

ORIGINAL RESEARCH

Research on cultivation paths of digital literacy for vocational school students from the perspective of lifelong learning: An analysis based on grounded theory

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Abstract

With the rapid development of information technology and the continuous adjustment of socioeconomic structure, digital literacy has become an indispensable core competitiveness for modern talents. This study adopted a qualitative research paradigm and grounded theory to examine the current state of digital literacy among vocational school students, analyze existing issues and shortcomings in digital literacy education from the perspective of lifelong learning, and construct a dynamic relational model for digital literacy cultivation. The findings revealed that the development of digital literacy among secondary vocational students is commonly constrained by weak foundational skills, insufficient technological adaptability and intrinsic learning motivation, lagging educational implementation and curriculum provision, and the absence of sustained learning planning. These factors interact with one another, collectively hindering the overall enhancement of digital literacy. Based on the model analysis, this study proposes a systematic cultivation pathway focusing on strengthening foundational competencies, activating personal development capacities, optimizing the structure of educational implementation, and guiding lifelong learning planning, thereby providing theoretical support and practical implications for vocational institutions seeking to improve digital literacy education and promote students' lifelong development.

Keywords

lifelong learning, vocational school students, digital literacy, cultivation paths, grounded theory

INTRODUCTION

As information technology continues to evolve, digital technology has permeated all aspects of society. On April 11, 2025, nine ministries and commissions, including the Ministry of Education, jointly released *Opinions on Accelerating the Advancement of Educational Digitalization*, which states: Guided by The Thought on Socialism with Chinese Characteristics for a New Era, we will thoroughly implement the spirits of the 20th National Congress of the Communist Party of China, the Second and Third Plenary Sessions of the

20th Central Committee, and the National Education Conference. We will fully implement our country's important expositions on education, especially the important instructions on educational digitalization, and further advance the national strategy for educational digitalization (Ministry of Education of the People's Republic of China *et al.*, 2025).

For vocational education students, improving digital literacy significantly promotes high-quality employment, expands employment opportunities, and serves as an essential prerequisite for adapting to future work (Wang & Ge,

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2024). In December 2021, the *14th Five-Year Plan for the Development of the Digital Economy* emphasized the need to enhance digital literacy and skills among all citizens and strengthen the cultivation of talents proficient in digital technology in vocational colleges (including technical schools), highlighting the importance of fostering vocational school students' ability to adapt to the digital age (Ministry of Education of the People's Republic of China, 2018).

The report of the 20th National Congress of the Communist Party of China pointed out that "we will advance the digitalization of education and build a learning society and a major learning country where lifelong learning is available to all" (Xi, 2022), providing a directional guide and action plan for accelerating the construction of a learning society in China. In today's rapidly changing social environment, the cycle of knowledge and technology updating has significantly shortened; vocational education students can no longer cope with the various challenges in their future careers, relying solely on the professional knowledge and skills acquired during their school years.

Although research on digital literacy has become increasingly abundant in academic discourse, in-depth investigations that focus specifically on students in Chinese vocational institutions and adopt a dynamic lifelong learning perspective are limited. Existing studies have largely concentrated on static assessments of the components of digital literacy (Zeng, 2024) or on integration strategies within specific courses (Zhao, 2024), lacking an analytical framework that integrates students' individual development, educational system support, and the lifelong learning process.

Lifelong learning theory emphasizes that in the digital era—where the half-life of knowledge is rapidly shrinking—learning must be a continuous, proactive, and adaptive process that spans the entire life course (Jarvis, 2007). Accordingly, examining digital literacy cultivation from a lifelong learning perspective requires moving beyond isolated skills training to focus on how to stimulate learners' intrinsic motivation, construct educational ecosystems that support sustained development, and connect school-based learning with the workplace and lifelong development (Knauf, 2016).

The cultivation of digital literacy in vocational education currently faces multiple practical challenges. First, there is a pronounced skills gap between the development of students' digital competencies and the rapidly evolving demands of industry. The pace of technological change far exceeds curriculum update cycles, resulting in a misalignment between the skills students acquire and actual job require-

ments at the time of graduation (Brown *et al.*, 2023). Second, learning modes tend to exhibit a passive response pattern characterized by insufficient intrinsic motivation and self-regulatory capacity, both of which are essential for lifelong learning. Vocational students often rely on task-driven, short-term learning and demonstrate limited ability to set digital competency development goals, plan learning pathways, or engage in reflective practice (Mejeh & Grieder, 2025). Third, there are breakpoints in systemic educational support. Digital literacy education within schools is frequently isolated from professional teaching and insufficiently aligned with authentic workplace contexts and ongoing career development support systems, failing to form a coherent "school-workplace-lifelong" cultivation continuum (Pangrazio & Sefton-Green, 2022).

Against this backdrop, this study adopted a lifelong learning perspective and employed grounded theory methodology to explore how digital literacy among secondary vocational students can be systematically enhanced by lifelong learning principles, thereby providing theoretical foundations and practical guidance for improving digital literacy levels and refining vocational education.

THEORETICAL FRAMEWORK: AN INTEGRATED PERSPECTIVE ON DIGITAL LITERACY AND LIFELONG LEARNING

The concept of digital literacy has evolved beyond its early focus on basic computer operations and has evolved into a multidimensional construct encompassing technological, cognitive, and socioemotional dimensions. Eshet-Alkalai (2004) conceptualized digital literacy as a set of skills required for survival in the digital age, including photo-visual literacy, reproduction literacy, branching literacy, information literacy, and socioemotional literacy. Van Deursen and Van Dijk (2011) developed an analytical model from the perspectives of access, skills, and strategies, distinguishing among operational skills, information skills, and strategic skills. Within the field of vocational education, digital literacy places emphasis on its integration with specific occupational contexts. In this sense, "vocational digital literacy" refers to the ability to use digital technologies effectively, critically, and ethically in professional work settings (Ferrari, 2013).

The concept of lifelong learning emerged in the 1970s and marked a profound shift in educational paradigms—from an emphasis on education provision under "lifelong education" to a focus on individual agency under "lifelong learning". This perspective requires individuals to pursue the continuous, voluntary development of knowledge, skills, and attitudes throughout their lives to adapt to changes in

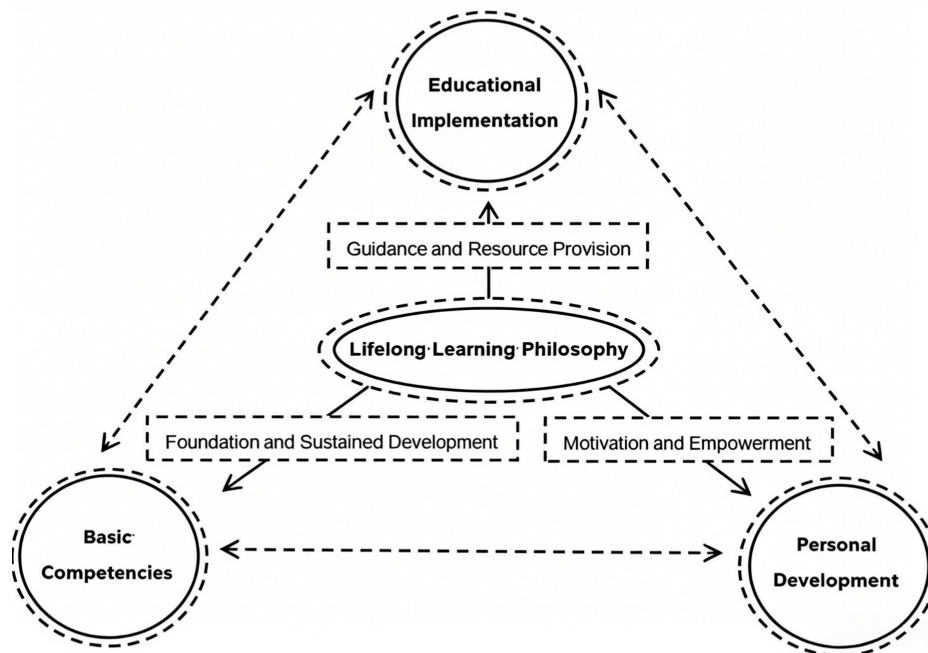


Figure 1. Integrated analytical framework of digital literacy and lifelong learning.

society, work, and personal life (Laal & Salamati, 2012). In the context of digital transformation, the connotations of lifelong learning are closely intertwined with the development of digital literacy: Digital technologies serve both as essential tools and learning content for lifelong learning, while their rapid evolution constitutes a core challenge that must be addressed through ongoing learning processes (Martin & Grudziecki, 2006).

Examining digital literacy through the theoretical lens of lifelong learning provides three key analytical dimensions for understanding the cultivation of digital literacy among vocational college students (Figure 1). First, the foundational competence dimension represents the basis of digital literacy development, encompassing device operation, basic software applications, and fundamental understandings of digital literacy. It corresponds to the essential skills reserve at the starting point of lifelong learning (Ala-Mutka, 2011). Second, the personal development dimension focuses on learners' internal agency, including motivation for proactive learning, willingness to engage in practice, and strategies for adapting to technological change. This dimension reflects the core of lifelong learning theory in terms of self-directed learning and functions as the driving engine linking current learning with future continuous development (Garrison, 1997). Third, the educational implementation dimension refers to external support systems, including curriculum design, instructional content, teaching methods, and the organization of practical activities. It constitutes the formal and institutionalized support component within the

lifelong learning ecosystem, aiming to provide scaffolding that supports students' transition from "dependent learning" to "autonomous learning" (Vygotsky, 1978).

RESEARCH DESIGN AND DATA PROCESSING

Research method

Grounded Theory is a systematic qualitative research methodology first proposed and established by sociologists Barney G. Glaser and Anselm L. Strauss in their seminal work *The Discovery of Grounded Theory* (1967). The core principle of this approach is that theory should be "grounded" in empirically collected data. Through a systematic process of data collection and analysis, theory is generated inductively from the bottom-up to explain social phenomena, rather than being deduced from preexisting theories or hypotheses for verification (Glaser & Strauss, 1967). This method is particularly suited to exploring research areas in which theoretical frameworks are underdeveloped or existing understandings are insufficient, emphasizing the generation of new insights through continuous interaction between the researcher and the data.

In its subsequent development, grounded theory has given rise to three major traditions. The classical grounded theory approach, represented by Glaser, emphasizes the natural emergence of theory and a relatively open stance toward the coding process. The proceduralized grounded theory approach, represented by Strauss and Juliet Corbin, stresses

systematic coding procedures and verification steps. The constructivist grounded theory approach, represented by Kathy Charmaz, places greater emphasis on the researcher's role and the influence of social contexts on meaning construction (Charmaz, 2006).

This study adopted the proceduralized grounded theory advocated by Strauss and Corbin (1998) as its methodological framework (Strauss & Corbin, 1998). This choice was informed by several considerations. First, proceduralized grounded theory offers clear and structured analytical procedures, including open coding, axial coding, and selective coding, which provide a highly operational framework for qualitative data analysis. This is particularly helpful for systematically identifying concepts, developing categories, and clarifying their relationships within complex datasets, especially for researchers new to qualitative inquiry (Corbin & Strauss, 2008).

Second, as this study aimed to construct an integrated model of digital literacy cultivation pathways, the emphasis of proceduralized grounded theory on establishing logical relationships between core and subcategories aligns closely with the need to develop a multilayered, dynamic pathway model encompassing foundational competencies, personal development, and educational implementation (Williams & Moser, 2019).

Third, this approach advocates the use of constant comparison, theoretical sampling, and memo writing to ensure theoretical saturation and methodological rigor. These practices facilitate a deeper understanding of the dynamic processes and influencing factors underlying the development of digital literacy among secondary vocational students, and effectively address the complexity of interactions between individual development and educational ecosystems within a lifelong learning perspective (Birks & Mills, 2015).

Data collection and processing

Following the principle of purposeful sampling, this study selected 10 vocational schools in the Yangtze River Delta region (including Shanghai, Jiangsu Province, and Zhejiang Province) as sample schools. The choice of students in the Yangtze River Delta region as interview subjects was based on the following considerations: In China, the Yangtze River Delta region is a pioneer in vocational education. This region has established a leading position in vocational education nationwide, relying on its high-quality institutional clusters and abundant resource foundations.

This study set the following prerequisites for sample subjects: (1) The ability to accurately understand the

interview questions and possess the knowledge reserve and expressive skills needed to clearly articulate their own views, (2) the ability to provide sufficient and detailed information in response to interview questions, and (3) the time and energy to participate in interviews and the willingness to cooperate with audio recording (Yu *et al.*, 2023).

To ensure the accuracy of the research results, this study selected vocational school students from different majors, including mechanical manufacturing, electronic information, education, tourism services, and finance and trade. Due to the high relevance between their professional practice and digital information, these students can effectively reflect the differentiated characteristics of the vocational student group in Internet usage scenarios.

In line with the above criteria, this study argues that vocational school students in different professional fields have significant differences in their needs for digital information application and acquisition methods, which is more conducive to reflecting the diversity and typicality of the research. Therefore, during sample selection, focus was placed on groups with a high frequency of information technology use to obtain more in-depth qualitative data. Meanwhile, considering the convenience of data collection and balancing demographic variables, such as gender ratio (15 males and 15 females) and grade distribution (10 first-year students, 10 second-year students, and 10 third-year students), this study selected 30 interviewees as the research sample. Through the design of a cross-regional and cross-major sample structure, this study ensures the general explanatory power of the research conclusions for vocational education scenarios. The basic information on the research subjects is shown in Table 1.

Interviews were conducted online, each lasting approximately one hour. Before the interviews, all the interviewees were informed of the principles of voluntary participation and confidentiality and signed an informed consent form. The researchers recorded the entire interview process, and after each interview, transcribed the audio into text materials word for word based on interview records and recordings (Fu, 2024). This study adopted semi-structured interviews, allowing interviewers to ask flexible questions based on interviewees' responses and to explore more details within the framework of the interview theme. The structure of the interview outline is shown in Table 2.

Coding process

This study used NVivo 11 software to conduct three-level coding of interview materials, obtaining a total of 48,000 words of text data. First, through open coding, important

Table 1: Basic information on research subjects

ID	Gender	Major	Grade	Age
A01	Male	Mechanical Design	Second Year	18
A02	Male	E-Commerce	Third Year	19
A03	Female	Mechanical Manufacturing Technology	Second Year	18
A04	Female	Preschool Education	Second Year	18
A05	Male	Food Processing Technology	First Year	17
A06	Male	Electronic Information	First Year	17
A07	Male	Marketing	Second Year	18
A08	Male	Tourism Service and Management	First Year	17
A09	Female	Financial Affairs	Third Year	19
A10	Female	E-Commerce	Second Year	18
A11	Female	Preschool Education	First Year	17
A12	Male	Computer Application	First Year	17
A13	Female	Accounting	First Year	17
A14	Male	Electromechanical Application Technology	Second Year	18
A15	Female	Tour Guide Management	Second Year	18
A16	Male	Computer Application	Second Year	19
A17	Female	Visual Communication	Third Year	19
A18	Male	Mechanical Design	Third Year	20
A19	Female	Tourism Services	First Year	19
A20	Female	Nursing	Third Year	20
A21	Male	Numerical Control Technology	First Year	18
A22	Female	Preschool Education	First Year	17
A23	Male	Automotive Maintenance	First Year	17
A24	Female	Nursing	Third Year	19
A25	Female	E-commerce	Third Year	19
A26	Male	Mechatronics Technology	Second Year	18
A27	Female	Accounting	First Year	18
A28	Male	Computer Applications	Third Year	19
A29	Female	Tourism Management	Third Year	19
A30	Male	Internet of Things Technology	Third Year	20

concepts, events, or themes in the interview materials were extracted to construct conceptual categories (third-level nodes); then, axial coding was used to process these related concepts to form main categories (second-level nodes); and finally, selective coding was used to summarize and combine the main category nodes to determine the core category (first-level node) (Zhang & Wu, 2023).

Open coding

Open coding is the initial step in grounded theory, involving line-by-line analysis of raw data, extraction of meaningful information segments, and assignment of conceptual labels. Through line-by-line analysis of 20 interview texts, key information segments were extracted and assigned

conceptual labels, resulting in 56 initial concepts. Through repeated comparison and induction, 20 basic categories were finally refined. A partial example of the coding process is shown in Table 3.

Axial coding

Axial coding is based on first-level coding, organizing, and integrating a large number of initial concepts, identifying connections and logical relationships between different concepts, and clustering related concepts into categories. By summarizing and integrating 20 basic categories, this study refined four main categories: Basic digital literacy abilities, digital literacy learning and practice, digital literacy education and curriculum, and digital literacy improvement and goals. Details are shown in Table 4.

Selective coding

Selective coding involves re-examining raw data, concepts, and categories based on the main categories refined during the axial coding stage, further extracting a core category, and integrating different main categories and subcategories into a theoretical framework to form a consistent theoretical structure. This study took "cultivation paths of digital literacy for vocational school students" as the core category and sorted out the following storyline: The cultivation of digital literacy is rooted in basic abilities, such as digital device usage, digital tool application, and understanding of digital literacy. Meanwhile, during the cultivation process, emphasis is placed on strengthening personal development abilities, such as proactive learning behavior, technological adaptability, and awareness of continuous learning, with educational implementation abilities (including digital literacy teaching, digital literacy practice, and digital literacy curriculum optimization) as the goal orientation. Furthermore, based on digital literacy improvement planning and digital literacy development goals, the overall improvement of digital literacy levels is achieved (Huang *et al.*, 2025).

Theoretical saturation test

The theoretical saturation test is mainly used to determine whether the collected data are sufficient and whether the theory constructed through coding and other processes is complete. Theoretical saturation is achieved when new data no longer provide new concepts, categories, or relationships to further enrich the theory. In this study, after analyzing the first 27 interviews, preliminary categories and relationships were identified. The remaining three interviewees (the 28th, 29th, and 30th) were then examined as a theoretical saturation test. Analysis of these three participants' data revealed no new concepts, categories, or relationships. Therefore, the coding content reached theoretical saturation, confirming that the collected data are sufficient.

Table 2: Semi-structured interview outline

Interview theme	Interview content
Introduction	There are no right or wrong answers to your responses; please answer based on your true experiences, observations, and thoughts. The interviews will be recorded, and the recording and transcribed documents will only be used for this study and will be handled in strict accordance with relevant confidentiality regulations.
Interviewee information	Demographic information of interviewees, including gender, age, educational background, identity, and major.
Relevant questions	<ol style="list-style-type: none"> 1. What digital devices do you own (e.g., mobile phone, computer, tablet)? What do you mainly use them for? 2. What digital software or tools (e.g., office software, image processing software, programming software) are you proficient in? Through what channels did you learn about them? 3. How would you understand digital literacy? What impact do you think digital literacy has on your current studies and future career development? 4. Do you usually take the initiative to learn new digital knowledge or skills? If yes, what motivates you to do so? Skip, if not. 5. Have you participated in practical activities, clubs, or competitions related to digital literacy? If yes, please share your experiences and gains. 6. What challenges do you think the update of social digital technology brings to you? How do you plan to cope with them? 7. In your school curriculum, are there any courses or teaching content specifically designed to improve digital literacy? If yes, do you think you have gained a lot from them? 8. What digital literacy-related courses or training activities do you hope the school will add? For example, courses on data security or artificial intelligence applications. 9. Based on your existing digital literacy learning experiences, do you think it is important to cultivate awareness of continuous learning? How should schools and society guide this? 10. Have you thought about continuing to improve your digital literacy after graduation? Why or why not? 11. What plans or goals do you have to improve your digital literacy in the future?

Table 3: Example of open coding process and results (excerpt)

Examples of raw data	Initial concept	Basic category
Mobile phones are generally used for entertainment, such as chatting, scrolling through TikTok, and playing games; computers are mainly used for making PPTs and playing games.	Digital Device Usage Scenarios	Digital Device Usage
Proficient in office software such as Word Processing System and Excel, as well as social software like WeChat.	Digital Software Mastery	Digital Tool Application
Digital literacy is the combination of abilities to acquire, evaluate, and share information learned in the process of using software.	Definition of Digital Literacy	Understanding of Digital Literacy
Will take the initiative to learn, mainly through online tutorials and consulting classmates.	Motivation and Methods of Proactive Learning	Proactive Learning Behavior
Have participated in clubs related to digital literacy, with the original intention of improving digital literacy capabilities.	Participation in Digital Literacy Activities	Digital Literacy Practice
The update of social digital technology brings challenges to everyone, such as the emergence of new technologies like artificial intelligence and robots.	Challenges of Technology Update	Technological Adaptability
The school offers computer courses, but they mainly focus on programming and office software use, and the course content is relatively superficial.	Current State of School Courses	Digital Literacy Teaching
Hope the school will add more club activities to stimulate interest through student-organized activities. Course needs and suggestions	Course Needs and Suggestions	Digital Literacy Curriculum Optimization
Awareness of continuous learning is very important because digital technology is easy to forget and requires constant knowledge updates.	Importance of Continuous Learning	Awareness of Continuous Learning
Need to continue improving digital literacy after graduation, because the content learned at school is limited and easy to forget.	Post-Graduation Learning Plan	Digital Literacy Improvement Planning
Plan to learn from the Internet and knowledgeable friends around, and take the initiative to ask for advice when encountering problems.	Future Learning Goals and Methods	Digital Literacy Development Goals
Total	56 Initial Concepts	20 Basic Categories

RESEARCH FINDINGS

This study conducted in-depth interviews with 30 secondary vocational school students and, using a procedural grounded theory approach, constructed and validated the "Digital Literacy Development Pathway Model for Secondary Vocational Students", as shown in Figure 2. The model clearly reveals that digital literacy development is a bottom-up, progressively supported, and dynamically cyclical systemic process. Based on the model's four-layer structure, the following section provides a layer-by-layer interpretation of the research findings in conjunction with the

expanded interview data.

Foundational competence construction layer: A fragile foundation for digital literacy development

The bottom layer of the model consists of digital device use, digital tool application, and understanding of digital literacy, which together form the foundation for the development of all higher-order digital competences. However, the interview data indicate that this foundational layer is generally characterized by tendencies toward superficiality and entertainment-oriented use. Digital device use is largely

Table 4: Axial coding

Main category	Basic categories	Connotation of category relationships
Basic Digital Literacy Abilities	Digital Device Usage, Digital Tool Application, Understanding of Digital Literacy	Basic digital literacy abilities (such as device usage, tool application, and literacy understanding) provide the necessary prerequisites for learning and practice. Without a solid foundation, learning new skills and participating in practical activities will become difficult.
Digital Literacy Learning and Practice	Proactive Learning Behavior, Digital Literacy Practice, Technological Adaptability	Experience gained through learning and practice can be fed back into education and curriculum design, helping to optimize course content and teaching methods to better meet the actual needs of learners and market trends.
Digital Literacy Education and Curriculum	Digital Literacy Teaching, Digital Literacy Curriculum Optimization, and Awareness of Continuous Learning	The design and implementation of education and curricula directly affect individuals' planning for digital literacy improvement; reasonable curriculum settings can help learners clarify improvement goals and paths.
Digital Literacy Improvement and Goals	Digital Literacy Improvement Planning, Digital Literacy Development Goals	Improvement planning refers to the steps and strategies for achieving development goals; through planning, learners can set specific short-term and long-term goals and take corresponding actions to achieve these goals.

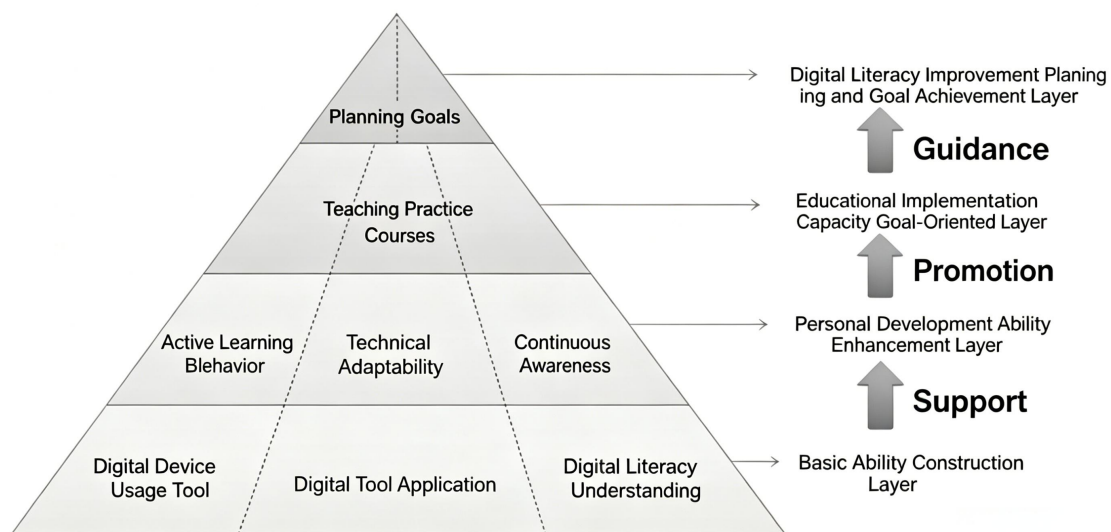


Figure 2. Path model for cultivating the digital literacy of vocational school students.

confined to consumption and social interaction. All 30 interviewed students owned smartphones, yet the vast majority primarily regarded them as tools for entertainment. As A21 (male, numerical control technology, second year) noted, "I mainly use my phone for gaming, watching short videos, and chatting. Apart from classes, I mostly use the computer to play games as well". Only a small number of students (approximately seven) reported actively using digital devices for skill development, such as watching instructional videos.

Digital tool application skills also remain at the basic operational level. Nearly all the students reported being able to use WPS or Office software, but mostly for completing teacher-assigned tasks. When it comes to more advanced functions or profession-related software, students generally expressed unfamiliarity or apprehension. As A25 explained, "The teacher taught us how to make tables in Excel, but

didn't go deeply into functions or charts. I wouldn't explore those on my own either".

At the same time, students' understanding of digital literacy is often vague and utilitarian. Many equated digital literacy simply with "being able to use computers and mobile phones", lacking a clear awareness of dimensions such as information evaluation, cybersecurity, digital creation, and ethics (Pangrazio *et al.*, 2020). A28 (male, computer applications, third year) added, "I think it's not just about using software, but also about knowing how to do things safely online and judge whether information is true or false, but the school doesn't really teach that". This weak and imbalanced foundational layer results in an unstable "base" for students' digital competences, making it difficult to support the development of higher-level abilities and directly undermining their confidence in adapting to new technologies.

Personal development capacity enhancement layer: A critical deficit in the internal motivation system

The second layer of the model includes active learning behavior, technological adaptability, and continuous learning awareness. This layer functions as the "engine" connecting basic skills with lifelong development, yet it is marked by a clear lack of momentum among the current student cohort. Students' active learning behaviors are scarce and largely passive, with learning activities driven more by external tasks than by intrinsic interest or career planning (Mejeh & Grieder, 2023). As A22 (female, preschool education, first year) stated, "I usually don't take the initiative to learn new software unless a dance class requires editing music, then I'll quickly learn something like CapCut (known as Jianying in China)". This "learning only when needed" pattern leads to fragmented knowledge that is difficult to accumulate systematically.

When confronted with rapid technological change, students' technological adaptability is often characterized by anxiety and avoidance. Faced with an endless stream of new applications and updates, many students felt overwhelmed. A26 (male, mechatronics technology, second year) remarked, "Technology updates too fast. I might just learn one thing today, and it's outdated tomorrow. I don't know how to keep up, so sometimes I just stop trying". They lack strategies for independently exploring new tools or transferring existing skills to new contexts.

Although most of the students acknowledged the importance of lifelong learning, continuous learning awareness has not yet been transformed into stable attitudes or concrete actions. Many perceived continuous learning as something that should occur "after entering the workforce" (A10, A17, A21). As A29 (female, tourism management, third year) noted, "Right now, getting the required certificates is the most important thing. If I need other skills later at work, I can learn them then". Academic pressure and vague perceptions of future careers weaken students' sense of urgency to engage in sustained digital learning during their school years (Imama *et al.*, 2025). This lack of vitality at the personal development layer means that even when students possess certain basic skills, they lack the initiative and agency to deepen, update, and apply them in new situations.

Educational implementation and goal-oriented capacity layer: Structural misalignment of external support systems

The third layer of the model encompasses teaching, practice, and curriculum, representing the structured support that schools are expected to provide. However, there is a

pronounced mismatch between educational provision, students' needs, and technological development. In terms of teaching methods, a tendency toward uniformity was evident, with an emphasis on procedural operation over cognitive understanding. Students reported that computer-related classes were largely based on teacher demonstrations followed by student imitation. As A23 (male, automotive maintenance, first year) described, "The teacher shows one step, and we follow one step. Once it's done, we forget it. Why it works or where else it can be used is rarely explained". Such approaches fail to effectively stimulate computational thinking or transferable problem-solving abilities.

At the same time, opportunities for digital literacy-related practice are scarce and disconnected from authentic contexts. Among the 30 interviewees, fewer than 10 had participated in digital competitions or project-based activities at or above the school level. A27 (female, accounting, first year) commented, "The school might have organized a PowerPoint competition, but not many people joined, and there wasn't much promotion. We want to know how what we learn can be used in companies for accounting or tax reporting". The lack of practical engagement prevents learning outcomes from being tested and refined in real-world settings. More critically, course content is outdated, lacks forward-looking perspectives, and is slow to update, failing to reflect the latest industry developments. As A30 (male, the Internet of Things technology, third year) pointed out, "Our major is called the Internet of Things, but much of what we learn is from years ago. We barely touch real sensor network construction or cloud platform applications".

Although the students showed a strong interest in emerging fields, such as artificial intelligence and big data analytics, these topics are rarely incorporated into the curriculum. Consequently, the educational implementation layer has not effectively fulfilled its goal-oriented or "scaffolding" function, and rigid, outdated teaching and curricula fail to ignite students' motivation to learn.

Digital literacy development planning and goal achievement layer: Blurred and fragmented lifelong development visions

The top layer of the model is the digital literacy development planning and goal achievement layer, which represents the ultimate direction of the entire cultivation process. The findings indicate that students' awareness at this level is the most ambiguous, with planning and action severely lacking. The vast majority of students do not have clear digital literacy development plans aligned with their personal career pathways. Their understanding of future

digital skill requirements is based on fragmented hearsay or imagination rather than systematic career exploration. When asked about plans, A24 (female, nursing, third year) stated, "I just want to do my internship well and pass the nursing certification exam. As for computer skills, the hospital will probably provide training". Thus, students tended to place responsibility for improving digital literacy on future employers rather than on themselves in the present. As a result, clear, staged developmental goals were largely absent, and learning behaviors became random and short-term due to the lack of goal-driven guidance. The positive cycle envisioned by the model—where top-level planning feeds back to guide lower-level capacity development and educational provision—has yet to be established.

An analysis of the 30 students showed that obstacles exist across all four layers of the digital literacy development pathway for secondary vocational students: An unstable foundation, weak personal development, misaligned educational implementation, and an empty goal layer. Together, these issues constrain overall digital literacy enhancement. The model clearly demonstrates that an effective cultivation system must simultaneously strengthen foundational competences, activate learners' personal agency, reform educational provision, and ultimately integrate these efforts into clear lifelong development planning to establish a sustainable, closed-loop pathway for digital literacy growth.

CULTIVATION PATHS OF DIGITAL LITERACY FOR VOCATIONAL SCHOOL STUDENTS FROM THE PERSPECTIVE OF LIFELONG LEARNING

From a lifelong learning perspective, digital literacy is no longer understood as a single skill or as the outcome of short-term training. Instead, it is conceptualized as a comprehensive competence that is continuously generated and dynamically evolving through the interaction of multiple factors. On this basis, this study constructed a dynamic relational model of digital literacy development (Figure 3), which systematically revealed the internal structure and optimization pathways of digital literacy cultivation across four dimensions: Foundational competence, personal development, educational implementation, and developmental planning.

Foundational competence construction layer: The starting point and structural support of digital literacy

In the context of the digital era, digital literacy is widely regarded as an essential competence for vocational students to achieve success in their future professional lives. It encompasses not only operational skills related to digital

tools but also key abilities such as information acquisition, evaluation, and communication, serving as a prerequisite for participation in digital learning and work environments. Empirical evidence indicates significant disparities in digital literacy development among higher vocational and vocational education students, with deficiencies in basic technical operations and digital learning strategies emerging as major constraints on further development. Accordingly, vocational institutions should systematically design foundational digital literacy courses by integrating information retrieval, data security, and digital communication into professional curricula. Through a combination of in-class practice and extracurricular training, students' proficiency in tool use can be gradually enhanced. Moreover, pedagogical approaches, such as project-based learning, can embed foundational knowledge within authentic task contexts, enabling students to internalize the functions and operational logic of digital tools through problem-solving processes, thereby laying a solid foundation for higher-level digital literacy development.

Personal development capacity enhancement layer: The driving mechanism of endogenous growth

The acquisition of foundational skills alone is insufficient to ensure the sustained development of digital literacy. Internal learning motivation, self-regulation capacity, and technological adaptability constitute the key forces enabling digital literacy to take root and evolve. At the personal development enhancement level, learners' initiative and strategic learning behaviors are particularly critical. Empirical studies have shown that students' digital literacy skills improved significantly through participation in research-based or inquiry-oriented projects, primarily by strengthening confidence in technology use and fostering strategic problem-solving thinking (Xu *et al.*, 2025). Consequently, cultivation at this level should incorporate reflective tasks and metacognitive strategies, such as learning journals, formative feedback, and peer assessment, to help students monitor their learning behaviors and outcomes, thereby gradually developing self-directed learning habits. In parallel, providing personalized learning resources and pathways, such as adaptive content delivered through online platforms, can enhance students' technological adaptability and stimulate sustained intrinsic motivation when encountering new learning contexts.

Educational implementation and goal-oriented capacity layer: Structural assurance for digital literacy development

Educational implementation capacity functions as a critical bridge between foundational competence and personal development, with its core role being the construction of a

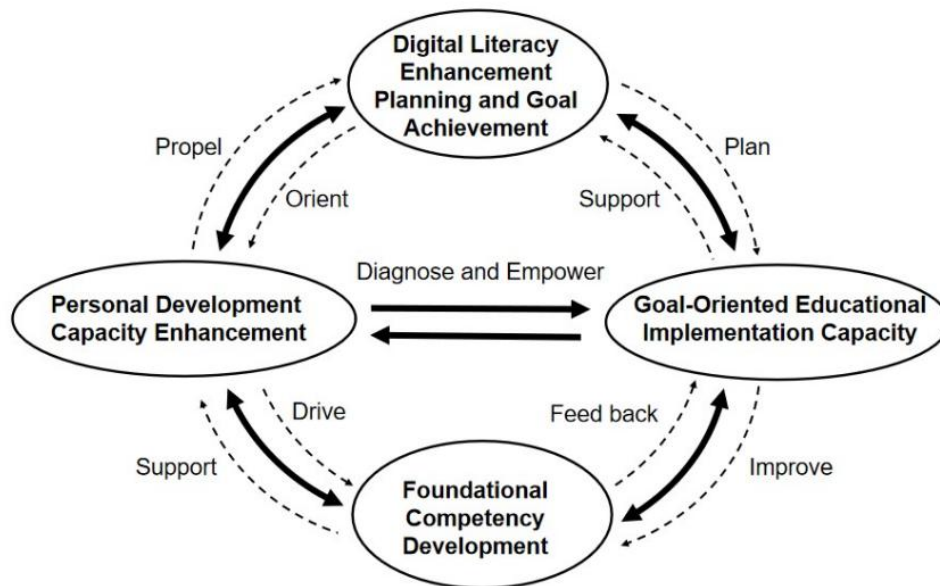


Figure 3. Dynamic relationship model of digital literacy cultivation.

goal-oriented, organized, and feedback-informed digital literacy learning ecosystem through curriculum structure, pedagogical approaches, and resource support. International research has consistently emphasized that isolated courses are insufficient to meet the systemic requirements of digital literacy cultivation; instead, interdisciplinary curriculum integration, collaborative teaching, and supportive learning environments are necessary to achieve goal-oriented educational implementation (Chan & Sung, 2025).

In practice, secondary vocational schools can establish modular curricula that integrate digital tool applications and data analysis with industry practice, allowing students to repeatedly apply and deepen digital skills across courses and practical activities. Furthermore, instruction should emphasize contextualized and task-driven design by organizing school-enterprise cooperative training and online collaborative projects that introduce real industry problems into the classroom, thereby transforming educational implementation into a robust support mechanism for digital literacy growth.

Digital literacy development planning and goal achievement layer: Directional guidance for lifelong learning

From a lifelong learning perspective, the digital literacy development planning and goal achievement layer centers on students' capacity to recognize and plan their long-term digital learning trajectories, including the continuous updating of digital competences in work and life contexts. Research suggests that purely skills-based training risks

fostering the misconception that "learning ends with training", whereas embedding digital competence development within a lifelong development framework more effectively promotes long-term engagement and career-oriented learning awareness (Jia & Huang, 2023). Therefore, cultivation at this level should emphasize career-oriented learning guidance through activities such as career development seminars and lifelong learning counseling, enabling students to align digital literacy development with future employment goals and career pathways. Encouraging students to establish phased learning goals and reflective mechanisms—such as documenting digital skill growth and showcasing learning outcomes—can facilitate a shift from short-term task completion to sustained developmental processes, promoting the internalization and accumulation of digital literacy.

Dynamic relationships and collaborative optimization mechanisms: Cyclical interaction and sustainable development

It is important to emphasize that the four layers do not operate in isolation; rather, they collectively sustain digital literacy development through dynamic coordination and cyclical interaction. The foundational competence layer provides the necessary skills and cognitive base for personal development, while personal development capacities activate these foundations through proactive learning behaviors and generate feedback to inform adjustments in educational design and resource allocation. Educational implementation integrates resources and learning contexts through goal-oriented guidance, yet its effectiveness is also

shaped by learners' developmental states. At the top level, digital literacy development planning exerts a backward influence by using clear long-term goals and career visions to guide practical activities across the lower layers. As a result, the development pathway evolves from a linear "teaching-learning" process into a recursive, feedback-driven system characterized by progression, iteration, and optimization. Consistent with the core tenets of lifelong learning, skill development unfolds throughout the entire career lifespan, and improvements at any single layer trigger adaptive adjustments across the system, ultimately achieving collaborative optimization and sustained growth in students' digital literacy.

CONCLUSION

Grounded in a procedurally grounded theory approach, this study systematically examined the current state and developmental pathways of digital literacy among secondary vocational students. The findings revealed that students' digital literacy development was constrained by multiple challenges, including weak foundational competences, insufficient learning motivation, lagging curricular structures, and the absence of sustained learning mechanisms. These issues reflect the practical difficulties faced by digital literacy education in vocational institutions and expose deeper structural tensions in talent cultivation amid digital transformation.

By constructing a dynamic relational model of digital literacy development from a lifelong learning perspective, this study offers a systematic framework for vocational institutions to enhance digital literacy education. The model underscores that digital literacy development is not the product of isolated skill training or short-term instructional interventions but rather a dynamic, cyclical process driven by the interaction of foundational skills, individual agency, educational implementation, and long-term planning. Only by embedding digital literacy cultivation within students' lifelong learning and career development frameworks—and by activating endogenous motivation through structured educational support—can digital learning move beyond task-oriented and fragmented practices toward stable and transferable literacy formation.

To translate these findings into action, policymakers and institutional leaders should: (a) Mandate foundational digital literacy certification; (b) embed digital competencies into all vocational curricula; (c) fund project-based and work-integrated digital learning activities; (d) upskill teachers in digital pedagogy; (e) provide personalized digital learning plans for students; (f) foster industry-school partnerships for curriculum co-design; (g) raise public

awareness of digital literacy as a lifelong skill; and (h) implement longitudinal assessment systems to monitor progress and close gaps.

Nevertheless, this study has certain limitations. As it relied primarily on qualitative data analysis, the findings were influenced by the sample scope and contextual conditions. Digital literacy development pathways may differ across regions, disciplines, and institutional settings. Moreover, the analysis of long-term digital literacy outcomes was mainly based on learners' cognitive perceptions and planning intentions without longitudinal tracking of sustained performance in authentic occupational contexts, which limited the generalizability of the model. Future research can build upon this model by integrating quantitative methods to validate the relationships among model components and by expanding multi-stakeholder perspectives to examine the interactive mechanisms among schools, enterprises, and industry environments. From a practical standpoint, vocational institutions should adopt a holistic pathway-oriented approach, embedding digital literacy goals into talent development programs and coordinating curriculum design, instructional practices, and learning guidance to provide stable support for students' lifelong digital literacy development.

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Author contributions

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Ethical approval

Not required.

Informed consent

Written informed consent was obtained from the participants for publication. The participants were informed that the interview data were only used for research purposes, and their information would be anonymized when presenting the research result. Moreover, they are also allowed to stop the

recording at any moment during the interview, and they can refuse to respond to any question asked during the review.

Declaration of conflicting interests

The authors declare no competing interest.

Generative AI use declaration

None.

Data availability statement

Data used to support the findings of this study are available from the corresponding author upon request.

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