

A study of factors influencing digital ethical literacy among elementary and secondary pre-service teachers: a structural equation modeling analysis

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ABSTRACT

With the application and development of generative AI technologies such as ChatGPT in the field of education and teaching, higher requirements have been put forward to improve the digital ethical literacy of pre-service teachers. However, there are still impediments to the current development of digital ethical literacy among pre-service teachers. Therefore, based on the social cognitive theory, this study aims to discuss the individual-level, behavioral-level, environmental-level, and social-level factors and their relationships that affect pre-service teachers' digital ethics literacy. A total of 524 pre-service teachers in China were used as the study population. The study found that the factors influencing pre-service teachers' digital ethics literacy include seven dimensions: personal values and digital ethics awareness at the individual level, digital ethics education competence and digital technology use skills at the behavioral level, resources and environment of the school and related educational policies at the environmental level, and social recognition at the social level. Among them, there are some interactions between the individual and behavioral dimensions, the environment and individual dimensions, the environment and behavioral dimensions, the individual, behavioral and environmental dimensions, and the social and individual behavioral dimensions two by two, and they play a positive influence on improving the digital ethical literacy of the pre-service teachers, but the interactions between the social and environmental dimensions are not significant. On this basis, the improvement of digital ethical literacy of pre-service teachers is discussed to provide some references for the related research on improving digital ethical literacy of pre-service teachers.

Keywords: Pre-service teachers, digital ethical literacy, influencing factors, structural equation modeling

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1. Introduction

When the innovative technology represented by artificial intelligence and big data intervenes in the education ecology, along with the deep integration of the two, it is difficult for the teaching organization to rely on the way of “wearing new technical shoes and walking on the traditional old road” to meet the general requirements of modern education environment for the education of people in the era. Strengthening the construction of teachers to promote education reform and improve the quality of education has become an important measure for countries around the world to develop education and occupy the high ground of high-quality human resources [1-2]. Enhancing pre-service teachers' digital ethical literacy is one of the main contents of China's efforts to promote the construction of the teaching force in the smart era, and it is also an important measure to cultivate a teaching force that is capable of fulfilling the requirements of parenting in the smart era [3-5].

As the key force of the future teaching force, pre-service teachers have high potential for digital ethical literacy and digital education needs [6-7]. Pre-service teachers will play an important role in all levels and aspects of education in the future, and will play an important role in the implementation and promotion of digital education, and the development of their digital ethical literacy is an important guarantee for the future teaching position to carry out educational and teaching activities [8-11]. Due to the specificity of the role of pre-service teachers, the digital ethical literacy they should have is not only the universal digital ethical literacy needed as students, but also the digital ethical literacy needed as teachers and knowledge transmitters [12-14]. The deep integration of digital technology and education and teaching helps to improve the quality of education in the era of the demand, and the collision with the pre-service teachers' own learning needs, for the cultivation of intelligent education literacy of pre-service teachers, provides a solid social environment and learning motivation foundation [15-18]. In the context of digital education, if primary and secondary pre-service teachers are difficult to develop digital ethical literacy, it will greatly affect the development of the future teaching force, unable to adapt to the future needs of teaching, and then hinder the professional development of teachers [19-20].

This study has certain theoretical contributions and practical value. (1) Theoretical contribution. The framework of factors influencing pre-service teachers' digital ethical literacy constructed in this study provides a reference for subsequent related studies. This study extends the application of social cognitive theory. (2) Practical value. This study provides a reference for measuring the influencing factors of pre-service teachers' digital ethical literacy, as well as designing, implementing and improving pre-service teachers' digital ethical literacy.

This study consists of the following seven parts. First, the second part, literature review, by sorting out what are the factors affecting teachers' digital ethical literacy in existing studies and formulating hypotheses. Second, the third part, the methodology used in the study, the design and implementation of the study, by designing, distributing and collecting questionnaires based on existing studies, and analyzing the questionnaire data. Then, Part IV and Part V, based on the results of data analysis, discuss how to improve teachers' digital ethics literacy. Then, Part VI, summarizes the theoretical contribution and practical value of this study. Finally, Part VII and Part VIII, sort out and summarize the conclusions and shortcomings of this study, and look forward to future research.

2. Theoretical Framework

2.1. Social cognitive theory

Social cognitive theory provides a "conceptual framework within which to examine the determinants and mechanisms of human thought, affect and action". In this theory, Bandura states that the factors of individual behavior change come from three main levels such as the individual himself, the individual's behavior and the environment. Later, Bandura further stated that the factors that

contribute to behavior change should come from the three levels of the individual, the environment, and the society, and pointed out that the three levels are independent of each other as well as interacting with each other, forming a triadic dynamic interactive deterministic relationship. Based on the social cognitive theory, this study considers pre-service teachers' digital ethical literacy as a part of pre-service teachers' individual behaviors, including four aspects: digital ethical awareness and cognition, digital ethical norms and laws and regulations, digital ethical decision-making ability, and digital social responsibility. Therefore, pre-service teachers' digital ethics literacy is influenced by four dimensions: individual, behavioral, environmental and social.

2.2. Individual Level

Individual-level factors refer to the influence of an individual's perceptions and awareness on his or her behavioral perceptions. It has been found that pre-service teachers' individual values and digital ethics awareness are influential factors in changing their digital ethics literacy. Among them, individual values include pre-service teachers' self-efficacy and individual motivation. Relevant studies have pointed out that teachers' beliefs, moral dispositions, and personal values can have a positive influence on their teaching and scholarship in digital ethics, and teachers' personal motivation has a certain influence on their teaching of digital ethics. Based on the above, we formulated the following hypotheses.

H1: PV have a positive and significant effect on DEEC.

H2: ADE has a positive and significant effect on DEEC.

2.3. Behavioral Level

Behavioral dimensions factors refer to the impact of individual behaviors and skills on their ideologies and competencies. Relevant studies have shown that the more positive the teachers' attitudes toward technology use or the more frequently they use it, the more aware teachers are of digital ethics and can have an impact on teachers' ability to teach digital ethics. Therefore, this study divided the factors at the behavioral level of pre-service teachers into the use of digital technology and the ability to teach digital ethics. In particular, the use of digital technology includes preservice teachers' attitudes toward the use of digital technology, frequency, and the impact of using the technology on their ability to teach digital ethics. Digital ethics education competence includes pre-service teachers' perceptions of digital ethics education, digital ethics teaching skills, and so on. In addition, research suggests that teachers' lack of proper use of digital technology early in their careers may pose some barriers to their ability to teach digital ethics. Based on the above, we formulated the following hypotheses.

H3: DTS have a positive and significant effect on DEEC.

H4: DTS have a positive and significant effect on ADE.

2.4. Environmental Level

Environmental dimensions refer to the influence of external environmental conditions on an individual's cognition, behavior, skills and perceptions. It has been found that the environment of pre-service teachers' institutions, digital resources, and school leaders may have some influence on the formation of their digital ethical literacy. Based on the above, we formulated the following hypotheses.

H5: SRE have a positive and significant effect on DEEC.

H6: REP has a positive and significant effect on DEEC.

H7: SRE has a positive and significant effect on PV.

H8: There is a positive and significant effect of REP on SRE.

H9: There is a positive and significant effect of REP on PV.

"The Survey of Schools: ICT in education" published by the European Union in 2011, found that some schools with policy support lacked the attention of school leaders and the implementation of concrete measures in the use of digital resources in education, resulting in their teachers' digital education

competencies not performing better than those schools that lacked policy support but carried out concrete actions. Based on the above, we formulated the following hypotheses.

H10: REP have an indirect positive and significant effect on PV through the mediation of SRE.

H11: SRE has an indirect positive and significant effect on DEEC through the mediation of PV.

H12: REP has an indirect positive and significant effect on DEEC through the mediation of SRE.

2.5. Social Level

Social dimensions factors refer to the influence of aspects of the social environment and related policies on individual cognition, behavior, skills, and perceptions. Research has shown that the implementation of policies can create a favorable social environment that is conducive to the good development of digital ethics education. Thus, it can be seen that the social environment and related policies that emphasize and recognize digital ethics education are one of the important factors that affect the digital ethics literacy of pre-service teachers. Based on the above, we formulated the following hypotheses.

H13: SR has a positive and significant effect on DEEC.

H14: REP has a positive and significant effect on Social Recognition SR.

H15: REP has an indirect positive and significant effect on DEEC through the mediation of SR.

2.6. Theoretical Framework

In summary, this study classified the influencing factors of pre-service teachers' digital ethical literacy into seven dimensions, including PV, ADE, DEEC, DTS, SRE, REP, SR, and constructed a hypothetical model of the influencing factors of digital ethical literacy for pre-service teachers, as shown in Figure 1.

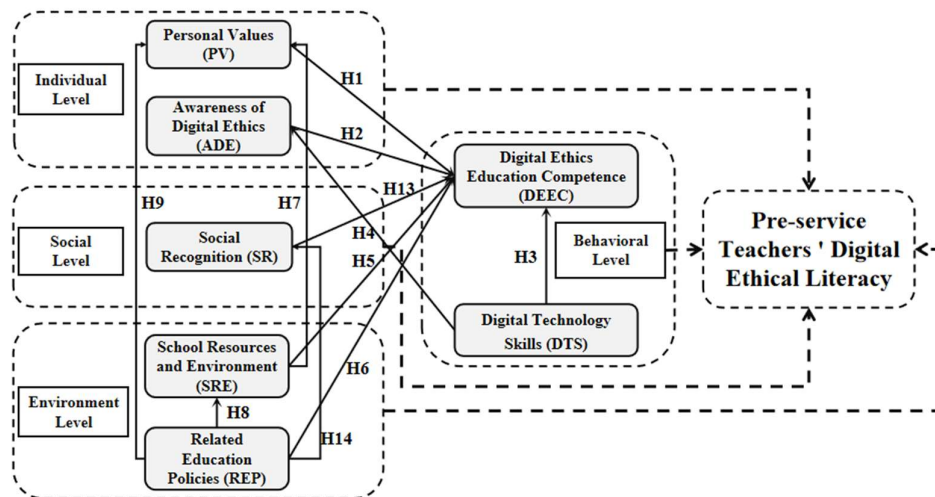


Fig. 1. Hypothetical model

3. Research Method

3.1. Research Design

In this study, the research questionnaire "Questionnaire on Influencing Pre-service Teachers' Digital Ethics Literacy" was modified and formed on the basis of reference to related studies and existing scales, with a total of 33 items, as shown in Table 1. The structure of the questionnaire included basic information on demographic variables such as gender, age, education level, and region of the school

attended by the pre-service teachers, as well as seven subscales such as PV, ADE, DEEC, DTS, SRE, REP, and SR, and was scored on a 5-point Likert scale.

Table 1. Questionnaire Scale

Construct	Coding	Items
Personal Values	PV1	I am able to use digital technology correctly while complying with ethical and legal requirements.
	PV2	I am able to protect my privacy and other data information.
	PV3	I am confident that I can handle digital ethics in education and teaching.
	PV4	I believe that being educated in digital ethical literacy will help my own future professional development as a teacher.
	PV5	I believe that educating students about digital ethical literacy will benefit them in the future.
Awareness of Digital Ethics	ADE1	I am able to judge the reliability and authenticity of data information.
	ADE2	I often follow news stories or events related to digital ethics.
	ADE3	I will focus on screening information for truthfulness, appropriateness, and fairness when citing.
	ADE4	I will respect the academic achievements of others and abide by the legal ethics related to intellectual property rights.
	ADE5	I am able to focus on protecting the privacy and security of information of others (including students) while complying with legal ethics.
Digital Ethics Education Competence	DEEC1	I believe that digital ethical literacy education for pre-service teachers is necessary in teacher education institutions.
	DEEC2	I believe that it is necessary to observe the ethics of line numbers in teaching and learning in primary and secondary education.
	DEEC3	I think it is necessary to teach digital ethics in primary and secondary education.
	DEEC4	I believe that being educated in courses related to digital ethics will increase my awareness of digital ethics.
	DEEC5	I believe that being educated in courses related to digital ethics will improve my basic knowledge of digital ethics.
	DEEC6	I believe that receiving training in teaching and learning related to digital ethics can deepen my knowledge of digital ethics.
	DEEC7	I believe that receiving practical training related to digital ethics will improve my ability to teach digital ethics.
Digital Technology Skills	UDT1	I use digital technology a lot.
	UDT2	I believe that regular use of digital technology enhances my digital ethical literacy.
	UDT3	I believe that regular use of digital technology fosters digital ethical literacy in students.
	UDT4	I think regular use of digital technology can better help us to develop a good digital ethic. (Not included in formal research)
School Resources and Environment	SRE1	My school provides a wealth of digital resources to enhance our knowledge of digital ethics.
	SRE2	Leaders at my school support programs, lectures, and activities related to digital ethics education.
	SRE3	My school has a series of lectures, clubs and competitions related to digital ethics education.
	SRE4	My school provides a great campus environment and learning atmosphere to enhance our digital ethics literacy. (Not included in formal research)
Related Education Policies	REP1	I agree that "policies at the national level can provide pre-service teachers with clear goals and directions for digital ethical literacy."
	REP2	I agree that "district-level policies can combine national policies with district realities to enhance the digital ethics literacy of pre-service teachers in district schools in a more specific and targeted way."
	REP3	I agree that "school-based policies at the school level can create conditions for pre-service teachers to improve their digital ethical literacy by taking into account the educational and teaching environments of pre-service and in-service teachers, the development of the school and the reality of the students".
	REP4	I think the enactment of the policy provides us with a strong support to improve digital ethics literacy. (Not included in formal research)
Social Recognition	SR1	I think the role of digital ethical literacy education is generally recognized at the societal level.
	SR2	I think it is generally recognized at the community level that primary and secondary schools are conducting IT or IT courses.
	SR3	I think there is a general consensus at the community level that IT teachers can enhance the digital ethical literacy of primary and secondary school students.
	SR4	I think there is a general recognition at the societal level that digital technology plays a positive role in human life and education, among other things. (Not included in formal research)

3.2. Data collection and questionnaire revision

Pre-service teachers from six representative colleges and universities in the eastern, central and western regions of China were selected for the study. All cases obtained the informed consent of the participants and complied with all ethical requirements. Sample questionnaire information is shown in Table 2.

Table 2. Sample Information

Demographics	Item	Frequency	Percentage (%)
Gender	Man	255	48.7
	Woman	269	51.3
Age	<18	79	15.1
	18-22	118	22.5
	22-25	159	30.3
	25-28	104	19.8
	>28	64	12.2
Academic Degree	College	100	19.1
	Bachelor	189	36.1
	Master	170	32.4
	PhD	65	12.4
Region	Eastern	164	31.3
	Central	166	31.7
	Western	194	37.0

The author conducted a pre-survey before the formal research and screened the questionnaires in terms of 2 indicators. The author eliminated 48 invalid questionnaires from the 203 predicted questionnaires and analyzed the data of the remaining 155 valid questionnaires. Using SPSS 24.0 software for reliability analysis, the Cronbach's α of the overall prediction questionnaire was obtained > 0.7 , KMO > 0.8 , and Bartlett's spherical test results reached a significant level ($P < 0.001$), indicating that the data obtained from the prediction questionnaires were suitable for factor analysis. After the principal component method, a total of seven load factors with initial eigenvalues greater than 1 were extracted, with a cumulative variance contribution rate of 68.15%, which has a good degree of explanation. Meanwhile, UDT4, SRE4 and SR4 with factor loadings less than 0.5, and REP4, which is self-contained and one-dimensional, were eliminated.

4. Results

4.1. Reliability and Validity Tests of Formal Questionnaires

The author excluded 73 invalid questionnaires from the 600 formal questionnaires recovered, and 524 valid questionnaires were recovered, with a recovery validity rate of 87.3%. SPSS 24.0 was used to analyze the reliability and validity, and the overall Cronbach's α value of the formal questionnaire was $0.922 > 0.7$, the KMO value was $0.933 > 0.8$, and the result of the Bartlett's spherical test reached a significant level ($p < 0.001$), which indicated that the questionnaire had a better reliability and validity and the seven common factors extracted by factor analysis could explain 67.658% of the variance. The 7 metrics extracted by factor analysis can explain 67.658% of the variance, indicating that the 7 metrics extracted in this study can effectively explain the 29 topics of the questionnaire, and the subscales compiled by the research questionnaire have good convergent validity and structural validity, as shown in Table 3.

Table 3. Reliability and Validity Analysis

Constructs	Items	Significance estimation				Question reliability		Cronbach's α	CR	AVE
		Unstd.	S.E.	z-value	p	Std.	SMC			
Personal Values	PV1	1.000				.787	.619	0.864	0.866	0.565
	PV2	1.034	.053	19.509	**	.819	.671			
	PV3	.933	.054	17.278	**	.742	.551			
	PV4	.919	.057	16.123	**	.695	.483			
	PV5	.922	.056	16.464	**	.709	.503			
Awareness of Digital Ethics	ADE1	1.000				.827	.684	0.869	0.889	0.571
	ADE 2	.868	.049	17.714	**	.734	.539			
	ADE 3	.921	.049	18.796	**	.753	.567			
	ADE4	.876	.049	17.878	**	.730	.533			
	ADE 5	.868	.049	17.714	**	.731	.534			
Digital Ethics Education Competence	DEEC 1	1.000				.739	.546	0.902	0.904	0.575
	DEEC 2	1.534	.081	18.938	**	.827	.684			
	DEEC 3	1.107	.067	16.522	**	.731	.534			
	DEEC 4	1.082	.063	17.175	**	.760	.578			
	DEEC 5	1.364	.077	17.714	**	.778	.605			
	DEEC 6	1.062	.063	16.857	**	.747	.558			
	DEEC 7	1.040	.064	16.250	**	.722	.521			
Digital Technology Skills	UDT1	1.000				.716	.513	0.765	0.771	0.529
	UDT2	1.182	.086	13.744	**	.770	.593			
	UDT3	1.161	.090	12.900	**	.694	.482			
School Resources and Environment	SRE1	1.000				.698	.487	0.760	0.760	0.514
	SRE2	1.037	.077	13.468	**	.709	.503			
	SRE3	1.137	.083	13.699	**	.743	.552			
Related Education Policies	REP1	1.000				.764	.584	0.809	0.810	0.587
	REP2	.916	.062	14.774	**	.728	.530			
	REP3	1.109	.072	15.403	**	.805	.648			
Social Recognition	SR1	1.000				.830	.689	0.806	0.812	0.591
	SR2	.755	.050	15.100	**	.672	.452			
	SR3	.812	.047	17.277	**	.796	.634			

4.2. Common Method Bias and Reliability and Validity Tests for Measurement Modeling

The common method bias test was applied to the measurement model using AMOS 24.0, which was analyzed to show that the chi-square value was reduced by 0.896 and the values of RMSEA, CFI, and TLI did not increase, indicating that the formal questionnaire did not have a significant common method bias.

CFA analysis of the measurement model showed that the overall fitness index of the measurement model was able to meet the model fit requirements ($\chi^2/df = 1.211 < 3$, RMSEA = 0.020 < 0.05, GFI = 0.947, NFI = 0.943, IFI = 0.989, CFI = 0.989, which were all greater than 0.90), which indicated that the measurement model had a good fit degree. The reliability and validity of the measurement model was further examined, and the CR value of each latent variable was greater than 0.7, and the AVE value was greater than 0.5, indicating that the latent variables had good combinatorial reliability and convergent validity, and that the measurement model had good discriminant validity, as shown in Table 3.

4.3. Path analysis for structural equation modeling

AMOS 23.0 was utilized to construct the structural equation model, as shown in Figure 2, and the path coefficients of the model were calculated, as shown in Table 4. The results show that the overall fitness indicators of the measurement model basically meet the model fitness requirements ($\chi^2/df = 2.309 < 3$, RMSEA = 0.050 < 0.08, NFI = 0.888 > 0.8, GFI = 0.901, IFI = 0.933, CFI = 0.933, which are all greater than 0.90), which indicates that the structural equation model's overall fit is good.

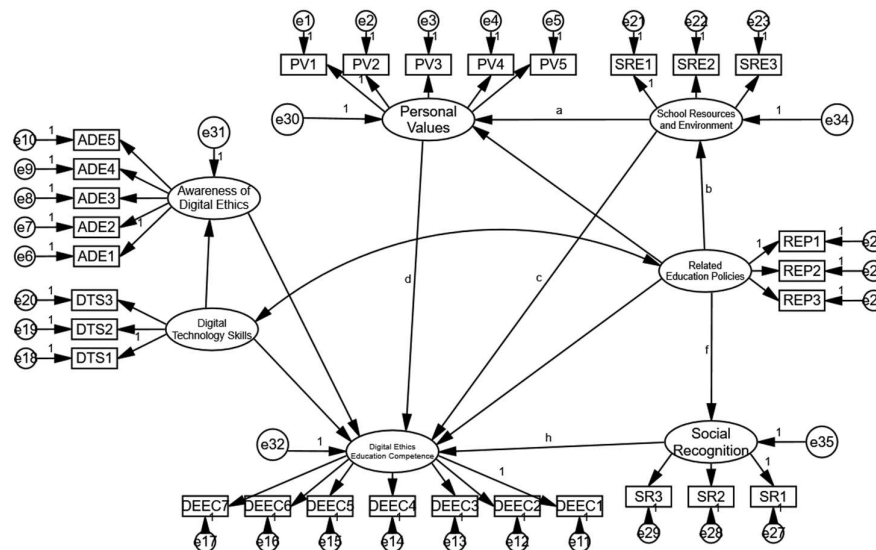


Fig. 2. The Structural Equation Model

Table 4. Path Analysis

Pairs of Predictor Variables	Estimate	S.E.	C.R.	β	P
H1: PV→DEEC	.183	.052	3.536	.235	***
H2: ADE→DEEC	.125	.039	3.203	.181	.001**
H3: DTS→DEEC	.067	.036	1.857	.103	.063
H4: DTS→ADE	.438	.053	8.219	.466	***
H5: SRE→DEEC	.183	.059	3.081	.212	.002**
H6: REP→DEEC	.137	.037	3.735	.187	***
H7: SRE→PV	.639	.064	9.967	.576	***
H8: REP→SRE	.144	.049	2.954	.168	.003**
H9: REP→PV	.250	.045	5.606	.264	***
H13: SR→DEEC	.159	.036	4.434	.232	***
H14: REP→SR	.094	.059	1.598	.087	.110

Note: *** denotes $P < 0.001$, **denotes $P < 0.01$.

The path analysis results for the influencing factors model of pre-service teachers' digital ethics literacy are presented in Table 3. Key findings indicate that:

- 1) At the individual level, PV ($\beta = 0.235$, $P < 0.001$) and ADE ($\beta = 0.181$, $P < 0.01$) have a significant positive impact on pre-service teachers' DEEC, substantiating the establishment of H1 and H2.
- 2) At the behavioral level, DTS have a significant positive impact on pre-service teachers' ADE ($\beta = 0.466$, $P < 0.01$), confirming H4. However, while DTS have a positive impact on DEEC, this effect is not statistically significant ($\beta = 0.103$, $P > 0.1$), leading to the rejection of H3.
- 3) At the environmental level, SRE have a significant positive impact on the pre-service teachers' DEEC ($\beta = 0.212$, $P < 0.01$) and PV ($\beta = 0.576$, $P < 0.001$). REP also have a significant and positive impact on pre-service teachers' PV ($\beta = 0.264$, $P < 0.001$), DEEC ($\beta = 0.187$, $P < 0.001$), and SRE ($\beta = 0.168$, $P < 0.01$), thus confirming the establishment of H6, H8 and H9.
- 4) SR has a positive but not significant impact on pre-service teachers' DEEC ($\beta = 0.232$, $P > 0.1$). Hence, H14 is rejected as it is not statistically significant.

4.4. Mediation Effect Tests for Structural Equation Modeling

In order to further explore the relationship between the indirect effects of the dimensions of digital ethical literacy among pre-service teachers, this study utilized AMOS 23.0 to analyze the mediated effects of the main paths between the above factors, as shown in Table 5.

Table 5. Bootstrap test of the mediating effect

Mediating Effect Test	Coefficient	S.E.	Bias-Corrected 95% Confidence Interval		P
			LLCI	ULCI	
H10: REP→SRE→PV	.092	.040	.021	.180	.010**
H11: SRE→PV→DEEC	.117	.035	.053	.190	.001**
H12: REP→SRE→DEEC	.026	.015	.006	.067	.007**
H15: REP→SR→DEEC	.015	.012	-.006	.043	.141
Total Indirect Effect	.249	.066	.131	.391	.000

The outcomes of the mediating effect analysis for the model of influencing factors on pre-service teachers' digital ethics literacy are presented in Table 5. The results indicate that:

- 1) REP can have an indirect positive impact on pre-service teachers' PV through the SRE ($\beta = 0.092$, $P < 0.01$), thus H10 is accepted.
- 2) SRE can have an indirect positive impact on pre-service teachers' DEEC through their PV ($\beta = 0.117$, $P < 0.01$), thus H11 is accepted.
- 3) REP can have an indirect positive impact on the DEEC of pre-service teachers through the SRE ($\beta = 0.026$, $P < 0.01$), thus H12 is accepted.
- 4) REP have a positive impact on the DEEC of pre-service teachers through SR. However, this effect is not statistically significant ($\beta = 0.012$, $P > 0.05$), thus H15 is rejected.

5. Conclusion and Discussion

Based on the social cognitive theory, this study constructed and validated a model of the influencing factors of pre-service teachers' digital ethical literacy from the individual, behavioral, environmental and social levels, using structural equation modeling, and drew the following conclusions through the questionnaire survey and quantitative data analysis.

5.1. *Individual & Behavioral Levels*

5.1.1. Influence of personal values, digital ethics, and digital ethical education competence. The results of the study show that hypotheses H1 and H2 are valid and that pre-service teachers' positive digital ethics personal values and awareness can improve their digital ethics education competence, which in turn enhances their digital ethics literacy.

5.1.2 Pre-service teachers' digital technology skills and their impact on the awareness of digital ethics and digital ethics education competence. The research hypothesis H4 is valid, indicating that the proper use of technology can increase the digital ethics awareness of pre-service teachers. This also supports part of the social cognitive theory that the improvement of pre-service teachers' behavioral skills in the use of digital technology can counteract the improvement of teachers' digital ethics ideology.

However, it was found that research hypothesis H3 was not valid, indicating to some extent that the improvement of pre-service teachers' skills in the use of digital technology does not necessarily contribute effectively to the improvement of their digital ethics education level and behavioral competence. To a certain extent, it also reflects the phenomenon that current pre-service teachers are still deficient in their ability to apply digital technology in education and have weak digital evaluation skills. For example, some teachers have the tendency of "technology-only" in the process of classroom teaching, or even the misuse of technology.

Therefore, to improve the digital ethics literacy of pre-service teachers at the individual and behavioral levels, on the one hand, we need to pay attention to the digital ethics literacy training program for pre-service teachers, and help pre-service teachers to gradually improve their ethical technological practice ability and digital ethics education ability. On the other hand, pre-service teachers themselves should improve their own digital ethics literacy and pay attention to and emphasize students' digital ethics literacy education. "Ethics are not merely 'rules and expectations' but also a basis for practice". Teachers must know how to protect student privacy, prevent cultural bias and discrimination, and maintain justice and equity in education when using these digital technologies.

5.2. *Environment and individual, behavior level*

5.2.1. Relevant Education Policies and School Resources and Environment. The results of the study indicate that hypotheses H8 and H9 are valid. To a certain extent, it shows that relevant educational policies can guide the direction for developing pre-service teachers' digital ethics conceptual development and facilitate the construction of school resources and environment. The building of school resources and environments, on the other hand, should give more consideration to the digital ethics education environment in which pre-service teachers are embedded and the development of the school, in order to create the conditions for establishing the development of pre-service teachers' digital ethics concepts. In particular, the school leadership and management should, on the basis of understanding the current situation of digital ethics education for pre-service teachers, appropriately adjust the digital ethics education program for pre-service teachers according to the policy requirements, and regularly update the school's digital resource construction, so as to create a good campus atmosphere and resource conditions for the cultivation of pre-service teachers' digital ethics literacy. Thus, the implementation of various educational policies at all levels and the construction of good school resources and environments play an important role in promoting the digital ethical literacy of pre-service teachers.

5.2.2. School resources and environment, relevant education policies and pre-service teachers' personal values and digital ethics education competency. The results of the study indicate that hypotheses H5, H6, H7, H8, and H9 are valid, which to a certain extent suggests that high-quality school

resources, a favorable environmental climate, and access to relevant educational policies have a positive impact on promoting pre-service teachers' ability to educate digital ethics and personal values, which in turn effectively enhances pre-service teachers' digital ethics literacy. With similar findings. Based on this, in order to effectively implement relevant educational policies and ensure the sound development of digital ethics literacy for pre-service teachers, we can learn from the EU's measure of issuing relevant policy documents or survey reports from time to time according to the development of the situation in order to assess the construction of the school's digital infrastructure environment and resources, as well as the current status of the development of digital ethics education in the school, and to support schools to carry out education for pre-service teachers in digital ethics literacy.

5.2.3. The role of policy in shaping digital ethics education. The results of the study show that hypotheses H10 and H12 are valid. To a certain extent, it shows that promoting the construction of digital ethics education resources and environment in schools from the policy perspective can, to a certain extent, promote pre-service teachers to pay attention to digital ethics education and thus strengthen their own digital ethics education capacity. In a case study published in Finland on "Ethical Considerations for Promoting the Use of Digital Technology in Basic Education Teaching," it was also shown that national and administrative-level policies and clear instructions from school leadership, as well as strong policy implementation and the building of school resources, can facilitate teachers' ethical use of digital technology. This also supports part of the Social Cognitive Theory that external policies and environments can facilitate changes in individual pre-service teachers' perceptions, cognitions, behaviors, and skills towards digital ethics education.

5.2.4. The influence of environmental factors on teachers' ethical awareness. The results of the study indicate that hypothesis H11 is valid. "The degree of investment and construction of school information technology environments and resources can influence teachers' personal ethical awareness, which in turn improves teachers' conceptions of teaching digital ethics". The conclusion is similar. It can be seen that the educational policy requirements for the development of digital ethical literacy of pre-service teachers are not only related to the personal values and digital ethical education competence of pre-service teachers, but also related to the provision of appropriate resources and a favorable environmental environment in the institutions where pre-service teachers work.

Therefore, to enhance the digital ethical literacy of pre-service teachers from the environmental level is mainly analyzed and researched from the aspects of building environmental resources and managing digital ethical education in schools, which is the focus and difficulty of all the research, aiming at exploring the value scale and code of conduct that can be understood and recognized by the majority of people with the goal of enhancing the digital ethical literacy of pre-service teachers.

5.3. *Social, individual behavior, and environmental dimension*

5.3.1. Social recognition and pre-service teachers' competence of digital ethics education. The results of the study show that hypothesis H13 is valid. To a certain extent, it shows that the support of digital ethics education for pre-service teachers at the societal level is effective in enhancing the digital ethics literacy of pre-service teachers. This also supports part of the Social Cognitive Theory that social acceptance can play a contributing role in pre-service teachers' digital ethical behaviors. Thus, the digital ethical literacy of pre-service teachers is also affected by the social environment, and it is important to raise the social level's concern and recognition of digital ethical education in order to help pre-service teachers' digital ethical literacy education.

5.3.2. Relevant education policies, social recognition and pre-service teachers' competence of digital ethics education. Based on the results of hypotheses H14 and H15 not being valid, the study found that the current education policy has not yet been widely recognized at the social level in the

implementation of the issue of enhancing the digital ethical literacy of teachers and students, which is a noteworthy finding that to a certain extent indicates that there are still certain problems in the implementation of the policy, and it should be a cause for concern for the relevant policy makers. However, the pre-service teacher group in China still exists in digital ethics literacy education and other related aspects, and the European Union has pointed out that social recognition has a certain impact on the individual's ability to apply digital technology and digital ethics awareness. Furthermore, in recent years, organizations or institutions such as those in Europe and the United States, the Asia-Pacific region, and UNESCO have paid attention to strengthening the training of teachers in digital ethics through the release of relevant policies. In view of this, for this reason, it is necessary to strengthen the recognition and importance of digital ethics literacy education at the social level from the perspective of education policy, and to provide clear but scientific guidance for the practice of digital ethics literacy education.

Therefore, to enhance the digital ethics literacy of pre-service teachers from the social level, the overall deployment of the digital ethics literacy of pre-service teachers should be taken into account, and the public's familiarity with and recognition of the digital ethics literacy of pre-service teachers and related educational policies should be enhanced to promote the implementation of digital ethics literacy education for pre-service teachers.

Conflict of interest statement

No potential conflict of interest was reported by the author. These authors contributed equally to this work.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Ethics statement

This study was reviewed and approved by Guangxi Normal University. Consent forms were obtained from participants before data collection.

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