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PAPER

Structural Relationship on Factors Influencing Digital Literacy of College Students

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ABSTRACT

In the era of rapid development of science and electronic technology, cultivating students' digital literacy has become one of the key goals. This study aims to explore the causal relationship between students' cognitive engagement, behavioral engagement, emotional engagement, and digital literacy. For this purpose, 454 college students participated in the survey held in March 2022. According to the results of the structural equation model, (1) students' cognitive engagement significantly influenced emotional engagement, behavioral engagement, and digital literacy. (2) Students' cognitive and behavioral engagement is related to their digital literacy. (3) Emotional engagement could not predict digital literacy. (4) Behavioral engagement moderated the relationship between cognitive engagement and digital literacy. This study emphasizes socio-emotional ability, which critically explores the value of online information between meaningful information and fake news. In conclusion, higher education should be designed to cultivate each dimension by clearly recognizing the sub-dimensions of digital literacy.

KEYWORDS

digital literacy, student engagement, cognitive engagement, emotional engagement, behavioral engagement, college student

1 INTRODUCTION

The arrival of digital media has greatly changed people's lives, and its influence on the entire field of life is also increasing. With this global trend, the school education model is also changing. Therefore, the *14th Five-Year Plan for National Informatization* of the Chinese government also lists "Digital Literacy and Skills Improvement for All" as one of the ten priority actions and proposes to set up regular and scenario-oriented digital skills courses in universities, middle schools, and primary schools [1]. Above all, improving Chinese college students' digital citizenship literacy is an objective needed to confirm the development trend of the global network society [2] [3] [4].

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Awareness of digital literacy is a prerequisite for college students to improve theirs. If college students take the initiative to know, understand, and use the modern digital network from their perspective, they can improve their digital literacy abilities [5] [6]. Furthermore, when students form a relatively stable thinking mode in their cognition of digital literacy, they will take the initiative to optimize their self-value, study motivation, and further mobilize their initiative and consciousness, which will easily enable them to cultivate and improve their digital literacy ability [1] [7] [8] [9]. In other words, improving college students' cognitive engagement ability can help them improve their behavioral and emotional engagement.

Bloom [10] insisted, "A student who learns a course with positive emotions should learn more easily and quickly than those who lack enthusiasm or interest or are afraid and anxious about learning materials." The structure of behavior is equivalent to cognition, and the motivation of behavior belongs to the emotional structure, which is mutually complementary and integrated with motivation. Therefore, cognition is the basis of emotion, and students' cognitive engagement significantly influences emotional engagement. Emotion is the validation of cognition. Studies have shown that with emotional engagement, college students can better identify and acquire digital content, actively communicate and collaborate, adopt more active and effective ways of using the internet, and expand their ability to create and innovate digital literacy [5] [6] [11].

To avoid negative behavior, students need to change their cognition first. An individual's existing cognition has a certain effect on their subsequent behavior. Some scholars say that if college students understand digital literacy, they can improve their social media experience by communicating with others [7] [12]. The stronger the understanding college students gain in communication with others, the higher the level of digital literacy [3] [6] [13] [14].

Therefore, this study aims to explore the relationship between cognitive, emotional, and behavioral engagement and digital literacy through the structural equation model and then improve college students' digital literacy by improving their engagement abilities. Here are the relevant research questions:

1. How high is the digital literacy level of college students?
2. Is there a relationship between college students' engagement abilities and digital literacy?
3. Does the digital literacy of college students improve through cognitive engagement, emotional engagement, and behavioral engagement?

2 LITERATURE REVIEW

2.1 Digital literacy

Scholars have proposed that the so-called digital literacy refers to mastering the skills and knowledge of digital media and technology, finding the information sources that can identify and find the required information, formulating strategies, and then critically accepting the discovered information and solving problems [15] [16]. Attaching importance to cultivate college students' digital literacy and strengthen the training of network talents and high-end digital talents is also one of the important goals of the country [1].

In addition, another equally broad definition of digital literacy, developed by the European Information Society, refers to the appropriate use of digital tools and facilities for the identification, access, management, assessment, analysis, and synthesis

of digital resources in order to build new knowledge and improve awareness and the ability to communicate with others [17].

Based on the specific concepts of Eshet-Alkalai [18] and the multi-literary concepts of the New London Group [19], digital literacy comes from four cross-dimensions: attitude, technology, cognition, and socio-emotional dimensions [20].

The attitude level of digital literacy refers to how confident and fluent students are in creating interesting content, an important skill for all students. The more self-conscious students are about how to cope with the digital environment and how to interact with it, the more capable they are of organizing their learning, thus improving the overall learning experience.

The technical dimension of digital literacy means that students have the skills and operational skills to use communication technology for learning and daily activities. For example, by understanding the file structure, managing data transfers, finding, downloading, and installing everyday applications, and sending files by e-mail.

The cognitive dimension of digital literacy relates to the ability to think critically in the cycle of searching, evaluating, and creating processes for digital information. It also means being able to evaluate and select appropriate software programs to learn or perform specific tasks. Such as podcast, video, map, and model information, these are multi-literary skills involving language, visual, audio, spatial, gesture (captured in the video), and multi-modal (such as multimedia resources) [20].

The socio-emotional dimension of digital literacy refers to users being able to use the Internet responsibly to communicate, socialize, and learn, and being able to observe "etiquette" by applying rules similar to those used in face-to-face communication, such as respecting and using appropriate language and writing to avoid misunderstandings and misconceptions; protecting personal security and privacy by being as private as possible and not disclosing unnecessary personal information; and identifying when they are threatened and knowing how to respond, for example, by ignoring, reporting, or responding to the threat.

With the progress of digital technology and the development of a digital society, the connotation of digital literacy is constantly enriched and improved. It is essential and valuable to students' personal and academic development. Therefore, these perspectives on digital literacy development and the integration of the four dimensions of the digital literacy framework constitute the theoretical basis of this study.

2.2 Student engagement

Engagement is the process of establishing and maintaining relationships or working together with others [21]. Students' classroom participation reflects their interest in teaching activities, enthusiasm, and other emotional states and forms a dynamic interaction in the educational environment [22] [23]. Thus, some scholars have defined classroom participation as the degree of active and enthusiastic effort of learners, such as emotional engagement and behavioral engagement in classroom activities [24] [25].

Student engagement is also called 'student involvement,' where 'involvement' means 'participation' [11] [26]. In addition, some scholars have a different understanding of the concept of student involvement as a variable and hold that student involvement is based on student behavioral engagement. The current concept of student engagement is summarized as behavior, cognitive, and emotional engagement [27] [28]. Some scholars say that the concepts of cognitive, emotional, and behavioral engagement overlap with previous studies. For example, the study of behavioral engagement is related to the study of student behavior and task

behavior [29] [30]. The study of emotional engagement is based on students attitudes [31] [32] and students' interests and values. Finally, the study of cognitive engagement is related to the study of students' motivational goals and self-regulated learning [33] [34].

Cognitive engagement carries out cognitive activities and acquires knowledge in the classroom. Cognitive engagement is a kind of "exercise of thinking," which involves students' mastering the learning content and thinking activities. For example, shallow participation is expressed as paraphrasing others' opinions, while deep participation is expressed as making meaningful comments [11] [35].

Behavioral engagement is when students carry out a series of classroom learning behaviors under the guidance of teachers; it is an outward manifestation of cognitive engagement. Behavioral engagement is the concrete behavior of students in the learning process. Although students' behavior in online learning environments is inaccurate and deceptive to some extent, the frequency, breadth, and depth of behavioral engagement can still reflect students' behavioral engagement [36].

Emotional engagement refers to students' emotional responses to the learning process, displayed as an emotional experience. When students participate in the completion of specific activities, they will have different emotional experiences [11] [38].

The relationship between these three elements is as follows: On the one hand, students' emotional engagement directly affects their cognitive and behavioral engagement. If students lack positive emotion, their cognitive activity will become mechanical and indifferent. Therefore, students who lack emotional motivation tend to get tired easily and find it difficult to persevere. On the other hand, students' cognitive and behavioral engagement also affects their emotional engagement. The stronger the students' cognitive abilities, the easier it is for them to feel a sense of achievement and build confidence [25]. It is an organic combination of cognitive engagement, behavioral engagement, and emotional engagement [15].

From the above analysis of existing research, there is a significant correlation between students' cognitive, behavioral, and emotional engagement. On this basis, this study connects students' behavioral engagement, cognitive engagement, and emotional engagement with students' own perceived level of digital literacy and attempts to improve students' levels through such education. Therefore, this study developed a theoretical model with cognitive engagement as the independent variable, emotional and behavioral engagement as the mediating variable, and digital literacy as the dependent variable. The relationship between variables in the theoretical model is shown in Figure 1.

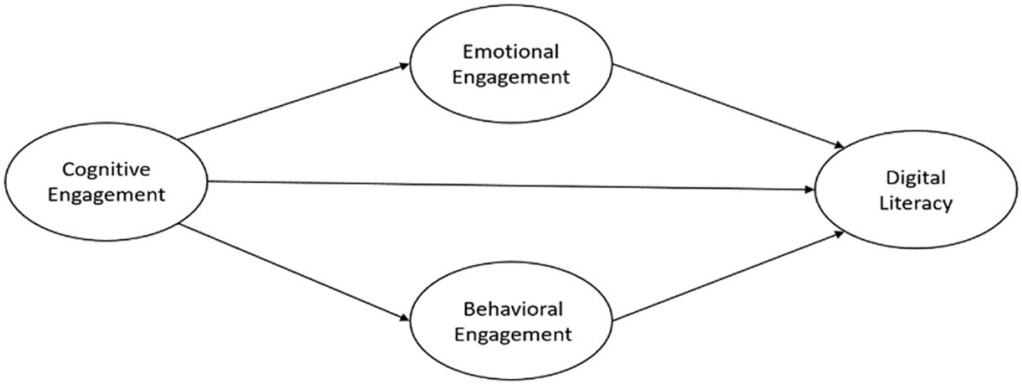

Fig. 1. Theoretical model

3 METHODS

3.1 Participants

The participants of this study are freshmen and seniors at a university in China's Henan Province. The survey was conducted by sending out questionnaires through an online system due to the COVID-19 pandemic. A total of 454 students voluntarily answered the survey through an online system. After deleting invalid investigations, 408 valid investigations were retained, with an effective rate of 89.9%. According to Table 1, the demographic data of the sample include gender, school year, and major. In the gender category, men accounted for 69.1% (282 samples). In the category of the academic year, sophomores accounted for 64% (261 samples). In the major category, undergraduates in the natural sciences accounted for 74.8% (305 samples).

Table 1. Demographic characteristics (N = 408)

Category		Samples (N)	Percentage (%)
Gender	Male	282	69.1
	Female	126	30.9
Grade	Freshman	45	11.0
	Sophomore	261	64.0
	Junior	74	18.1
	Senior	28	6.9
Major	Social science	103	25.2
	Natural science	305	74.8
Total		408	100

3.2 Digital literacy

Digital literacy consists of four parts: the attitude level, the technical level, the cognitive level, and the social-emotional level [20]. The scale in this study is divided into four categories: attitude level (7 items), technical level (6 items), cognitive level (2 items), and social emotional level (2 items). In this digital literacy scale, Cronbach's alpha is .914, indicating a good level of internal consistency, an AVE greater than .50 (.731), and structural reliability (CR) significantly greater than .70 (.915) which indicates that the data is suitable [38].

All of the above items were measured on a 1 to 5 Likert scale (strongly agree, strongly disagree) before and after the questionnaire, with 1 being "strongly disagree" and 5 being "strongly agree," and the higher the score, the more positive the response level.

3.3 Student engagement

The school engagement scale is divided into three categories [11] [27]: cognitive engagement (6 items), emotional engagement (4 items), and behavioral engagement (5 items). Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to investigate the reliability and validity of the formalized scale. The Alpha

values of cognitive, emotional, and behavioral participation of college students were .924, .894 and .908, respectively, indicating a good level of internal consistency. In addition, the AVE is greater than .50 (from .667 to .777) and the CR is significantly greater than .70 (from .909 to .924), indicating that the data are suitable. On the Likert scale, responses range from 1 (never) to 5 (completely able) (see Table 2).

Table 2. Measurement of constructs

Variables	Items	Loadings	Cronbach's Alpha	CR	AVE
Cognitive Engagement	CE1	.880	.924	.924	.753
	CE2	.880			
	CE3	.870			
	CE4	.840			
Emotional Engagement	EE1	.980	.894	.911	.777
	EE3	.670			
	EE4	.960			
Behavioral Engagement	BE1	.810	.908	.909	.667
	BE2	.850			
	BE3	.840			
	BE4	.800			
	BE5	.780			
Digital Literacy	DA	.750	.914	.915	.731
	DT	.880			
	DC	.910			
	DSE	.870			

According to the criteria given by Fornell and Larcker [38], if the square root of AVE arithmetic is greater than the absolute value of the correlation coefficient between potential variables, it indicates that the internal correlation is greater than the external correlation. It further indicates that there are differences between potential variables, resulting in the judgment validity being high. The bold values represent the square root of AVE, and other values in represent the correlation coefficients between potential variables. It can be found that the bold values (.868, .881, .817, and .855) are all larger than other values, indicating that the validity of the measurement model meets the requirements (see Table 3).

Table 3. Discriminant validity

Factors	CE	EE	BE	DL
CE	**.868**			
EE	.660	**.881**		
BE	.760	.560	**.817**	
DL	.700	.480	.700	**.855**

Notes: The square root of AVE was represented in bold on the correlation matrix's diagonal, CE = Cognitive engagement, EE = Emotional engagement, BE = Behavioral engagement, DL = Digital literacy.

3.4 Procedures

In order to achieve the expected results of the scale, a pilot test was conducted, and 408 samples were recovered. SPSS 26.0 was used for EFA detection. The factor loading coefficient is less than 0.5, and some indistinguishable items are removed. The formal investigation took place between 16 and 30 March and lasted for two weeks. The same answers for all items, or surveys with a response time of less than 1 minute, were removed. The teacher informed all participants of the research purpose and obtained their consent. Participants filled out online questionnaires over a 25-minute period.

The following steps and methods were adopted in this study to process the collected survey data: First, SPSS 26.0 software was used to analyze the reliability, EFA, frequency, and correlation of the collected data. Secondly, CFA was used for convergent validity analysis. Finally, AMOS 26.0 software was used for testing, and the optimal structural equation model was selected to analyze the mediation effects.

4 RESULTS

4.1 Correlation and descriptive analysis

In this study, the Pearson correlation coefficient was used to analyze all potential variables and explore their internal relationships. As shown in the correlation coefficients between the four potential variables, ranged from .472 to .726 ($p < .01$), showing a significant positive correlation. The correlation between behavioral engagement and cognitive engagement was the highest ($r = .726$, $p < .01$). The second highest correlation was between cognitive engagement and digital literacy ($r = .667$, $p < .01$). However, the correlation between emotional engagement and digital literacy was minimal ($r = .472$, $p < .01$).

Moreover, Kline [39] proposed that if the absolute values of skewness and kurtosis are less than 2 and 7, respectively, then the data is normally distributed. As described in, the mean value ranges from 3.474 to 3.660, the standard deviation ranges from .696 to .868, the skewness ranges from –.477 to .034, and the kurtosis ranges from –.160 to .487, which meets the Kline standard. Therefore, the survey data is normally distributed (see Table 4).

Table 4. Correlation and descriptive analysis (N = 408)

Factors	CE	EE	BE	DL
CE	1			
EE	.648***	1		
BE	.726***	.570***	1	
DL	.667***	.472***	.646***	1
Mean	3.607	3.660	3.561	3.474
Standard Deviation	.791	.868	.781	.696
Skewness	.034	–.093	–.477	.049
Kurtosis	–.160	.402	.474	.487

*Note: ***p< .001.*

4.2 Research model verification

In this study, maximum likelihood estimation is used for fitting the model. Through the comparison of key fitting indicators, we can check whether the fitting results of each observation structure dimension are consistent with the previous model conception. The fitting results of the structural equation model are shown below. In this study, the χ^2/df ratio of 2.840 (p = .000), the comparative fitting index (CFI) .970, the Tucker-Lewis index (TLI) .960, and the approximate root mean square error (RMSEA) .070 all met the requirements, indicating that the questionnaire design had good structural validity. Therefore, structural equation model was selected as the research model (see Figure 2).

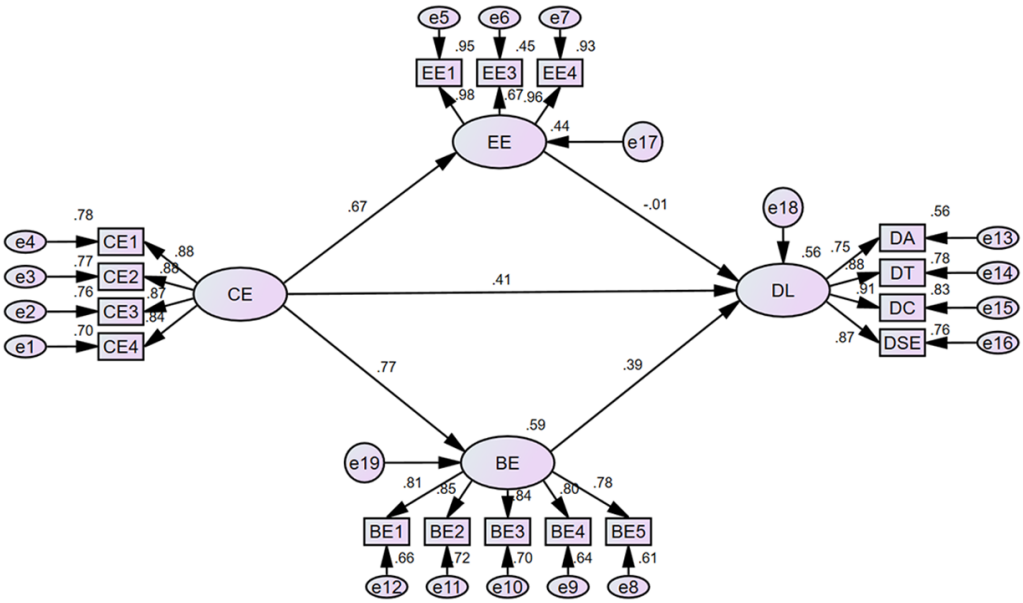

Fig. 2. Standardized path coefficients in research model

Notes: Model Fit = χ^2/df 2.840, CFI .970, TLI .960, RMSEA .070, CE = Cognitive engagement, EE = Emotional engagement, BE = Behavioral engagement, DL = Digital literacy.

As shown in Table 5, most of the path coefficients are significant, except for the correlation between emotional engagement and digital literacy. Specifically, cognitive engagement had a significant positive predictive effect on affective engagement (β = .670, p < .001), cognitive engagement and behavioral engagement (β = .770, p < .001). In addition, behavioral cognition contributed significantly to digital literacy (β = .390, p < .001), and cognitive engagement had a profound positive effect on digital literacy (β = .410, p < .001).

Table 5. Results of hypothesis test

Hypotheses	Path	β	B	S.E.	C.R.	P	Testing
H1	CE → EE	.670	.810	.060	14.550	***	Support
H2	CE → BE	.770	.730	.050	14.230	***	Support
H3	EE → DL	–.010	.000	.030	–.130	.900	Reject
H4	BE → DL	.390	.310	.060	5.490	***	Support
H5	CE → DL	.410	.310	.060	5.140	***	Support

*Note: ***p < .001.*

Path analysis can reflect the degree of the independent variable on the dependent variable, including direct and indirect effects. The total value of direct and indirect effects is the total effect of the independent variable on the dependent variable. In the structural model of this study, the direct, indirect, and total effects among variables are given.

Cognitive engagement had a significant direct effect on affective engagement ($\beta = .670$, $p < .001$), behavioral engagement ($\beta = .770$, $p < .001$) and digital literacy ($\beta = .410$, $p < .001$). Affective engagement had no significant direct effect on digital literacy ($\beta = -.010$, $p > .05$). Affective engagement had no significant indirect effect on digital literacy ($\beta = .290$, $p > .05$) (see Table 6).

Table 6. Direct, indirect, and total effects of structural model

Path	Direct Effect	Indirect Effect	Total Effect
CE → EE	.670***	.000	.670***
CE → BE	.770***	.000	.770***
EE → DL	–.010	.000	–.010
BE → DL	.390***	.000	.390***
CE → DL	.410***	.290	.710***

*Note: ***p < .001.*

In this study, the bootstrapping method was used to test the mediating effect with 2,000 sampling times. As shown in Table 7, only cognitive engagement has a significant effect on behavioral engagement and digital literacy, with an indirect effect value of .220 (SE = .050, 95% CI adjusted for bias = [.140, .330]). The confidence interval does not contain 0 and $p < .001$, indicating that behavioral engagement is the key mediating factor between cognitive participation and digital literacy.

Table 7. Mediating effects of bootstrapping

Path	Point Estimate	Product of Coefficients		Bootstrap 2,000 Times 95% CI Bias-Corrected		
		SE	Z-Value	Lower	Upper	P
CE → EE → DL	.000	.040	.000	–.080	.060	.960
CE → BE → DL	.220	.050	4.400	.140	.330	.000

5 CONCLUSION

This study demonstrated the structural equation model to determine the path coefficient between student engagement and digital literacy. According to prior literature, students' cognitive engagement can promote their behavioral and emotional engagement. In particular, many researchers have found that promoting students' emotional perception can lead to positive educational achievements [6] [40] [41]. However, in this study, students' emotional engagement did not significantly predict digital literacy. This discussion means that 'educational achievement' and 'digital literacy,' which are affected by emotional engagement, have different development mechanisms. For the digital generation, digital literacy may be a property that naturally transfers rather than a cognitive dimension [42]. Therefore, the consequences

of low emotional engagement could potentially implicate that critical thinking and awareness that identify the right or wrong of information should be raised. In this regard, some scholars pointed out that teachers need to be correctly helping to establish self-awareness, change in learning attitudes, and lack of emotional communication, emphasizing their attempts to increase students' emotional engagement [7].

Nevertheless, this study helps to understand the causal link between student engagement and digital literacy. Students behavioral engagement particularly played a key mediating role in the relationship between cognitive engagement and digital literacy. The results showed that as students' cognitive abilities improved, so did their behavioral abilities, which also improved their digital literacy, thus creating a positive and effective learning process. These results are in a similar context to the arguments that existing personal perceptions influence subsequent behavior [12]. Furthermore, it contrasts with studies claiming the growth of digital literacy through emotional interaction with others [4] [43]. In addition, the results of this study showed that students' cognitive engagement is not only the basis of digital literacy but also promotes their emotional and behavioral engagement. Finally, this discussion proved the stability of the cognitive-emotional-behavioral cycle for college students.

Through the above research, implications for systematic educational development and design can be derived to foster the digital literacy of college students. Such as college students' young generations could easily acquire cognitive literacy that searches digital information and attitude literacy that produces content confidently and fluently [20]. Hence, it is necessary to emphasize the abilities of the socio-emotional dimension, which critically explores the value of online information between meaningful information and fake news and the use of the Internet responsibly as the subject of information provision. In this way, college education should be designed so that each dimension can be cultivated by clearly recognizing the sub-dimensions of digital literacy.

In particular, since current college students lack formal digital literacy learning experiences in primary and secondary schools, the role of universities is important. At this time, it is required to consider how to improve college students' digital literacy in the socio-emotional dimension. For example, it is possible to communicate with manners on the Internet, and appropriate countermeasures against threats should be specifically provided. In addition, it is necessary to check whether the attitude literacy of college students regarding ICT and mobile use is sufficient compared to that of youths.

This study investigated the digital literacy of college students, but there is a limitation in that the change in digital literacy could not be analyzed. Therefore, it was impossible to confirm how digital literacy was formed. However, if such a path is revealed, universities can provide educational support more efficiently. To this end, we propose a follow-up study to explore the formation and growth process of each college students' digital literacy.

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