pharmacy research.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Part 3: Open-ended questions

1. What digital skills do you think will be most important for your employment in the future? What specific suggestions do you have for improving digital literacy training for pharmacy students?

(Please fill in:)

Appendix B: Digital Literacy Enhancement Guidelines for Pharmacy Students

To support the digital transformation of vocational education and the digitization of pharmaceutical industry workflows—and in response to this study's evidence-based findings on students' digital literacy status, shortcomings, and pathways for improvement—this guideline adopts the overarching principle of "curriculum-embedded, context-driven, and evidence-verifiable". It establishes a comprehensive framework for pharmacy students' digital literacy, including competency standards, curriculum mapping, signature tasks, assessment blueprints, faculty development, and mechanisms for continuous improvement.

Purpose

To enhance the digital literacy of pharmacy students in alignment with both academic and career competence goals, and to establish a transferable, assessable, and sustainable development system.

Scope

The target group comprises full-time pharmacy students in higher vocational education, covering all three academic years (general education, professional training, and integrated/final year). Teaching activities span classroom instruction, laboratory and practical sessions, integrated projects, and collaborative practices involving schools, hospitals, and enterprises.

Design Principles

1.Evidence-led

Guided by the diagnostic results of this study, the guideline prioritizes addressing identified weaknesses in security and compliance, structured collaboration, and authentic learning contexts. All proposed improvements are supported by both process and outcome evidence, ensuring auditability and reusability.

2.Framework Alignment

The guideline's five dimensions of digital competence—information management, technical proficiency, digital security, communication & collaboration, and content creation & knowledge construction—are systematically mapped to widely recognized digital literacy frameworks. Each dimension is operationalized through observable classroom behaviors, sample evidence, and clearly defined scoring anchors.

3.Security-by-Design

Security and compliance are treated as embedded and essential components rather than supplementary concerns. Key measures include unified account systems with minimal privileges, data de-identification, activity logging, and traceable accountability. These principles are integrated into every course and project, and reflected in task design and assessment criteria.

4.Curriculum-Embedded

Digital literacy objectives are fully aligned with the learning goals of pharmacy core courses. Each core course includes at least one signature task, directly linked to both the course's key competency outcomes and real-world industry scenarios.

5.Authentic Contexts

Tasks are structured around high-frequency professional scenarios (e.g., prescription review, adverse drug reaction monitoring, quality control, and pharmaceutical communication). Real, de-identified, or synthetically generated data are used, along with industry-standard tools or open-source alternatives, to ensure contextual authenticity.

6.Assessability

Both formative and summative assessments are employed. Evaluation is supported by an assessment blueprint, scoring rubrics, and an evidence-matching table (including search logs, data flow records, version history, meeting notes, and compliance checklists). Assessment processes are designed to be traceable and verifiable.

7.Equity & Access

A layered, compensatory, and reinforcement-based approach is adopted: onboarding boot camps, peer mentoring, and scheduled tutoring sessions. Early warning systems and individualized remedial tasks are provided for students with lower starting levels, aiming to close gaps in training and resource access.

8.Policy & Industry Coherence

Instructional goals, task designs, data flows, and key performance indicators are aligned with national policy directives and industry workflow standards. A coordination mechanism is established between the college and relevant stakeholders (hospital pharmacy departments, pharmaceutical companies, regulatory agencies), supporting iterative co-construction on an annual basis.

Competency Framework and Learning Outcomes

This framework adopts five key dimensions of digital literacy: Information Management [IM], Technical Proficiency [TP], Digital Security Awareness [SEC], Digital Communication and Collaboration [COL], and Content Creation and Knowledge Building [CON]. Each dimension is structured across three progressive levels:

Introductory level: aligned with first-year foundational and laboratory-based courses

Application level: aligned with second-year core professional courses and practical training

Integration level: aligned with comprehensive assessments, capstone projects, and industry internships

All course examples are drawn from the existing curriculum, allowing instructors to directly adopt them and assign concise, task-based evidence within classroom settings.

1.Tiered Competency Descriptions and Course Anchors

Introductory Level: “Able to locate, record, and comply”

Students at this level are expected to demonstrate basic capabilities such as information retrieval, data organization, and adherence to security protocols (e.g., access control and audit logs). These foundational competencies are recommended to be embedded into courses such as Basic Chemistry Laboratory, Biochemistry, and Introduction to Clinical Medicine, through exercises that produce reproducible search records and structured data tables. These courses are already scheduled for the second semester of the first year, enabling a seamless learning progression.

Application Level: “Able to apply, apply correctly, and explain clearly”

This level focuses on students’ ability to apply digital skills accurately in professional contexts. Courses such as Pharmacology, Pharmaceutical English, Drug Dispensing Laboratory, and Pharmaceutical Service Practices should incorporate scenario-based tasks involving prescriptions or case studies. Recommended outputs include team-based task division with version tracking, consistent interpretation formats, and data visualizations, culminating in structured oral or written reports tailored for both patients and professionals.

Integration Level: “Able to solve real-world problems through synthesis”

At this level, students are expected to integrate digital competencies to address complex, authentic issues. Suggested implementations include regulatory data management, prototype dashboards, and evidence-based briefings within courses such as Pharmacotherapeutics, Pharmaceutical Service Practicum, and Pharmaceutical Regulations and Management, as well as during comprehensive assessments or graduation projects. Deliverables should form cross-dimensional evidence portfolios, supported by oral defense.

Multiple rounds of classroom feedback indicate that students strongly prefer integrating digital skills—particularly data retrieval and processing—into professional coursework, and request earlier exposure to industry-relevant systems and scenarios. In response, this framework binds micro-tasks that emphasize practical utility directly to course milestones, thereby avoiding the need for additional standalone digital literacy courses or broad curricular overhauls.

2. Sample Learning Outcomes Matrix

This matrix is intended to serve as a reference for instructors, who may adjust indicators and tasks according to course-specific contexts.

Dimension	*Introductory Level (Y1: Foundational/Laboratory Courses)*	*Application Level (Y2: Core Courses/Practicals)*	*Integration Level (Y3: Capstone/Graduation Projects)*
IM	In Basic Chemistry Lab, complete a reproducible literature search and citation list, including search strings and inclusion/exclusion criteria. In Biochemistry, organize raw data and apply standardized file naming conventions.	In Pharmacology, conduct a structured search on a drug-use problem and extract evidence. In Pharmaceutical English, complete an abstract and bilingual terminology table.	In Pharmacotherapeutics and Pharmaceutical Services Practicum, write a 1000–1500-word evidence-based briefing per case and defend it orally, including full citations and evidence grading.
TP	In Basic Chemistry Lab, complete a reproducible literature search and citation list, including search strings and inclusion/exclusion	In Drug Dispensing Technology Lab, batch process prescription fields and generate a checklist of issues. In Pharmaceutical Service Practices,	In the final assessment or graduation project, build a lightweight dashboard or data pipeline; submit calculation log and reproducible experiment

	criteria. In Biochemistry, organize raw data and apply standardized file naming conventions.	produce a one-page key metrics card.	package.
SEC	In all Y1 assignments involving data, apply strong passwords and minimum access permissions; submit screenshot of operation log and a self-check checklist.	In Pharmaceutical Regulations and Management, complete a "before-and-after de-identification" sampling check. For prescription tasks, submit a permission matrix and version tracking records.	In the graduation project/internship portfolio, complete archiving and re-publication review of compliance materials; incomplete items are excluded from final evaluation.
COL	In *Intro to Clinical Medicine* or *Biochemistry*, build a RACI matrix and version history for a team task; submit a one-page meeting summary.	In Pharmaceutical Service Practices and Pharmacology, complete a group presentation with peer review forms, document areas of improvement, and update versions accordingly.	In Pharmaceutical Services Practicum and final assessments, deliver cross-role presentations and oral defense; submit a reflection report.
CON	In Basic Chemistry Lab, create a draft	In Pharmaceutical English and	In Pharmacotherapeutics

	infographic or data visualization with legend and explanation.	Pharmaceutical Service Practices, produce parallel materials: one for patients and one for professionals.	or Graduation Project, develop a structured knowledge product (e.g., briefing or dashboard manual) to be finalized after peer review.

3.Micro-Classroom Tasks and Evidence Requirements (Cross-Course Applicable)

Classroom activities prioritize "small-scale, observable" micro-tasks. Each task is designed to complete core steps within one to two class sessions, with the remaining components compiled as a post-class evidence package. The standard six-piece evidence set includes: Search records、 Data flow diagrams、 Version history、 Meeting minutes、 Final deliverables、 Compliance tracking artifacts.

Student feedback collected through multiple open-ended responses revealed a strong preference for "real systems and case-based tasks." In response, de-identified or synthetic data may be used in classroom scenarios, with a primary emphasis on methodological reproducibility and process-oriented learning.

4.Alignment with Student Learning Expectations (Teaching Recommendations)

Most students prefer to integrate literature searching and data processing directly into their professional coursework. They also express interest in early exposure to practical scenarios such as prescription review, pharmacovigilance, and quality assurance. Therefore, instructors are advised to prioritize frequently encountered, real-world problems specific to the course when designing tasks. Concise and high-frequency exercises are more likely to be accepted, internalized, and transferred to other contexts.

Curriculum Embedding & Course Mapping

Classroom-based micro-tasks with “compact and dense” design are more likely to be adopted and reused. Each course should identify only one primary integration point, where core task steps are completed within one to two class sessions. Remaining components are submitted as assignments to complete the six-part evidence package. Integrated projects and final-year activities will then serve to recombine these distributed competencies, forming end-to-end scenario-based solutions and oral defenses.

1.Course-to-Task Embedding Map (Sample Version, Adaptable to Local Curriculum)

A visual or tabular mapping of courses to embedded tasks will follow here. It can be customized based on specific course structures and institutional teaching arrangements.

Semester/Course	Suggested Embedding Points (One-Sentence Classroom Activity)	Coverage Dimensions	Classroom Duration	Submissions and Evidence (Minimum Six-Piece Set)
Second Semester :“Fundamental Chemistry Experiments”	Starting from a set of original experimental records, complete a reproducible search and basic cleaning, and visualize a key result.	[IM][TP][SEC]	1–2 class period	Search queries and logs, data dictionary and cleaning steps screenshots, finished charts, minimum permissions and log screenshots, naming and version records
Second	Focusing on common	[CON][CO	1 class	Dual-version

Semester :“Introduction to Clinical Medicine ”	medication education points, groups created two versions of information cards, “patient version” and “professional version,” and completed a peer review.	L][IM]	period + after class	cards, reference entries and citations, review forms and revision records, meeting minutes (≤1 page)
Second Semester: Biochemistry	Using enzyme kinetics data as an example, create a standardized one-page results report and write a method description.	[TP][CON][IM]	1–2 class period	Caliber table, charts and explanations, method records, file naming and versioning
Third Semester: “Pharmacology”	Focusing on the use of a specific drug, complete a systematic search and evidence extraction, and give a 2-minute oral presentation.	[IM][CON]	1class period	Retrieval and exclusion records, evidence excerpt table, 2-minute outline
Third Semester: “Pharmaceutical Professional English “	Translate the output from the previous task into an English abstract and create a glossary of terms.	[CON][COL]	1class period	English abstract, glossary (Chinese-English), version history
4th Semester:	Batch-process	[TP][SEC]	2class	Field mapping and

Pharmaceutical Compounding Techniques Laboratory	simulated prescription fields, generate a list of issues and severity ratings (prescription review prototype).	[IM]	period	data dictionary, issue list, permission matrix and data masking examples
4th Semester: “Pharmaceutical Services Training”	Conduct a“patient communication demonstration + debriefing” in a prescription scenario, document the process, and iterate.	[COL][CON][SEC]	1class period	Presentation materials, minutes and improvement list, operation logs and re-release review
4th Semester: “Pharmaceutical Affairs Management and Regulations”	Complete a “de-identification before and after sampling verification” and record under the comparison of regulatory provisions	[SEC][IM]	1class period	Data Masking Rules and Sample Evidence, Compliance Self-Checklist, References and Entry Links
4th Semester: “Pharmacotherapy”	Write a 1,000–1,500-word evidence-based report based on a case study and give a	[IM][CON][COL]	1class period + after class	Quick Report Text and Charts, Search and Inclusion/Exclusion Records, Review

	5-minute presentation.			and Revision Records
5th Semester: "Comprehensive Pharmacy Skills Assessment"	Integrate prescription review, patient education, and small signage into an end-to-end demonstration, and complete an audit checklist	Five-dimensional integration	Assessment period	Full Process Evidence Package: Flowchart, Rule Table and Issue List, Dual Version Materials, Data Dictionary and Kanban Prototype, Compliance Materials
7th Semester: "Graduation Project (Thesis)"/Internship	Select a pain point in a company/hospital for a small-scale improvement project, and submit a methodology report and a transferable process	Five-dimensional integration	According to the training program	Methodology Report, Final Product and User Manual, Defense Materials, Permission Matrix and Logs, Post-Mortem Report

2. Teaching Organization and Suggested Proportions

Classroom instruction should primarily follow a "demonstration first, then hands-on" model. Instructors are encouraged to demonstrate a small-scale exemplar, after which students complete the core steps using course-relevant data within the same session. Each course is recommended to allocate 4%–8% of the participation grade to micro-tasks, in order to avoid displacing core content instruction. In capstone stages, these fragmented pieces of point-based evidence accumulated throughout the semester are consolidated into chain-based evidence through oral defense sessions and targeted compliance checks.

3.Evidence Standards and Baseline Thresholds

Only task outputs supported by traceable evidence are counted toward performance assessment. Assignments involving data or external-facing materials must undergo minimum access control configuration, data de-identification, and activity logging prior to submission. Samples that fail spot checks will not be counted in the final participation grade. For prescription scenarios, pharmacovigilance excerpts, and quality dashboards, students are required to undergo an end-to-end audit and oral defense during integrated skill assessments or graduation projects.

Year-by-Year Examples of Dimension-Based Task Embedding

The learning progression follows a scaffolded path from “able to retrieve, record, and comply”, to “able to apply, articulate, and collaborate”, and ultimately to “able to integrate, defend, and transfer.” Each sample task is designed to be demonstrable within a class session and completable within the same week. Deliverables should emphasize observable, verifiable evidence, supporting streamlined grading and review.

Teaching teams should select the most appropriate anchor points based on the course schedule at their institution. For example: Introductory-level tasks may be scheduled in second-semester courses such as Basic Chemistry Lab or Introduction to Clinical Medicine.

Application-level tasks may align with third- to fourth-semester courses such as Pharmacology, Pharmaceutical English, Drug Dispensing Technology Lab, Pharmaceutical Service Practices/Practicum, and Pharmaceutical Regulations and Management. Integration-level tasks should be implemented in Pharmacotherapeutics, Pharmacy Comprehensive Skills Assessment, or Graduation Project modules. The approach does not aim for comprehensiveness within a single class. Instead, instructors demonstrate one critical operation first, and students complete the supporting evidence components within the same week, submitting them according to the grading rubric. Each dimension requires only one to two minor exercises per semester, and a 4%–8% weighting in participation grades is sufficient for consistent implementation.

Dimension	Introductory Level (Y1: Foundational Courses)	Application Level (Y2: Core Courses)	Integration Level (Y3: Capstone & Assessment)
[IM]	Complete a reproducible literature search and citation assignment in the basic laboratory or medical overview unit, including the search query, inclusion/exclusion criteria, and a brief summary. Classroom demonstrations can be conducted in "Basic Chemistry Laboratory" or "Clinical Medicine Overview."	Complete a systematic search and evidence extraction for a specific type of medication issue, accompanied by a two-minute oral presentation. This is suitable for the terminology comparison exercises in Pharmacology or Pharmaceutical Professional English.	Produce a 1,000–1,500-word evidence-based short report based on a case study and defend it. This is suitable for the demonstration points in Pharmacotherapy and comprehensive skills assessment.
[TP]	Complete a field and basic charts based on the foundational	Complete batch cleaning and indicator summarization on	In the comprehensive phase, build a reproducible

	experimental data, accompanied by a data dictionary and step-by-step screenshots, suitable for completion within the "Fundamentals of Chemical Experiments" course.	simulated prescriptions or inventory tables, accompanied by a scope table and small diagrams, suitable for inclusion in "Pharmaceutical Compounding Techniques Experiment" or "Pharmaceutical Services Practice."	experimental package consisting of a mini dashboard or method report to provide a data foundation for the final presentation, suitable for inclusion in comprehensive skill assessments or graduation projects.
[SEC]	Apply minimum access controls and submit operation log screenshots for any data-related assignments. Compile a one-page self-checklist. Recommended as part of introductory coursework.	Conduct a de-identification sampling check and self-review before re-publishing assignments in Pharmaceutical Regulations & Management. Submit permission matrices and sampling records.	Complete archiving and compliance closure tasks for graduation portfolios. Submissions not meeting the standard are excluded from final assessment. Suitable for capstone or graduation stages.
[COL]	Establish a RACI matrix and write meeting minutes for group work. Include	In a scenario-based task, complete a peer review and revision cycle. Submit a	Deliver a cross-role oral defense and reflection report during final

	screenshots of version histories. Recommended for Biochemistry or Intro to Clinical Medicine.	"priority revision list." Suitable for Pharmaceutical Service Practices or Pharmacology.	presentations. Merge documentation with IM/CON outputs. Suitable for Comprehensive Skills Assessment.
[CON]	Submit a one-page infographic or bulletin draft with caption and explanation. Suitable for Basic Chemistry Lab.	Produce two parallel short-form texts—one for patients, one for professionals—highlighting terminology and visual alignment. Recommended for Pharmaceutical English and Service Practicum.	Deliver structured knowledge products, such as a finalized evidence brief, dashboard user guide, or handover workflow, as part of the final evaluation package.

All submissions involving data or external-facing content must, by default, undergo a [SEC] micro-cycle (Security and Compliance checks). Submissions that do not meet minimum thresholds are permitted one opportunity for revision and re-submission within a specified timeframe, thus avoiding the discouragement caused by high-pressure, one-time assessments.During comprehensive skills assessments or graduation projects, the point-based evidence collected throughout the semester should be consolidated by dimension, forming a coherent grading pathway and a traceable evidence archive. All anchor points are derived from existing course plans, ensuring they can be adopted without requiring additional administrative approval.

Assessment Strategy

The evaluation operates in a minimal closed-loop system based on "key actions in the classroom + evidence supplementation within the same week." The classroom only demonstrates methods and completes core steps, while students submit a minimal set of evidence within the same week. Assignments involving data or external materials are automatically subject to [SEC] gatekeeping and can only be scored after passing. It is recommended that each course allocate 4%–8% of the total score to this component, without altering the existing chapter progress. In the fifth semester and graduation phase, point-based evidence is consolidated into linear evidence, with a unified conclusion reached through oral defense and spot checks.

Grading is centered around four keywords: "reproducible, traceable, understandable, and compliant." Each dimension is defined by four performance levels as anchor points: the introductory level requires only complete evidence and the ability to recount key steps to achieve a passing grade; the proficient level requires the ability to explain method selection and complete one effective revision after peer feedback; the excellent level requires the ability to transfer outcomes to adjacent contexts or produce generic templates for team output. Written descriptions are directly incorporated into the course grading rubric.

Indicator	Basic	Qualified	Proficient	Excellent
Reproducibility of Method & Process	Able to describe main steps	Steps complete; peers can largely replicate	Parameters and conventions are clear; reproducible by others	Outputs templated or scripted; transferable upon handover
Completeness & Traceability of Evidence	Core results present but scattered	Main conclusions traceable to	Full alignment of conclusion → data →	Conflicting evidence handled;

		sources/data	source; indexed	version & change logs included
Information Quality & Communication	Generally accurate but limited readability	Clear structure; consistent text/visuals	Audience-specific clarity; key points highlighted	Dual-audience maturity; includes concise reading guide
Collaboration & Iteration	Signs of task division, but poor traceability	Includes RACI/minutes and one revision round	Peer feedback applied effectively; version improved	Proactively optimized; approach documented for reuse
Application & Transferability (Optional Bonus)	Output limited to current task	Reusable within same course	Transferable to adjacent course or scenario	Generates lasting impact or adopted by other groups

Faculty Development and Support

With the goal of improving students' digital literacy, faculty development and teaching support should form a closed loop of “system-capability-resources-quality.” At the system level, the direction and standards should be clearly defined; at the capability level, a digital literacy profile and development path for teachers should be constructed; at the resource level, stable and accessible technical, data, and field support should be provided; and at the quality level, assessment and improvement should be conducted in an evidence-based and verifiable manner. The following recommendations are aligned with institutional governance and policies, progressing from institutional and teaching support system development to professional/course-level empowerment and quality assurance.

At the institutional level, teacher digital literacy can be established as a core component of professional development, with the five dimensions of digital literacy incorporated into the teacher competency framework. Corresponding capability benchmarks and phased achievement requirements should be established: during the onboarding phase, focus on basic search and citation skills, standardized presentation of data and charts, and minimum compliance with teaching materials; during the in-service phase, focus on cross-course collaboration, evidence-based teaching improvement, and contributions to open resources; during the core phase, emphasize the external dissemination of resources and paradigms and peer leadership. Governance units (academic affairs, teacher development center, information technology, and compliance departments) have formed a collaborative mechanism, each responsible for academic standards, competency training, platform availability, and compliance review, ensuring consistent direction, clear responsibilities, and traceable processes.

Teaching support should be centered on "capability building, resource provision, and service closure." In terms of capability building, tiered training is organized around five dimensions of digital literacy: the foundational module clarifies the baseline requirements for evidence-based teaching and compliance for all faculty; the thematic module discusses disciplinary practices across different digital literacy dimensions for professional clusters (e.g., clinical, pharmacy, pharmaceutical affairs); advanced modules are co-hosted by core teachers and external experts to establish transferable lesson plan paradigms and scoring references. In terms of resource provision, the college maintains a sustainably updated "digital teaching resource repository" covering database and tool access instructions, sample data and field dictionaries, blank templates and generic scales, compliance examples, and re-publication review points, with version management and change logs ensuring citability. In terms of service closure, the Teaching Support Center provides a unified entry point for design consultation, technical and data consultation, compliance pre-review, and teaching analysis interpretation, with clear response timelines and review paths, enabling teachers to complete scheme argumentation, account permission configuration, and material archiving through a single window.

The empowerment goal is to enable course teams to convert the five dimensions of competence into observable teaching evidence and consistent quality language within the existing teaching rhythm. At the professional/course level, three types of tools can be used: The first is the “competence-evidence mapping” explanation, which clarifies the focus of a course in different dimensions of digital literacy and the corresponding evidence forms. Second, “general scoring references” use four qualities—reproducibility, traceability, understandability, and compliance—as common criteria across courses, aligned with internal course weightings; Third, a lightweight mechanism of “peer calibration and external review” regularly calibrates boundary examples through graded statement calibration and introduces external reviews at key points to enhance consistency and external validity. The aforementioned tools are uniformly provided by the college, including sample examples and version control, with course teams adapting them accordingly.

Technical and Environmental Support (Platform, Data, and Space). Effective faculty development relies on stable technical and environmental conditions. The platform side emphasizes accessibility and continuity, including academic databases, office and statistical tools, learning management and collaboration systems, and controlled storage and archiving spaces; the field side emphasizes usability and bookability, including digital classrooms, recording studios, and remote access environments.

The evaluation and incentives for teacher development should revolve around “competency achievement—evidence accumulation—public contribution.” Competency achievement is based on the completion of phased training and the evidence-based achievement of teaching materials; evidence accumulation is based on the continuous improvement of course-level “competency-evidence mapping” and the accumulation of reusable examples; public contribution is based on the updating of resource library entries, peer guidance, and dissemination within and outside the school. Correspondingly, clear measurement criteria should be established in workload, job evaluation, and honorary recognition to ensure that long-term investments in competency development and teaching support are institutionally recognized.

Quality assessment emphasizes a few key indicators and verifiable evidence chains. At the departmental level, several key indicators can be tracked throughout the semester: teacher training participation and completion rates, resource repository usage and update activity, platform and data service availability, course-level evidence completeness and compliance achievement, peer evaluation consistency, and adoption of external review opinions. Monitoring serves to identify improvement priorities and establish a closed-loop action process: identifying issues, proposing solutions, validating and documenting outcomes in the next round of teaching, thereby achieving synergistic evolution of systems, capabilities, resources, and quality.

In summary, the core of teacher development and teaching support lies in organizing development goals using consistent competency language, organizing teaching materials and processes in an evidence-based and compliant manner, supporting teaching activities with a stable and accessible resource system, and promoting continuous improvement through a verifiable quality mechanism. Through directional arrangements at the macro governance level, structured provision at the meso support system level, and competency empowerment at the micro course level, a solid and transferable foundation for teachers can be provided for the practical application of digital literacy in the classroom.

Evaluation form Index of item objective congruence (IOC)

«THE GUIDELINES TO DEVELOP THE DIGITAL LITERACY OF PHARMACY STUDENTS IN SCHOOL OF PHARMACY, JIANGSU FOOD&PHARMACEUTICAL SCIENCE COLLEGE»

Dear Experts:

The purpose of this questionnaire is to assess the current level of digital literacy among pharmacy students and to provide indicators for the development of digital literacy education in this field. Covering students' behavioral habits, self-assessed abilities, and their educational context regarding digital tools and technologies.

We sincerely invite you to evaluate each item in the questionnaire for its content validity. If the item clearly aligns with the purpose of measuring digital literacy among pharmacy students, please select +1. If you are unsure whether the item is aligned with the survey purpose, please select 0. If the item does not reflect the goal of assessing digital literacy, please select -1. Kindly tick the corresponding option. Furthermore, we welcome and appreciate any comments or suggestions you may provide to help improve the quality and relevance of this instrument.

Thank you very much for your valuable time and expertise!

Name: EKAPUM

Position: LECTURER

Affiliation: SWU

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
Survey on Digital Literacy Status and Needs of Pharmacy	Background information	1	Your grade level is?			✓	
		2	Birthplace?			✓	
		3	What digital devices do you typically use? (Multiple			✓	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
Students			choice)				
	Behavioral Frequency Scale	4	How often I use online databases (e.g., PubMed, CNKI) to search for pharmacy-related literature or information?			√	
		5	how often I regularly organize and back up my digital notes, research data, or files?			√	
		6	How often do I look up references through search engines or databases when completing coursework?			√	
		7	How often I learn/use specialized pharmacy software (e.g., drug management systems, laboratory information management systems)?			√	
		8	How often I use data analysis tools (e.g., Excel, SPSS) to process the results of my experiments during labs or internships?			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
		9	How often I use Microsoft Office software (e.g., Word, Excel, PowerPoint) to write reports or create presentations			✓	
		10	The frequency with which I regularly update and manage my passwords (including academic accounts, email, social media, etc.)?			✓	
		11	How often do I take additional security measures (e.g. VPN, data encryption) when using public networks			✓	
		12	I regularly back up important personal data and academic documents to prevent the frequency of data loss			✓	
		13	How often I use collaboration tools (e.g., Google Docs, Trello) to work with others on team assignments?			✓	
		14	How often do I participate in				

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			online discussions or telecourses through online tools (e.g. Tencent Meetings, Nail)?			✓	
		15	How often I use social media or instant messaging tools (e.g., WeChat, QQ) to discuss study issues with classmates or tutors?			✓	
		16	How often I use digital tools (e.g., WPS, Canva) to create pharmacy-related charts, posters, or presentations			✓	
		17	How often I use video editing software or multimedia tools to produce digital content for professional research or projects			✓	
		18	How often I organize and share pharmacy-related learning through electronic note-taking software (e.g., Evernote, OneNote)			✓	
		19	Does the school provide opportunities for specialized			✓	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			digital literacy training (e.g., digital skills lectures, workshops, etc.)?				
		20	Have I ever learned relevant skills such as information management, digital security or technology operations through courses or resources provided by my school?			✓	
		21	Do I have access to tutoring or help with digital skills from teachers or relevant departments at my school?			✓	
		22	Does the school provide students with formal training in the use of specialized pharmacy software or other digital resources (e.g., data analysis software, pharmacy information systems, etc.)?			✓	
		23	have I had sufficient opportunities to apply digital literacy to practical projects or tasks in my pharmacy courses during my			✓	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			studies?				
	Likert Scale - Self-Assess ment	1	I am able to effectively search academic resources (e.g., pharmacy research articles, databases) online.			✓	
		2	I can judge the accuracy and reliability of online information and screen credible academic materials.			✓	
		3	I am able to effectively organize and manage my digital files and data so that I can find and use them later.			✓	
		4	I am proficient in using Microsoft Office (e.g. Word, Excel, PowerPoint) for academic work and report writing.			✓	
		5	I am able to use specialized pharmacy software (e.g., drug management systems or laboratory information management systems) for data recording and analysis.			✓	
		6	I am able to select appropriate digital tools to			✓	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			accomplish pharmacy-related tasks (e.g., database queries, charting, etc.) based on actual needs.			✓	
		7	I can effectively protect personal privacy and am familiar with commonly used password management and data encryption methods.			✓	
		8	I understand and can apply basic network security measures to prevent malware and data leakage.			✓	
		9	I am able to recognize phishing and other cyber-attacks and take the necessary steps to protect against them.			✓	
		10	I am able to communicate effectively via email or instant messenger to complete group assignments or projects.			✓	
		11	I am able to use digital collaboration tools (e.g.,				

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			Google Docs, Trello) to work with classmates on tasks.			√	
		12	I am able to utilize video conferencing tools (e.g. Tencent Meetings, Teams) to participate in distance learning or discussions.			√	
		13	I am able to use a variety of digital tools (e.g., video editing software, image processing tools) to create and present my scholarship.			√	
		14	I am able to integrate and reconfigure existing knowledge through digital tools to create new content.			√	
		15	I am able to use digital tools (e.g., electronic notes, knowledge bases) for knowledge management and sharing in pharmacy research.			√	
	Open-ended questions	1	Do you feel that your school provides you with sufficient support to improve your digital literacy (e.g.,				

It's important to consider whether open-ended questions will truly yield genuine information and if the data will be too dispersed.

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			information and literature searching, data processing, or pharmaceutical specialty software operation)? If not, what other resources or training do you think you need to help you improve these skills?		✓		
		2	What digital skills do you think will be most important for your employment in the future? What specific suggestions do you have for improving digital literacy training for pharmacy students?			✓	
Consent to adoption				☑ Yes		☐ No	

Evaluation form Index of item objective congruence (IOC)

«THE GUIDELINES TO DEVELOP THE DIGITAL LITERACY OF PHARMACY STUDENTS IN SCHOOL OF PHARMACY, JIANGSU FOOD&PHARMACEUTICAL SCIENCE COLLEGE»

Dear Experts:

The purpose of this questionnaire is to assess the current level of digital literacy among pharmacy students and to provide indicators for the development of digital literacy education in this field. Covering students' behavioral habits, self-assessed abilities, and their educational context regarding digital tools and technologies.

We sincerely invite you to evaluate each item in the questionnaire for its content validity. If the item clearly aligns with the purpose of measuring digital literacy among pharmacy students, please select +1. If you are unsure whether the item is aligned with the survey purpose, please select 0. If the item does not reflect the goal of assessing digital literacy, please select -1. Kindly tick the corresponding option. Furthermore, we welcome and appreciate any comments or suggestions you may provide to help improve the quality and relevance of this instrument.

Thank you very much for your valuable time and expertise!

Name: Zhiyang Lv
Position: Dean, School of Pharmacy and Pharmaceutical Engineering
Affiliation: Jiangsu Food& Pharmaceutical Science College

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
Survey on Digital Literacy Status and Needs of Pharmacy	Background information	1	Your grade level is?			√	
		2	Birthplace?			√	
		3	What digital devices do you typically use? (Multiple choice)			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
Students	Behavioral Frequency Scale	4	How often I use online databases (e.g., PubMed, CNKI) to search for pharmacy-related literature or information?			√	
		5	how often I regularly organize and back up my digital notes, research data, or files?			√	
		6	How often do I look up references through search engines or databases when completing coursework?			√	
		7	How often I learn/use specialized pharmacy software (e.g., drug management systems, laboratory information management systems)?			√	
		8	How often I use data analysis tools (e.g., Excel, SPSS) to process the results of my experiments during labs or internships?			√	
		9	How often I use Microsoft Office software (e.g., Word, Excel, PowerPoint) to write reports or create presentations			√	
		10	The frequency with which I			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			regularly update and manage my passwords (including academic accounts, email, social media, etc.)?				
		11	How often do I take additional security measures (e.g. VPN, data encryption) when using public networks			√	
		12	I regularly back up important personal data and academic documents to prevent the frequency of data loss			√	
		13	How often I use collaboration tools (e.g., Google Docs, Trello) to work with others on team assignments?			√	
		14	How often do I participate in online discussions or telecourses through online tools (e.g. Tencent Meetings, Nail)?			√	
		15	How often I use social media or instant messaging tools (e.g., WeChat, QQ) to discuss study issues with classmates or tutors?			√	
		16	How often I use digital tools (e.g., WPS, Canva) to create			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			pharmacy-related charts, posters, or presentations				
		17	How often I use video editing software or multimedia tools to produce digital content for professional research or projects			√	
		18	How often I organize and share pharmacy-related learning through electronic note-taking software (e.g., Evernote, OneNote)			√	
		19	Does the school provide opportunities for specialized digital literacy training (e.g., digital skills lectures, workshops, etc.)?			√	
		20	Have I ever learned relevant skills such as information management, digital security or technology operations through courses or resources provided by my school?			√	
		21	Do I have access to tutoring or help with digital skills from teachers or relevant departments at my school?			√	
		22	Does the school provide students with formal training in the use of specialized pharmacy software or			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			other digital resources (e.g., data analysis software, pharmacy information systems, etc.)?				
		23	have I had sufficient opportunities to apply digital literacy to practical projects or tasks in my pharmacy courses during my studies?			√	
	Likert Scale - Self-Assessment	1	I am able to effectively search academic resources (e.g., pharmacy research articles, databases) online.			√	
		2	I can judge the accuracy and reliability of online information and screen credible academic materials.			√	
		3	I am able to effectively organize and manage my digital files and data so that I can find and use them later.			√	
		4	I am proficient in using Microsoft Office (e.g. Word, Excel, PowerPoint) for academic work and report writing.			√	
		5	I am able to use specialized pharmacy software (e.g., drug management systems or laboratory			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			information management systems) for data recording and analysis.				
		6	I am able to select appropriate digital tools to accomplish pharmacy-related tasks (e.g., database queries, charting, etc.) based on actual needs.			√	
		7	I can effectively protect personal privacy and am familiar with commonly used password management and data encryption methods.			√	
		8	I understand and can apply basic network security measures to prevent malware and data leakage.			√	
		9	I am able to recognize phishing and other cyber-attacks and take the necessary steps to protect against them.			√	
		10	I am able to communicate effectively via email or instant messenger to complete group assignments or projects.			√	
		11	I am able to use digital collaboration tools (e.g., Google Docs, Trello) to work with			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			classmates on tasks.				
		12	I am able to utilize video conferencing tools (e.g. Tencent Meetings, Teams) to participate in distance learning or discussions.			√	
		13	I am able to use a variety of digital tools (e.g., video editing software, image processing tools) to create and present my scholarship.			√	
		14	I am able to integrate and reconfigure existing knowledge through digital tools to create new content.			√	
		15	I am able to use digital tools (e.g., electronic notes, knowledge bases) for knowledge management and sharing in pharmacy research.			√	
	Open-ended questions	1	Do you feel that your school provides you with sufficient support to improve your digital literacy (e.g., information and literature searching, data processing, or pharmaceutical specialty software operation)? If not, what other resources or training do you think you need to			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			help you improve these skills?				
		2	What digital skills do you think will be most important for your employment in the future? What specific suggestions do you have for improving digital literacy training for pharmacy students?			√	
Consent to adoption				√ Yes		☐ No	

吕志丽

Evaluation form Index of item objective congruence (IOC)

«THE GUIDELINES TO DEVELOP THE DIGITAL LITERACY OF PHARMACY STUDENTS IN SCHOOL OF PHARMACY, JIANGSU FOOD&PHARMACEUTICAL SCIENCE COLLEGE»

Dear Experts:

The purpose of this questionnaire is to assess the current level of digital literacy among pharmacy students and to provide indicators for the development of digital literacy education in this field. Covering students' behavioral habits, self-assessed abilities, and their educational context regarding digital tools and technologies.

We sincerely invite you to evaluate each item in the questionnaire for its content validity. If the item clearly aligns with the purpose of measuring digital literacy among pharmacy students, please select +1. If you are unsure whether the item is aligned with the survey purpose, please select 0. If the item does not reflect the goal of assessing digital literacy, please select -1. Kindly tick the corresponding option. Furthermore, we welcome and appreciate any comments or suggestions you may provide to help improve the quality and relevance of this instrument.

Thank you very much for your valuable time and expertise!

Name: Chiyu Ge

Position: Vice Dean, Pharmaceutical Engineering College

Affiliation: Jiangsu Food& Pharmaceutical Science College

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
Survey on Digital Literacy Status and Needs of Pharmacy	Background information	1	Your grade level is?			√	
		2	Birthplace?			√	
		3	What digital devices do you typically use? (Multiple choice)			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
Students	Behavioral Frequency Scale	4	How often I use online databases (e.g., PubMed, CNKI) to search for pharmacy-related literature or information?			√	
		5	how often I regularly organize and back up my digital notes, research data, or files?			√	
		6	How often do I look up references through search engines or databases when completing coursework?			√	
		7	How often I learn/use specialized pharmacy software (e.g., drug management systems, laboratory information management systems)?			√	
		8	How often I use data analysis tools (e.g., Excel, SPSS) to process the results of my experiments during labs or internships?			√	
		9	How often I use Microsoft Office software (e.g., Word, Excel, PowerPoint) to write reports or create presentations			√	
		10	The frequency with which I			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			regularly update and manage my passwords (including academic accounts, email, social media, etc.)?				
		11	How often do I take additional security measures (e.g. VPN, data encryption) when using public networks			√	
		12	I regularly back up important personal data and academic documents to prevent the frequency of data loss			√	
		13	How often I use collaboration tools (e.g., Google Docs, Trello) to work with others on team assignments?			√	
		14	How often do I participate in online discussions or telecourses through online tools (e.g. Tencent Meetings, Nail)?			√	
		15	How often I use social media or instant messaging tools (e.g., WeChat, QQ) to discuss study issues with classmates or tutors?			√	
		16	How often I use digital tools (e.g., WPS, Canva) to create			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			pharmacy-related charts, posters, or presentations				
		17	How often I use video editing software or multimedia tools to produce digital content for professional research or projects			√	
		18	How often I organize and share pharmacy-related learning through electronic note-taking software (e.g., Evernote, OneNote)			√	
		19	Does the school provide opportunities for specialized digital literacy training (e.g., digital skills lectures, workshops, etc.)?			√	
		20	Have I ever learned relevant skills such as information management, digital security or technology operations through courses or resources provided by my school?			√	
		21	Do I have access to tutoring or help with digital skills from teachers or relevant departments at my school?			√	
		22	Does the school provide students with formal training in the use of specialized pharmacy software or			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			other digital resources (e.g., data analysis software, pharmacy information systems, etc.)?				
		23	have I had sufficient opportunities to apply digital literacy to practical projects or tasks in my pharmacy courses during my studies?			√	
	Likert Scale - Self-Assessment	1	I am able to effectively search academic resources (e.g., pharmacy research articles, databases) online.			√	
		2	I can judge the accuracy and reliability of online information and screen credible academic materials.			√	
		3	I am able to effectively organize and manage my digital files and data so that I can find and use them later.			√	
		4	I am proficient in using Microsoft Office (e.g. Word, Excel, PowerPoint) for academic work and report writing.			√	
		5	I am able to use specialized pharmacy software (e.g., drug management systems or laboratory			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			information management systems) for data recording and analysis.				
		6	I am able to select appropriate digital tools to accomplish pharmacy-related tasks (e.g., database queries, charting, etc.) based on actual needs.			√	
		7	I can effectively protect personal privacy and am familiar with commonly used password management and data encryption methods.			√	
		8	I understand and can apply basic network security measures to prevent malware and data leakage.			√	
		9	I am able to recognize phishing and other cyber-attacks and take the necessary steps to protect against them.			√	
		10	I am able to communicate effectively via email or instant messenger to complete group assignments or projects.			√	
		11	I am able to use digital collaboration tools (e.g., Google Docs, Trello) to work with			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			classmates on tasks.				
		12	I am able to utilize video conferencing tools (e.g. Tencent Meetings, Teams) to participate in distance learning or discussions.			√	
		13	I am able to use a variety of digital tools (e.g., video editing software, image processing tools) to create and present my scholarship.			√	
		14	I am able to integrate and reconfigure existing knowledge through digital tools to create new content.			√	
		15	I am able to use digital tools (e.g., electronic notes, knowledge bases) for knowledge management and sharing in pharmacy research.			√	
	Open-ended questions	1	Do you feel that your school provides you with sufficient support to improve your digital literacy (e.g., information and literature searching, data processing, or pharmaceutical specialty software operation)? If not, what other resources or training do you think you need to			√	

Projects	Modular	Number	Projects	Options			Suggestion
				-1	0	+1	
			help you improve these skills?				
		2	What digital skills do you think will be most important for your employment in the future? What specific suggestions do you have for improving digital literacy training for pharmacy students?			√	
Consent to adoption				√ Yes		☐ No	

VITA