Learning Approaches Influence on College Students' Digital Literacy: The Role of Self-Determination Theory

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Xiaoxia Tian, Kyung Hee Park(✉)
Woosuk University, Wanju, South Korea
khpark@woosuk.ac.kr

Abstract—The development of digital literacy is believed to be achieved through individual learning and improvements. This study explored the mutual relations between college students' learning approaches and digital literacy by using Self-determination theory (SDT). Structural equation modeling (SEM), part of a quantitative methodology, was designed with data collected through 639 students from three types of universities. SEM was used to verify the crucial indirect influence of SDT by comparing various effects of learning approaches. The results indicated that personal character, deep learning approach, autonomous and relational motivation significantly affect digital literacy. Firstly, age was an influential factor that surpassed various characteristics compared to gender and university type. Secondly, the more students were involved in the deep learning approach, the higher their digital literacy level, and deep learning has proven to significantly enhance their motivation such as autonomy, competence, and relatedness. Furthermore, among SDT, autonomy and relatedness were crucial factors in improving digital literacy, while competence's influence was relatively insignificant. Such results provide valuable insights into the motivational process of improving college students' digital literacy. We demonstrated that any university or society cannot develop its digital literacy in a conventional way.

Keywords—digital literacy, learning approaches, self-determination theory, college students

1 Introduction

Digital literacy has a profound impact on those who live in a digital environment in the 21st century [1], [2], [3], [4]. It is critical to promote college students' digital literacy to catch the changing needs for digital skills in the labor market and society [5], [6]. Furthermore, digital literacy causes a crucial challenge in the educational systems [3], [7], which requires college students to adopt a flexible and integrated learning approach.

Student learning approaches tend to be dichotomous into deep and surface approaches [8]. They have different learning approaches and are possibly at different stages of their cognitive development, which utilize the approach in a digital environment [9]. In addition, Hamm and Robertson [10] claimed that no matter whether

deep learning or surface learning approaches are used, students are not simply divided into deep learners and surface learners. The learning approaches are usually used by the learner depending on the changes of some internal and external factors.

Moreover, the internal incentive has been considered a key element that affects learning approaches [11], [12]. Deci and Ryan's [13] self-determination theory (SDT) deserving deep investigations under learning contexts was successfully applied to various settings. SDT emphasizes autonomy, competency, and relatedness as key factors of motivation [11]. The three elements have been repeatedly utilized to study the underlying factors of students' learning needs and activity processes [14]. In particular, young people in the 21st century have developed their own learning needs by collecting and connecting various information in social media or online environments [5]. However, not all age groups of college students are equal in digital literacy, they differ in technology, ability, and social emotion [1], [15], [16].

Previous research has demonstrated the impact of learning approaches on learning task-based performance [8], [17], internal motivation [18], [19], [20], and academic achievement [17], [21]. Moreover, the current research focuses on the relationship between learning approaches and information technology [10], [22], e-learning [23], [24], [25]. As far as self-determination theory is concerned, its influence on education mainly focuses on student engagement [26], [27] and e-learning [28], [29], [30]. However, few studies on the influence of learning approaches and SDT on digital literacy.

Therefore, this study explores its objectives as follows: (1) whether college students' personalities and internal features influence their digital literacy; (2) whether there are differences in the college students' learning approaches to digital literacy; and (3) whether SDT (autonomy, competence, and relatedness) mediates the relationship between college students' learning approaches and digital literacy.

2 Literature review

2.1 Learning approaches

The origin of students learning approaches is attributed to the achievements of Marton and Säljö [31], who separated learning approaches into two categories: deep and surface. The feature of the deep learning approach is to understand and process information, participate in high-level activities, combine new and old knowledge, handle tasks and solve problems. A surface learning approach, on the contrary, is less likely to make complex connections between knowledge in books and real life, and tends to engage in low-level cognitive activities [32].

Dinsmore and Alexander [33] conducted a PsycINFO database search of deep learning and surface learning, and identified 221 studies for a comprehensive data table. Three theoretical frameworks were proposed: approaches to learning (AL), the model of domain learning (MDL), and the information processing theory (IPT) model. Considering that AL is often used to presume the individual's approaches or intentions, AL theoretical framework was used in this study. As an illustration, Chamorro-Premuzic et al. [8] described the process of deep learning and surface learning as follows: the deep learning approach was featured by engaging topics and a desire to

learn specific content or knowledge. Conversely, students who chose the surface approach were not interested in the task and wanted to spend the least time and effort to complete it.

Based on this theoretical perspective, students who embrace a deep learning approach reflect an inherent concern in the subject knowledge, participate actively in and enjoy the learning process. Vice versa, students rarely think actively and are primarily driven to complete tasks by using the surface learning approach [17]. Therefore, it is necessary to explore which learning approaches students mainly adopt in the digital age.

2.2 Digital literacy

Gilster [34] firstly put forward the term digital literacy and defined it as the ability to access, retrieve, collect, and integrate information presented on the Internet and multimedia. It also emphasized that digital literacy is actually about deeper issues such as cognitive, critical evaluation, and inferential capability. This definition emphasizes critical thinking more than technical ability. Furthermore, Alkali and Amichai [1] found that digital literacy does not simply refer to the ability to use and operate digital devices; moreover, it includes various complicated skills, such as cognition, sociology, and emotion, to adapt to the digital environment effectively.

In the digital era, the ability to obtain, incorporate, handle, appraise and create digitized information is necessary for everyone [2], [35]. Digital literacy is composed of three dimensions: technology, cognition, and ethics [7]. According to UNESCO [36], digital literacy refers to an essential skill required for the use of digital media, information processing, and knowledge creation. Digital literacy stems from the three intersecting dimensions of technology, cognition, and socio-emotional [37]. As mentioned above, while scholars have divided the dimensions of digital literacy differently, the meanings of these terms overlap.

Therefore, the concept of digital literacy indicates that: first, it is the information technology that a person masters through using digital devices to identify, attain, analyze, manage, evaluate, and synthesize informational resources; Second, under the circumstance of digital involvement, it is the ability to actively participate, communicate with others, innovate information, and solve problems; Third, it requires social emotions, including critical thinking and moral cognition.

2.3 Self-determination theory

Self-determination theory (SDT) is founded on the motivation theory notion and targets describing the psychological needs that may affect students' experiences and performance [11]. Ryan and Deci [11] also pointed out that the basic components of SDT comprise four mini-theories: cognitive evaluation theory [26], [38]; organismic integration theory [39]; causality orientations theory [13] and basic needs theory [11]. Besides, basic psychological needs attain an important status in SDT.

Meanwhile, the three basic needs of SDT were defined by Ryan and Deci [11]: competence, autonomy, and relatedness. More specifically, competence shows that students feel that they can be involved in the learning process. Autonomy concerns the willingness to complete tasks autonomously within a relevant context. Finally,

relatedness refers to taking on tasks that require cooperation and communication with other students.

Reeve [27] pointed out that the three psychological needs are the source of students' internal motivational tendencies to pursue novelty, seek out optimal challenges, exercise and expand their abilities. According to SDT, when peoples' basic psychological needs are satisfied, they are more likely to arouse intrinsic motivation; that is, when people enter a circumstance in which they feel autonomous, competent, and relevant, in this case, they have an inherent desire to actively participate in the new environment [40].

2.4 The relationship between variables

Information searching is part of the technical dimension of digital literacy. Heinström [22] found that there is an interaction between the influence of personal characteristics and learning approaches on information acquired, and students who regularly take advantage of deep learning approaches tend to find high-quality information. Furthermore, the more students go into deep learning, the more proficient they consider themselves to be in computer use and information seeking [23]. Several studies have shown that different learning approaches adopted by students lead to different results. The surface approach is to be related to lower quality results, while the deep approach is inclined to connect with higher quality results [30], [31]. Therefore, Different learning approaches result in different levels of students' digital literacy [10], [16]. Thus, the hypothesis presented is as follows:

- H_1: Deep learning has a positive influence on digital literacy.
- H_2: Surface learning has a negative influence on digital literacy.

Motivation is integral to students engaging in deep or surface learning approaches [41]. Supporting students' tendency for autonomy also correlates with a deeper, more comprehensive level of information processing and more passion dedicated to learning tasks [42]. Moreover, Vansteenkiste et al. [18] pointed out that autonomic motivation plays an essential moderating role concerning learning outcomes, just as depth of learning and test performance. Therefore, the hypothesis presented is as follows:

- H_3: Deep learning contributes positively to autonomy.
- H_4: Surface learning contributes positively to autonomy.

Competence has been considered as a crucial dimension that impacts the learning abilities and outcomes of learners in the digital era [28], [43]. Moreover, students with a higher perception of competence and control reported more intrinsic interest in school-related activities [4], [19]. Furthermore, Vos et al. [20] suggested that intrinsic motivation, in respect of competence, is intricately connected to the use of deep strategies. Intrinsically motivated students also demonstrated a high degree of in-depth strategy use. Therefore, the hypothesis presented is as follows:

- H_5: Deep learning contributes positively to competence.
- H_6: Surface learning contributes positively to competence.

Marton and Säljö [31] pointed out that students' adoption of learning approaches is closely linked to their perception of the learning atmosphere. Fransson [44] suggested that students have a tendency to take a superficial approach if they are perceived to have little personal relevance to the materials to be learned. In addition, Students with collaborative activities scaffold by their classmates and teacher significantly impact their learning approaches [29]. Thus, a hypothesis is provided as follows:

- H_7: Deep learning contributes positively to relatedness.
- H_8: Surface learning contributes positively to relatedness.

Although the positive relationship between students' motivation and digital literacy was only found in a few studies, digital learning often requires students to have high levels of personal autonomy and participate in asynchronous classrooms [30]. Furthermore, in a society increasingly dominated by technology and digital information, students need complementary digital skills and competencies to live, learn and work better [45]. Reeve [27] pointed out that the learning environment and students' motivation influence each other; meanwhile, the relationship between students, teachers, and peers should be promoted to enhance digital literacy. Therefore, the hypothesis presented is as follows:

- H_9: Autonomy contributes positively to digital literacy.
- H_{10}: Competence contributes positively to digital literacy.
- H_{11}: Relatedness contributes positively to digital literacy.

Ryan and Deci [46] conducted extensive and in-depth research on many areas of life and found that people tend to lead to better and deeper learning and performance, as well as more positive emotional experiences, when autonomic motivation is supported. Aharony [23], who explored the attitude of LIS (Library and Information Science) students towards Web 2.0, drew a conclusion that compared to the students with a surface learning approach, the students who chose a deep learning approach were more motivated to learn web applications and environment. When students' internal psychological needs are met to different degrees, their participation in the learning process and performance are also different [14], [18], [22], [27]. Therefore, the hypothesis is provided as follows:

- H_{12}: Autonomy/Competence/Relatedness mediate between deep learning and digital literacy.
- H_{13}: Autonomy/Competence/Relatedness mediate between surface learning and digital literacy.

3 Methodology

3.1 Research model

In the proposed model (see Figure 1), deep learning and surface learning represents an exogenous latent variable. SDT posits that their satisfaction with psychological needs mediates individuals' motivation. An endogenous latent variable presented

students' overall contentment with the following needs: autonomy, competency, and relatedness as indicators. Such a design is to verify the crucial influence of SDT by comparing the direct and indirect effects of the exogenous variables.

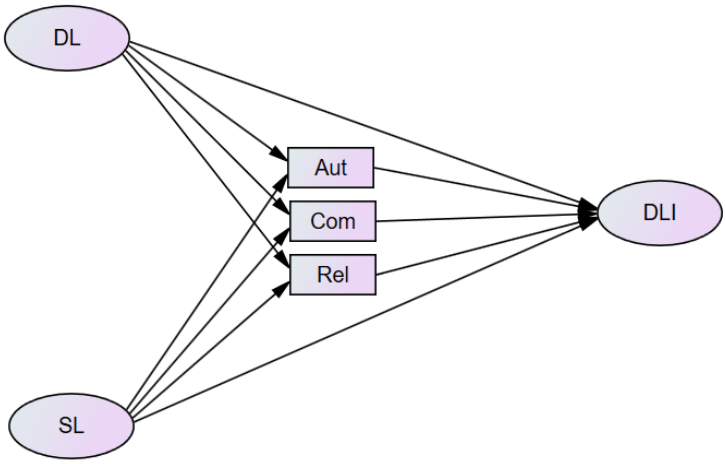

Fig. 1. Research model

Note: *DL*(Deep Learning), *SL*(Surface Learning), *Aut*(Autonomy), *Com(*Competence), *Rel(*Relatedness), *DLI(D*igital Literacy)

3.2 Participants

Data were collected from three types of universities in Henan Province: 211 university, a regular university, and a higher vocational college. Due to the COVID-19, students attended online classes, and data collection lasted for two weeks from October 2021. The survey was implemented online where interested individuals could participate voluntarily without payment. When students took online class courses, their teachers conducted the questionnaire survey and explained what digital literacy means. Then, the teacher sent the online link to the students, and they answered it by themselves. There were 667 surveys in total, and 639 valid surveys were included, with an effective rate of 95.8%. The distribution of demographic variables can be seen in Table 1.

Table 1. General characteristics of participants (N=639)

Variables Category		Samples (N)	Percentage (%)
Gender	Male	442	69.2
	Female	197	30.8
Age	16-18 years old	144	22.5
	19-21 years old	438	68.5
	22-24 years old	53	8.3
	over 25 years old	4	0.6

Variables Category		Samples (N)	Percentage (%)
University	985/211 university	223	34.9
	regular university	217	34.0
	higher vocational college	199	31.1
Grade	Freshman	240	37.6
	Sophomore	125	19.6
	Junior	233	36.5
	Senior	41	6.4
Major	Social science	62	9.7
	Natural science	577	90.3
Total		639	100.0

3.3 Measures

Study Process Questionnaire (R-SPQ-2F) of learning approaches. Biggs' [47] Study Process Questionnaire (SPQ) has indicated that a two-factor structure best describes the major learning approaches [48], [49]. Biggs et al. [32] revised the SPQ and provided research evidence consistent with its internal structure to support its use [48], [50]. The R-SPQ-2F comprises 20 items, divided into two approaches - deep and surface. Each approach consists of 10 items with responses on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Self-determination theory. Sheldon et al. [51] used the need satisfaction items to assess general experiences of autonomy, competence, and relatedness. In accordance with Sheldon and Niemiec's 9-item Basic Psychological Needs Satisfaction Scale, Du et al. [52] compiled its Chinese version and tested its reliability and validity among college students. Answers were made on a 5-point Likert scale, ranging from 1 to 5. The reliability for each sub-scale was autonomy .820, competence .860, and relatedness .800.

Digital literacy. Combining the digital literacy framework introduced by the European Union [53] and China's national conditions, Song and Qian [54] compiled a digital literacy questionnaire for college students, divided into five dimensions: information research, communication and cooperation, innovation, staying safe online, and problem-solving. A full version of the 22 items was measured through 5-point Likert-type scales with anchors from1 to 5.

3.4 Validity and reliability

To examine the internal structure of the measurement scale (51 items), a principal component analysis, based on a varimax rotation, was utilized on the data (N=639). Firstly, the distribution of sample data and the independence of each variable were estimated by using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of Sphericity. The results displayed that Bartlett's test had a significant test statistic ($p<.001$), and the KMO value was .947, indicating that the data was sufficient for structure detection. Furthermore, as a consequence of the exploratory factor analysis (EFA), the six factors with eigenvalues larger than 1.0 were retained and accounted for 63.499% of

the total Variance. In addition, factor loadings for each factor were larger than 0.4, indicating practical significance [55].

To confirm whether the factor constructs suited for the model, Confirmatory Factor Analyses (CFA) were carried out, as shown in Table 2. According to the modification indices, correlated error items have been changed. Therefore, the fit of the model was improved to a sufficient level ($X^2/df = 2.456$, the Comparative Fit Index [CFI] = .961, the Goodness of Fit Index [GFI] = .941, the Tucker–Lewis Index [TLI] = .955, the Root Mean Square Error of Approximation [RMSEA] = .048).

The reliability of each scale was estimated by the internal consistency of Cronbach's alpha. The final Cronbach's alpha values for all scales were greater than 0.7 and qualified. Average Variance Extracted (AVE) needs to be higher than 0.5 to meet the acceptance criteria, but 0.4 (from .427 to .627) is also acceptable. Because Fornell and Larcker [56] suggested that if AVE is lower than 0.5, but Composite Reliability (CR) is higher than 0.6 (from .746 to .910), the convergent validity of the construct can still be suitable.

Table 2. Results of the EFA, CFA, and reliability

Variable	EFA		CFA		Cronbach's alpha
	Eigenvalue	*Variance explained*	*CR*	*AVE*	
Deep learning	2.121	5.302	.827	.493	.821
Surface learning	1.259	3.148	.746	.427	.745
Self-determination theory	3.599	8.998	.862	.557	.861
Digital literacy	18.420	46.050	.910	.627	.908

4 Results

4.1 The relationship between variables and digital literacy

General characteristics were expressed as medians and standard error, and normality tests were performed for different groups using the Kolmogorov-Smirnov test. However, the variables did not follow a normal distribution for both males and females, and the Mann-Whitney U test was performed for between-group comparisons. Furthermore, age and university category groups were compared using a non-parametric method for non-normal distribution.

The results showed no significant difference between genders and digital literacy ($p = .586$). However, significant differences were found between different ages in digital literacy ($p < .001$). Furthermore, there were significant differences between the university category and digital literacy ($p = .020$). Finally, significant differences were also found between different grades in digital literacy ($p = .007$) (See Table 3).

Table 3. Independent-samples median test

Item	N	Median	Hypothetical Median	Standard Error	P-value
Gender	639	4	3	.018	.586
Age	639	4	3	.022	.000
University	639	4	3	.032	.020
Grade	639	4	3	.039	.007

To explore the influence of college students' digital literacy, the test order of four regression models was as follows: Model 1 (age), Model 2 (Model 1 + university type, grade), Model 3 (Model 2 + DL, SL), and Model 4 (Model 3 + SDT). Gender was not included in the regression analysis as male and female students did not differ significantly in digital literacy. Table 4 sums up the hierarchical regression results concerning predicting digital literacy regarding students' age, learning approaches, and self-determination theory.

Table 4. Hierarchical regression coefficients on student's digital literacy

Step	Predictors	B	*B*	P-value	R^2	DR^2	F
1	Age	-.215	-.182	.000	.033***	.032	21.82
2	Age	-.21	-.177	.000	.033***	.029	7.262
	University	-.002	-.003	.949			
	Grade	-.006	-.009	.853			
3	Age	-.188	-.159	.000	.171***	.164	26.117
	University	.030	.036	.369			
	Grade	.029	.044	.364			
	DL	.490	.434	.000			
	SL	-.292	-.365	.000			
4	Age	-.116	-.098	.013	.344***	.338	55.355
	University	.055	.067	.063			
	Grade	.020	.029	.497			
	DL	.127	.113	.016			
	SL	-.184	-.230	.000			
	SDT	.507	.501	.000			

Note: ***$p < .001$

Following the hierarchical model of the fourth step, age was determined as a significant predictor of digital literacy; the younger the student, the higher their digital literacy lever (β = -.098, p = .013). With regard to learning approaches, the deep learning had a positive influence on digital literacy (β = .113, p = .016), and the surface learning had a negative influence (β = -.230, p < .000). Moreover, the results show that SDT had a greater effect on digital literacy (β = .501, p < .000).

4.2 Hypotheses testing

Next, the hypothesized relationships were assessed by exploring the path coefficients in the structural equation model (See Table 5). Most of the hypothesized relationships were significant, exclusive of the paths that link: (1) surface learning and relatedness (H_8), and (2) competence and digital literacy (H_{10}). Deep learning had a direct positive effect on digital literacy (β = .332, p < .000), and surface learning had a negative effect on digital literacy (β = -.187, p < .000). As in prior studies, autonomy (β = .156, p < .000) and relatedness (β = .199, p < .000) had a direct positive impact on digital literacy.

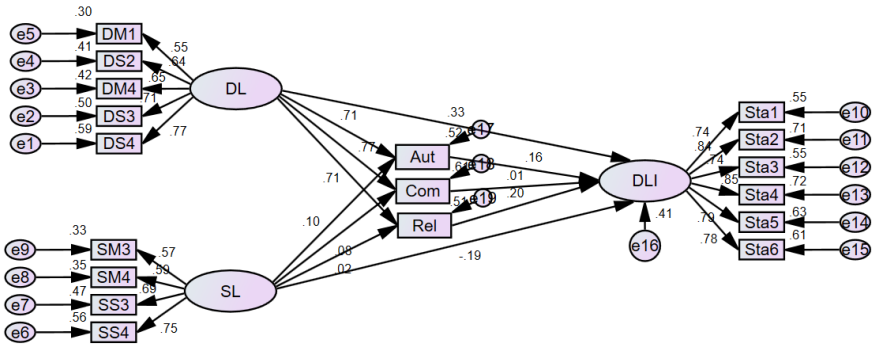

Fig. 2. Standardized path coefficients and fit indices of digital literacy

Note(s): Index of research model fit - X^2/df = 3.777, CFI .936, GFI .915, TLI .922, RMSEA .066
DL(Deep Learning), *SL*(Surface Learning), *Aut*(Autonomy), *Com(*Competence), *Rel(*Relatedness), *DLI(D*igital Literacy)

Table 5. Structural equation model path coefficient results

Hypothesis	Path	*B*	S.E.	C.R.	P-value	Testing result
H_1	DL→DLI	.332	.076	3.941	.000	Supported
H_2	SL→DLI	-.187	.028	-4.545	.000	Supported
H_3	DL→Aut	.714	.048	17.355	.000	Supported
H_4	SL→Aut	.102	.032	2.788	.005	Supported
H_5	DL→Com	.775	.050	18.748	.000	Supported
H_6	SL→Com	.082	.032	2.352	.019	Supported
H_7	DL→Rel	.715	.054	17.172	.000	Supported
H_8	SL→Rel	.018	.036	.480	.631	Not supported
H_9	Aut→DLI	.156	.041	2.954	.003	Supported
H_{10}	Com→DLI	.010	.045	.170	.865	Not supported
H_{11}	Rel→DLI	.199	.037	3.800	.000	Supported

Lastly, the bootstrap method with 2000 resamples was utilized to investigate the indirect effect of SDT on the relationship between learning approaches and digital literacy, as shown in Table 6. All of the mediating effects of SDT through deep learning were statistically significant, but in the case of surface learning, only the effects of

autonomy were significant. Therefore, we obtained results that statistically authenticate hypothesis testing.

Table 6. Mediation effect test of structural equation model (Bootstrapping)

Path	Point estimate	Product of coefficients		Bootstrap 2000 times 95% CI		
		SE	*Z-value*	*Lower*	*Upper*	*P-value*
DL→Aut→DLI	.714	.037	19.297	.640	.782	.001
DL→Com→DLI	.775	.032	24.219	.706	.833	.001
DL→Rel→DLI	.715	.035	22.143	.640	.777	.001
SL→Aut→DLI	.102	.050	2.040	.006	.206	.036
SL→Com→DLI	.082	.046	1.783	-.005	.173	.059
SL→Rel→DLI	.018	.047	.383	-.074	.113	.702

5 Discussion

What factors contribute to college students' digital literacy? Do demographic factors or personal characteristics influence digital literacy? Do their learning approaches describe individual differences in digital literacy? Using the structural equation decomposition method by regression coefficients might help answer some of those questions.

Firstly, the significant effect of age on digital literacy was demonstrated. The study found that the younger, more curious, more open to experience, and deeper learning of undergraduates, the higher their digital literacy level. Age was an influencing factor that surpassed various personal characteristics compared to gender and university type. In this regard, Li and Ranieri [43] surveyed Chinese middle school students' digital literacy and found that age significantly impacts digital technology and cognition. Moreover, Appel [15] concluded that, compared with younger students, senior students are more familiar with theoretical and practical knowledge of computers. However, this study found that the younger the age, the higher the digital literacy. This can be understood as a personal difference between the same generation and digital literacy between generations. This is because digital literacy is absolutely and physically affected by access to information technology.

Secondly, there was an important finding that the deep learning approach facilitates the development of digital literacy. Research has shown that students who embrace a deep approach are inclined to achieve higher quality educational achievements than those who choose a surface approach [21]. Furthermore, the more frequently students utilize deep learning strategies, the higher their information literacy level [16]. In particular, deep learning has proven to significantly enhance students' internal motivations such as autonomy, competence, and relatedness. Since deep learning approaches can be a factor that creates differentiation in digital literacy, active encouragement for deep learning is required.

In addition, this study confirmed that students who are prone to use surface learning have lower digital literacy. It can be understood that this is due to the negative relationship between the non-cognitive characteristics of not understanding goals or intentions (surface learning) and the digital literacy to know potential intentions.

Therefore, rather than diplomatically grasping students' learning approaches, attentiveness should be paid to the unique characteristics of each learning approach.

Lastly, the extensive SDT research has shown that when motivation is considered autonomous, people have more interest, confidence, and excitement, which is reflected in increased expression, perseverance, and creativeness [11]. Specifically, it is worth paying attention to the strong and significant influence of relatedness among SDT. Networking in the current social media environment is becoming quite complex and diverse. This study demonstrated that relatedness is a significant factor in enhancing digital literacy. Then again, when digital literacy is regarded as an ability, competence among SDT has been assumed to be a major influencing factor [2], [3], [4]. However, the influence of competence in this study was not significant. These results imply that the 'cultivating' of digital literacy should be avoided from a functional perspective.

6 Conclusion

The development of digital literacy is believed to be achieved through individual learning and improvement efforts. This study provides an empirical analysis on the characteristics of college students' digital literacy.

In particular, digital literacy tends not to be learned in the same way, and it can be inferred that digital literacy is acquired in various ways depending on individual differences such as age, learning approach, and autonomy. This result explained the various levels of the digital experience of the younger generation. In conclusion, these findings explain that universities or societies cannot develop customarily students' digital literacy in a conventional way. Additionally, it is necessary to consider the gap in information based on age or physical environment. China has very different educational environments between regions, and there can be inferential results concerning digital literacy in cities where information technology has not developed yet.

In the context of digitization and a lifelong learning society, digital literacy has been mainly discussed from competency development, and it is necessary to raise an issue about the perspective. Therefore, we propose a plan to acquire digital literacy by stimulating autonomous motivation. Rather than growing digital literacy through cooperative relationships, college students' reflection and critical thinking can have a more significant effect.

In addition, it also mentions the active use of deep learning that can recognize students' various learning approaches. This is because deep learning is a useful approach to developing self-beliefs of autonomy, competence, and relatedness compared to surface learning.

Furthermore, it is necessary to check from a new perspective for various educational support institutions for college students. The operation entity or university should consider whether their efforts are truly beneficial to students' change and growth. This is because digital literacy is essential for them to live and work in an increasingly dominated society by technology and digital information.

The limitation of this study is that the survey was implemented only in some parts of China. Therefore, for these findings to have a widespread impact, similar studies should be duplicated elsewhere to understand of how personality traits, learning ap-

proaches, and self-determination theory influence college students' digital literacy. In addition, to have a wider perspective, the researchers suggest that future studies should include students from other regions and conduct a comprehensive and in-depth study of each student's personality traits.

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8 Authors

Xiaoxia Tian (First author) is a PhD candidate in department of education at Woosuk University in South Korea, works a lecturer at Huanghe Jiaotong University in China.

Kyung Hee Park (Corresponding author) is an assistant professor in department of education at Woosuk University in South Korea, special areas of expertise in lifelong education, global citizenship education and global competency.

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