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Evaluation and Empirical Research on Teachers' Information Literacy in the Context of Smart Education

Chenyue Hu*

Chongqing Youth Vocational and Technical College, Chongqing 401320, China

***Corresponding author:** Chenyue Hu, h_chenyue@163.com

Abstract: The development of smart education has led to the integration of emerging technologies such as artificial intelligence with education. It is a prerequisite for teachers to have high information literacy for conducting education and teaching work. This study conducted a questionnaire survey on 412 teachers in a certain area. The results showed that teachers' information literacy is above the middle level, and there are significant differences in information literacy between teaching experience and educational background. The evaluation showed that information ethics, information awareness, and information application have a significant positive impact on professional development, and information knowledge and information awareness have a positive predictive effect on information ethics.

Keywords: Teachers' information literacy; Smart education; Empirical research

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1. Introduction

At present, smart education has injected new vitality into the reform and development of education, and the education industry has gradually moved towards informatization, which has changed the approaches and methods of education and teaching to some extent. In 2008, the concept of "Smarter Planet" put forward by IBM (International Business Machines) set off a great storm in the world, the concept was gradually developed in the field of education, and the term "smart education" appeared [1]. In the 21st century, high-tech information technologies such as artificial intelligence, big data, virtual reality, blockchain, Internet of Things, and others have triggered disruptive changes in human society, and further promoted the transformation and evolution of traditional education to a new paradigm of smart education [2]. With the development of artificial intelligence and its impact on education, promoting education to accelerate the leap in the direction of intelligence, smart cities, smart schools, smart classrooms, smart learning, and so on is encouraged, and mankind has stepped into the era of smart education.

With the development of modern information technology, the application of information technology in higher education has become the main direction of education reform and development, and the promotion of

information technology and education has become a new state of education. In the Ten-Year Development Plan for Education Informatization (2011–2020), it is proposed that "we should explore the in-depth integration of information technology and education, innovate the talent training model, strengthen the construction and application of smart campuses, and promote the modernization of education methods, so as to promote the improvement of the quality of education." In 2018, the Ministry of Education issued the "Education Informatization 2.0 Action Plan" [3], which clearly puts forward the general requirements, target tasks, and implementation actions of education informatization construction, and suggests a series of specific plans for teachers, using artificial intelligence as a means of teacher training, promoting teachers to update their concepts, improving professionalism, and enhancing their teaching ability, so as to effectively improve teachers' information technology. In 2019, the Ministry of Education issued the "Opinions on the Implementation of the National Primary and Secondary School Teachers' Information Technology Application Ability Project 2.0," which pointed out that "information technology, as a tool and means of teaching for teachers, plays a key role in improving the overall information literacy of teachers, and the comprehensive utilization of emerging information technology to build an all-round mechanism for cultivating and developing teachers' information literacy is the responsibility of schools and other education departments." The proposal of relevant national policies makes the requirement of comprehensively improving teachers' information literacy more urgent and should be actively implemented by all regions and schools in accordance with the relevant policies.

2. Research tools

Tools such as Amos, LISREL, Mplus, EQS, and R packages can all be used to construct structural equation models. When it comes to the question of which structural equation modeling tool to use in this study, considering the large and complex variables in the research design, the use of Amos, a fully functional data processing tool, can better overcome these difficulties. It supports parallel analysis of data, does not require code programming, and only requires simple and intuitive visual programming to establish a model, greatly improving the efficiency of data analysis. Therefore, this study selected Amos24.0 software as the tool to draw structural equation models.

Assuming three errors, namely X1, X2, X3, latent variables, and the path coefficients from latent variables to X1, X2, X3, the regression equation (1) of the measurement model is as follows:

$$\begin{aligned} X1 &= \lambda 1\xi 1 + \delta 1 \\ X2 &= \lambda 2\xi 2 + \delta 2 \\ X3 &= \lambda 3\xi 3 + \delta 3 \end{aligned} \qquad (1)$$

The structural equation model needs to be validated by using fitness indicators to evaluate whether the assumed path relationship diagram matches the collected data. If the fitness criteria are met, it indicates that the actual scale data collected conforms to the theoretical model of the research hypothesis. The following three types of indicators are usually used to test the matching between the structural equation model and the data. The structural equation model adaptation indicators obtained through sorting are shown in **Table 1**.

Table 1. Structural equation model adaptability

Structural equation model adaptability	Statistical test quantity	Adaptation standards or critical values
Absolute fit index	λ^2	$P > 0.5$
	RMR	< 0.05
	RMSEA	< 0.08
	GFI	> 0.90
	AGFI	> 0.90
Value added fitness index	RFI	> 0.90
	IFI	> 0.90
	CFI	> 0.90
Minimalist fit index	PGFI	> 0.50
	PNFI	> 0.50
	CN	> 200

3. Evaluation indicators and research hypothesis

3.1. Evaluation indicators

Through literature review, it was found that various institutions such as UNESCO, the International Association for Educational Technology in the United States, and the Chinese Ministry of Education have all implemented specific regulations on educational information literacy through the introduction of evaluation frameworks and standards. This study conducts a comprehensive analysis of the evaluation frameworks and standards. The main content of the evaluation frameworks and standards issued by various institutions involves five aspects: information awareness, information knowledge, information application, information ethics, and professional development. Among them, information awareness refers to teachers' awareness of actively utilizing information technology to optimize and innovate teaching models in the process of education and teaching; information knowledge refers to the knowledge mastered by teachers to carry out teaching activities smoothly, including basic information knowledge and relevant equipment operation knowledge; information application refers to the application of information technology knowledge mastered by teachers in classroom teaching and the evaluation and reflection of its effectiveness; information ethics refers to teachers complying with laws and regulations when applying information, ensuring the information security of students and others; teacher professional development refers to the use of information technology by teachers to acquire relevant teaching knowledge to promote their multifaceted development [4].

The understanding of teachers' information literacy in foreign countries includes the technical level, management evaluation level, and moral awareness level. In the current context of smart education, although China has not yet proposed evaluation indicators or standards for teachers' information literacy, many experts and scholars have conducted relevant research on the current situation and development trends of teachers' information literacy. Rong conducted a survey on the information literacy of rural teachers from six aspects, including information awareness, information collection, information processing, information application, information evaluation, and information ethics. He found that rural teachers have good information ethics, but there are shortcomings in information processing and application [5]; Peng *et al.* believed that the information literacy level of university teachers should include awareness, knowledge, ability, and morality, and found that

university teachers have good information knowledge and ethics, but some lack information ability [6]; Chen *et al.* believed that in order to investigate teachers' information literacy, we should start from two aspects: one is to investigate the knowledge that each person's information literacy should include, and the other is to investigate the information application ability and information society responsibilities needed in teaching activities [7]; Chen *et al.* conducted a survey on teachers' information literacy and believed that it includes aspects such as information awareness, information knowledge and ability, methods of obtaining information, and level of information teaching. It was found that teachers' information literacy is better in terms of information demand awareness [8].

Overall, although various experts and scholars have different dimensions in investigating teachers' information literacy, it is not difficult to see that information awareness, information knowledge, information application, and information ethics are all important indicators commonly shared by scholars in their research and investigation. In the context of educational informatization, which has emerged with the accelerated development of artificial intelligence and other technologies, teachers' information literacy still needs to be extended to innovation and professional development based on it. Based on several references and evaluation indicators, the final evaluation indicators are shown in **Table 2**.

Table 2. Evaluation index system

Evaluation index system	Primary indicators	Secondary indicators	Operational definition
1	Information awareness	Information discrimination	Having the awareness to distinguish the authenticity, authority, and usefulness of information
		Awareness of information updates	Having the awareness of updating information in a timely manner
		Optimizing teaching	Having the awareness of actively utilizing information technology to optimize teaching and cultivate talents
		Innovating teaching mode	Having the awareness of actively utilizing information technology to innovate teaching models
2	Information literacy	Information fundamentals	Understanding basic knowledge of information security and property rights
		Current situation of information application	Understanding the current status of information applications and the latest information concepts and technologies
		Teaching equipment operation	Proficient in using smart teaching software
		Common software operations	Proficient in using common office software
3	Information applications	Resource collection, processing, and integration	Ability to acquire, process, integrate, and produce information
		Teaching design, implementation, and evaluation	Ability to design, implement, and evaluate information-based teaching
		Integrated innovation	Ability to integrate innovative information technology with subject teaching
		Effective communication and exchange	Ability to choose appropriate information exchange methods to communicate with others
		Evaluation and reflection	Ability to evaluate and reflect on the effectiveness of information resource utilization

Table 2 (Continued)

Evaluation index system	Primary indicators	Secondary indicators	Operational definition
4	Information ethics	Information ideology and morality	Reasonably using network resources and avoiding browsing and disseminating harmful information
		Information law	Paying attention to the personal intellectual property and privacy involved in the use and sharing of information
		Information safety	Preventing computer viruses and paying attention to data backup
5	Professional development	Acquiring subject knowledge	Ability to utilize information technology to continuously acquire subject knowledge
		Acquiring teaching knowledge	Ability to utilize information technology to continuously enhance teaching knowledge
		Collaborative teaching and research	Ability to utilize information technology for collaborative teaching and research
		Improving efficiency	Ability to utilize information technology to improve work efficiency

3.2. Research hypothesis

Based on the analysis of research literature, empirical data, theoretical experience, and exploratory research by domestic and foreign experts and scholars, the following hypotheses are made regarding the relationship between latent variables of teachers' information literacy, as presented in **Table 3**.

Table 3. Research hypothesis

Research hypothesis	Hypothesis content
Hypothesis 1 (H1)	Information knowledge has a positive impact on information ethics
Hypothesis 2 (H2)	Information knowledge has a positive impact on information application
Hypothesis 3 (H3)	Information awareness has a positive impact on information ethics
Hypothesis 4 (H4)	Information awareness has a positive impact on professional development
Hypothesis 5 (H5)	Information ethics has a positive impact on professional development
Hypothesis 6 (H6)	Information applications have a positive impact on professional development

4. Empirical study

4.1. Questionnaire

The survey questionnaire mainly consists of three parts:

(1) Introduction: This section briefly introduced the purpose of this study and the questionnaire survey. To protect personal privacy of the survey subjects, the questionnaire was only used for internal research purposes, in order to collect the most authentic and effective data.

(2) Basic characteristics: This section included the gender, age, teaching experience, professional title, teaching period, education background, teaching subjects, and teaching area of the teacher. This part was mainly used for descriptive statistics of the sample in the future.

(3) Evaluation of teachers' information literacy: This section included 20 items from five dimensions. Based on the previously specified indicators and combined with the information from expert interviews, the scale was appropriately modified, mainly from five first-level indicators and twenty second-level indicators. The reliability and validity analysis of the scale items showed that the

reliability value of the scale items was 0.917, the validity value was 0.923, and the *P* value of the Bartley test was 0.000 (< 0.05). These results indicated that the scale had good reliability and validity. Each question was divided into five levels from low to high, corresponding to "completely inconsistent" with 1 point, "not very consistent" with 2 points, "average" with 3 points, "relatively consistent" with 4 points, and "very consistent" with 5 points. Different levels represented the attitudes and tendencies of the survey subjects.

4.2. Research subjects

This study selected full-time teachers from a school in Chongqing as the research subjects and conducted a survey using a random sampling method through online distribution of questionnaires. A total of 412 questionnaires were collected in this survey. The questionnaires were analyzed using the method of collection and organization, and those that did not comply with statistical rules were deleted. In the end, 388 valid questionnaires were obtained, with a questionnaire response rate of 94%. Among the survey subjects, there were 251 women, accounting for 64.7%, and 137 men, accounting for 35.3%. The higher number of women among the survey subjects was due to the fact that there were more women in the teaching profession, thus the sample was in line with the actual situation.

4.3. Research method

Using preliminary survey data, SPSS25.0 software was used for statistical analysis, and Amos24.0 software was used to construct a structural equation model. By identifying, evaluating, and correcting the model, the fitting degree of the hypothesis model was improved, and the research hypothesis was validated. Lastly, the research conclusion was summarized.

5. Results

A structural model of teachers' information literacy was built in Amos24.0 software. 388 valid data were imported into Amos24.0 software, followed by identifying, evaluating, and correcting the model, and the results obtained were shown in **Figure 1**.

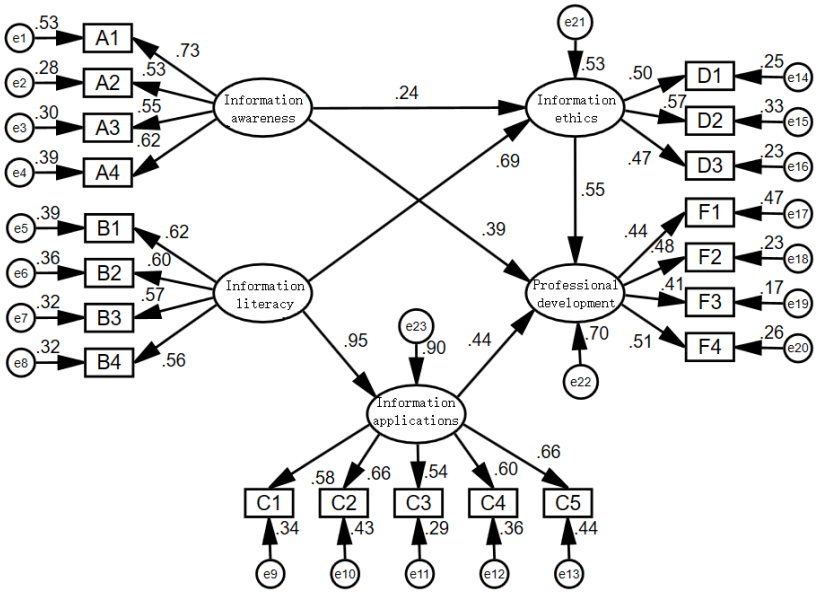

Figure 1. Structural equation modeling of teachers' information literacy

In structural equation modeling, the effect of a potential variable on another variable is indicated by an arrow, i.e., the variable to which the arrow points indicates a direct effect, as shown by the model plot in the figure and the standardized coefficient results; the number on the arrow indicates the standardized coefficient, the higher the number the greater the effect. The results show that H1–H6 are all verified and valid.

5.1. Statistical analysis

From the analysis of the study, it can be seen that there is a significant difference between the teaching age in the three dimensions of information awareness (0.018), information application (0.035), and professional development (0.011). It is found that the mean values of the scores of teachers with 1–5 years of teaching experience are all slightly lower than those of teachers in other teaching age groups, so more attention should be paid to the cultivation of information literacy in the group of newly recruited teachers and the improvement of the information literacy of in-service teachers should not be slackened; there is a significant difference between the academic qualifications in the dimensions of information awareness (0.003), information ethics (0.014), and professional development (0.039), and the scores of the college-educated teachers were lower than those of teachers in other educational levels, while the highest scores were found in the group of teachers who were graduate students and above. The possible reason for this is that the teachers with college degrees are generally older and do not have a sufficient understanding of information literacy, while the teachers with graduate degrees and above have more exposure to information literacy and therefore will pay more attention to the improvement of information literacy.

5.2. Hypothesis testing

The path coefficients of information knowledge and information awareness on information ethics are 0.690 and 0.242, respectively, which leads to the conclusion that information knowledge and information awareness have a positive impact on information ethics, which is consistent with research hypotheses H1 and H3, as shown in **Table 4**.

Table 4. Path relationship with information ethics

Path relationship	Path coefficient	*P*	Hypothesis number	True/False
Information ethics ← Information knowledge	0.690	***	H1	True
Information ethics ← Information awareness	0.242	***	H3	True

The path coefficients of the influence of information knowledge on information application are 0.947, which indicates that information knowledge has a positive influence on information application, which is consistent with the research hypothesis H2, as shown in **Table 5**.

Table 5. Path relationship between information application and information knowledge

Path relationship	Path coefficient	*P*	Hypothesis number	True/False
Information application ← Information knowledge	0.947	***	H2	True

The path coefficients of information awareness, information application, and information ethics on professional development are 0.385, 0.442, and 0.554, respectively, which implies that information awareness, information application, and information ethics have a positive impact on professional development, which is consistent with the research hypotheses H4, H5, and H6, as shown in **Table 6**.

Table 6. Path relationship with professional development

Path relationship	Path coefficient	*P*	Hypothesis number	True/False
Professional development ← Information awareness	0.385	***	H4	True
Professional development ← Information application	0.442	***	H5	True
Professional development ← Information ethics	0.554	***	H6	True

6. Conclusions and recommendations

In the current context of smart education, educational technology is developing rapidly, and teachers' information literacy must be continuously improved with the development of the times. Based on the above findings, strategies for the improvement of teachers' information literacy are proposed from three levels.

Establishing a strong information awareness can cultivate high information literacy in teachers, strengthen their information ethics and professional development, and ensure they keep up with the pace of the times. Firstly, teachers should have the concept of discerning and updating information. In the information age, teaching resources have become more diversified, uneven, and intricate than ever before, and reasonable use of teaching resources can make the classroom icing on the cake. The authenticity, authority, and usefulness of information should be correctly judged, and information resources in education and teaching should be appropriately used. Through the platform of mutual communication and learning, it is necessary to timely update the information knowledge related to the subject and beneficial to their own development, for continuous learning and keeping up with the pace of social development. Secondly, teachers should realize the importance of teaching innovation and optimization. The development of innovative consciousness is indispensable in the information age. Teachers should realize the importance of innovation in education and teaching, keep pace with the times, and seize the opportunity to realize the enhancement of their own innovative consciousness. In the process of education and teaching, teachers take the initiative to use information technology to optimize teaching, and apply the knowledge and skills they have in reserve to innovate the education and teaching mode and cultivate talents.

In the information age, teachers should make the enhancement of information literacy their daily task, constantly enrich their information knowledge, and take the initiative to learn from and share with colleagues. Teachers can make a learning plan according to their own situation and use their free time to learn what is suitable for them, including learning the basics of information security and property rights, the information knowledge of the subject, the informatization knowledge of teaching, and the basic operation knowledge of relevant teaching equipment and office software. In continuous learning, teachers summarize and update their own concepts, and in the network teaching and research activities, they communicate and share knowledge with other outstanding teachers. The accumulation of information knowledge through continuous learning leads to internalization of information knowledge and enhancement of one's own wisdom in the process of communication and sharing, followed by externalization into one's own teaching ability in the process of education and teaching, and the enhancement of teaching ability prompts teachers to update their own concept of teaching and to acquire deeper teaching knowledge, and so on and so forth. Teachers develop to become truly intelligent teachers through such learning.

Enhancing the ability to apply information is the basis for promoting teachers' professional development. Survey data showed that the lower the age of teaching, the weaker the teachers are in information application, and newly recruited teachers will be rusty in the application of information, which leads to a more rigid

integration of information technology and subject teaching. In today's context of smart education, teachers need to have the ability to integrate the innovative application of information technology with subject teaching, in addition to mastering the ability to retrieve, collect, process, and integrate information resources effectively, and evaluate the effectiveness of their use. Firstly, teachers, as the designers and implementers of information technology teaching in schools, should be fully aware of the relationship between the "human-machine-human" triad, break the traditional teaching mode, carry out personalized teaching implementation and evaluation using information technology according to the characteristics of different students, and help students develop into smart talents in the process of smart teaching through targeted teaching. Secondly, the whole learning process of students in the era of smart education will be memorized by intelligent machines and the results will be counted quickly. With the support of digitalization and intelligent technology, teachers must record and understand the learning situation of each student, and assess and reflect on the effectiveness of the use of information resources through reasonable, scientific, and comprehensive learning evaluation. Based on the evaluation results, teachers can innovate the integration of information technology and subject teaching in the process of teaching and learning in order to promote professional development.

With the rapid development of information technology in education today, teachers need to have a good network information ethics and adhere to the principle of "moral first" in teaching, which is an important guarantee for the promotion of teachers' professional development. Firstly, teachers should set a good moral example for students. In the information age, people can express their views and opinions on the network platform, where students will also see the relevant content. The development of students requires a positive network environment, in which a good network culture should be maintained. In the Statistical Report on the Development Status of China's Internet Network released by the Internet Information Center of China, it is shown that as of June 2019, the size of China's Internet users has reached 854 million, of which a larger proportion is accounted for by the student population. Teachers' cognition and behavior will subconsciously affect students, and as teachers, they should set a moral example for students and help them grow up healthily in a positive network environment. Secondly, teachers should follow the code of information ethics. Teachers should use Internet resources reasonably and avoid browsing and spreading harmful information. In the process of learning and exchanging ideas with other teachers, they should focus on taking the initiative to state the source of the intellectual property rights of others, and prevent misappropriating the research results of others. Additionally, they should adopt the correct channels for downloading teaching software to ensure genuine software is used, and implement effective technical means to prevent Trojan horse programs, and emphasize data backup.

Teachers' professional development has been an essential part of developing their information literacy. Teachers nowadays can make use of rich online platforms to realize multi-resource, collaborative teacher professional development. Survey data showed that teachers of younger teaching age and relatively lower academic qualifications are weaker in terms of professional development, and this group of teachers can pay special attention to the following suggestions. Firstly, teachers should acquire specialized knowledge to improve teaching ability. Under the premise of having a certain degree of information awareness and information application ability, teachers should be able to use information technology to continuously acquire subject knowledge, watch the teaching videos or micro-courses of excellent teachers on the network platform learning community, learn their teaching highlights, and then apply them to their own teaching process in conjunction with their disciplinary characteristics, so as to continuously improve their knowledge of teaching. Secondly, teachers should carry out effective collaborative teaching and research. Teachers can use information technology to realize a wider range of information sharing and communication, and carry out network collaborative

teaching and research with teachers in the same school or even excellent teachers in other regions, so as to learn together and promote the innovation of teaching methods and approaches through continuous learning.

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Disclosure statement

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