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Factors affecting middle school students' information literacy in the internet plus education environment

Liang Yu[1] · **Yuanyuan Zhang**[1] · **Meiqi Sun**[1]

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Abstract

Information literacy facilitates student learning and developing in the open education environment, while factors such as learning environment, technical support, and core competencies are critical to enhance the literacy. This study conducted a 2-year follow-up experiment with a sample of 2084 students to investigate how the Internet Plus education environment affect students' information literacy in a middle school from west part of China. A two-level linear model was constructed to analyze the class and student factors affecting students' information literacy. The results indicated that students' collaborative skills, problem-solving ability, and daily online time significantly affected their information literacy. However, teacher's gender, years of working, management style, and information literacy did not positively relate to students' information literacy. Meanwhile, class size had an indirect effect on students' information literacy via students' problem-solving ability, collaborative skills, daily online time, and frequency of electronic device use.

Keywords Internet plus education · Information literacy · Influencing factor · Middle school student

✉ Liang Yu
yuliang@swu.edu.cn

Yuanyuan Zhang
864523162@qq.com

Meiqi Sun
835449505@qq.com

[1] Faculty of Education, Southwest University, No.2 Tiansheng Road, BeiBei District, Chongqing 400715, People's Republic of China

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Introduction

In November 2021, the Chinese government issued the Guiding Opinions on Facilitating the Advancement of Internet Plus Education, requiring the comprehensive implementation of Internet Plus Education across all levels and types of educational institutions. Internet Plus Education is a new form of utilizing a new generation of information technology to update the concept of education, change the mode of education, and promote the innovative development of education (Chen et al., 2022). Nevertheless, the fundamental basis of Internet Plus Education lies in the information literacy of students.

Information literacy is crucial for students to learn and develop in the Internet Plus environment, especially in enhancing students' multiple competencies and academic development (Deng & Fu, 2018; Feng & Li, 2020). Some researchers have concluded that policy factors and pedagogical factors are the two most important factors that affect students' information literacy (Qin, 2015). Several studies have shown that the development of students' competencies cannot be achieved without both environmental support and teachers' guidance (Wu, 2020). With regard to environmental factors, some studies have explored the relevance of students' information literacy in terms of their geography (Kim et al., 2014), type of school (Tang & Hu, 2013), and the digital environment (Wang & Fu, 2006). However, these studies have basically verified hypotheses by one-time cross-sectional data but less by longitudinal follow-up surveys. Various research have been conducted to examine the impact of instructor characteristics, such as age, gender, and information literacy level, on students' information literacy level (Wang & Fu, 2006; Wu et al., 2022). However, little research has been conducted to study the association between class size and students' competency literacy (Weber et al., 2018). On the one hand, it is commonly known that small-class size teaching is beneficial for student growth (Yao et al., 2021). Many studies, however, have found that the larger the class size, the better for students' academic growth (Zheng & Yang, 2018). Class teachers' management styles, on the other hand, have significant influences on the classroom climate and their roles in increasing students' information literacy, which cannot be overlooked (Weber et al., 2018).

Furthermore, previous studies did not distinguish between the samples' learning environments, and learners' learning environments vary greatly in their informatization levels, making it difficult to systematically explore the factors influencing information literacy in environments of the same informatization level. The sample in this study is from a district in Northwest part of China, which is an Internet Plus education demonstration district established by the Ministry of Education of China. All primary and secondary schools in the district have an Internet Plus education environment, i.e., they are equipped with campus network hardware and software facilities, every classroom is equipped with an interactive whiteboard that can access the Internet, and both teachers and students have Internet-accessible terminals inside and outside of the classroom, such as computers, tablets, and cell phones, which enable blended teaching and learning

combined with online and offline teaching. Therefore, this study explores the factors influencing students' information literacy in the Internet Plus education environment.

Therefore, this study took the middle school as an example to track the development of students' information literacy. Firstly, a two-year follow-up study was conducted to investigate the change of information literacy levels of 1073 students in the first year and 1011 students in the second year. Then, we analyzed the data of class teachers and 1103 students in 21 classes to investigate the factors affecting the information literacy level of middle school students in the Internet Plus education environment from the students' technology behavior and class level, and finally proposed corresponding strategies to provide support and assistance for cultivating the students' information literacy.

Theoretical basis

Internet plus education environment and information literacy

The literacy is a state of readiness or a tendency to a particular intellect (Arthur et al., 2018). According to numerous studies, literacy is characterized by a well-rounded individual with rich, beautiful, stable, and naturally revealed values or worldviews, who has developed mature thinking through extensive learning and thinking training, and who is suited to the demands of social and lifetime development (Chen et al., 2021). The OECD defines it as the ability to successfully cope with complex needs in a given situation, which requires knowledge, cognition, skills, and psycho-social resources such as emotions, attitudes, values, and motivation, the formation of mature thinking and the ability to develop it, and the possession of rich, beautiful, stable embedded and naturally revealed values or worldviews (Guo, 2017). The above definition can be summarized as that, literacy is an internal style of thinking, a mix of information, abilities, and attitudes that, with extensive practice, can solve complicated issues under certain conditions (Gao & Chen, 2021). The present study applied the concepts of information literacy defined as "the interest, attitude and ability of individuals to appropriately use digital technology and communication tools to access, manage, integrate and evaluate information, construct new knowledge and communicate with others in order to participate effectively in society" (Lennon et al., 2003, p. 8). In educational contexts, information literacy, which integrates multiple disciplines, is frequently mentioned in the age of information technology and digitalization (Gao & Chen, 2021). Internet Plus has been integrated with various industries, such as the Internet, big data, and the Internet of Things, in order to enhance and update educational practices (Yu et al., 2022). The greatest manifestations of the Internet's impact on the educational setting are the adaptability of teaching platforms and the expansion of classroom space (Liu et al., 2018).

Numerous studies have provided evidence to support the idea that the Internet Plus education environment fosters an environment characterized by openness, decentralization, and collaboration, resulting in a blend of networking, vibrancy, and reality, as well as the facilitation of open sharing(Li & Lin, 2018; Wu, 2020; Yin, 2016; Yu et al., 2022). Therefore, the development of students' information literacy in the

Internet Plus education environment is extremely significant. According to the connotation of the Internet Plus education environment, the core competencies of middle school students' information literacy mainly consist of two aspects. First, the ability to gather and manage information resources, which involves expanding and comprehending the use of devices and platforms, as well as accessing, analyzing, and managing information resources. Second, the ability to create and sharing information resources, which includes information transformation, information sharing, resources development, and high-level capabilities such as security use of information. The present study used the International Computer Information Literacy Study (ICILS) proposed by The International Association for the Evaluation of Educational Achievement (IEA) to measure students' information literacy (Tang, 2015).

Triadic reciprocal determinism

Information ecology demonstrates information, people, and the environment are the three elements of information ecology study (Xiao, 2011), and emphasizes the interactive relationship between people and people, people and the environment, and people and information. From the perspective of people, only people can consciously handle with information from their surroundings, which means that they input, process, store, output, and control information in the network environment (Xie, 2000). From the viewpoint of environment, the information environment might be either a local or micro area, or a macro ecological space (Li, 1998). As for the macro area, Internet Plus technology provides the technical means and supporting environment for the operation quality of information ecological field (Yin, 2016), which connects class and after-class, expands offline to online, and provides comprehensive and immediate support for learning. Individual behavior is strongly explained by the interaction between human intrinsic factors, behavior, and environment (Wu et al., 2020). According to Bandura's, the triadic reciprocal determinism, behavior, person, and environment are an interdependent whole in which the influence between two factors is bidirectional, and the influence between two factors can be influenced by the third factor (Bandura, 1986). Information literacy can explain students' behavior in the Internet Plus education environment, which may be directly influenced by some environmental variables, behaviors, or a combination of environmental and behavioral interventions. Based on this, the present study investigates the factors affecting middle school students' information literacy in the Internet Plus education environment and analyzes the mediation model by the interaction between environment, behavior, and performance.

Factors affecting middle school students' information literacy in the Internet Plus education environment

Based on Bandura's the triadic reciprocal determinism, the behavior of students is primarily influenced by the individual and the environment, which are considered the most immediate elements. Within the realm of formal education, the classroom setting serves as the fundamental environment for students, exerting the most

immediate and profound impact on their development and learning outcomes. Hence, the present study aims to examine the impact of both individual and class variables on students' information literacy.

Student factors

This study chose the technology behavior factors and the ability factors of middle school students in an Internet Plus education environment as the influencing factors at the student level, with the former including the daily online time and the frequency of electronic device use, and the latter including problem-solving ability and collaborative skills. Individual factors, including age, gender, ethnicity, and family background and other demographic factors (Wei, 2018), have been shown to have a multifaceted effect on students' information literacy. Many studies analyzed the technology behaviors such as online time, Internet frequency, ICT self-efficacy, and ICT use purpose (Senkbeil & Ihme, 2017). In addition, there are studies that conduct correlation analysis with other core competencies in the information technology environment, such as problem-solving and cooperation ability (Yu et al., 2022). The development of students' information literacy is closely linked to their information technology usage behaviors and experiences. Engaging in regular practice can contribute to the acquisition of competence, thereby affecting students' information literacy in the context of Internet-based education. It has been found that the daily online time has a significantly negative effect on information literacy, and the frequency of using information technology devices has no significant effect on information literacy (Yang et al., 2018). However, other study has come to the opposite conclusion, Appel (2012) investigated the time of students' device use in and out of school, and found that the time of device use in school had no significant relationship with students' information literacy, while the time of technology use outside of school, such as at home, positively related to information literacy, which is most likely related to the study subject and environment. Students' use of information technology is largely a process of problem-solving and collaboration, and students' technology use in the Internet Plus environment emphasizes the interconnectedness of them (Wang, 2021).

Class factors

The study selected the gender, years of working, management style, and information literacy of the teacher, as well as class size, as influential factors at the class level. Schools and teachers are external factors that directly affect the students' learning behaviors and abilities, with teachers' guidance playing an important role in enhancing students' information literacy. From the perspective of environmental level, the education environment mainly refers to the school education environment, including the place of teaching activities, school climate, and teacher–student relationship (Tian, 1995). The school environment comprises two environments: physical one and non-physical one. The physical

one refers to the physical space of the school, such as the school' ICT environment, school resources, and school type. San et al. (2018) found that the information environment of the school, such as digital resources and mechanism guarantee, positively correlates with students' information literacy, while the ICT infrastructure of the school and students' information literacy negatively correlated. Wu et al. (2022)found that school type negatively correlated with students' information literacy. Nevertheless, there is a dearth of research examining the impact of an enhanced information technology environment on the information literacy of students. Little research has focused on the relationship between class size and students' information literacy, which tends to have an impact on students' competence by affecting teachers' behaviors (Bonesronning, 2003) or students' behaviors (Finn et al., 2003). Numerous studies have been discussed at the teacher level, with some studies demonstrating that teachers' gender, age, and work experience have no significant effect on students' information literacy (Wu et al., 2022). Moreover, other studies revealed that teachers' ICT use and information literacy have a significant effect on students' information literacy (Aesaert & van Braak, 2014; Boulton, 2017; Wu et al., 2022). However, little research has explored the effect of class teachers on students' information literacy. After all, class teachers take on more responsibilities among teachers, spend the most time with students, and are more conducive to providing personalized instruction and cultivating capacity (Zhang et al., 2021). Many studies have revealed that the management style of class teacher has a great impact on the learning behaviors and emotions of middle school students (Xu, 2015). However, it remains necessary to ascertain if this management style also exerts an impact on the information literacy of middle school students.

In summary, based on relevant theories and literature review, a model of the factors affecting information literacy of middle school students in the Internet Plus education environment was constructed at the student and class levels, as shown in Fig. 1. Therefore, the following three study questions guided the design of this study.

(1) Does the Internet Plus education environment significantly affect the information literacy of middle school students?
(2) Do the class teacher's gender, years of working, management style, information literacy, and class size significantly affect the information literacy of middle school students?
(3) Do the daily online time, frequency of electronic device use, problem-solving ability, and collaborative skills of middle school students have significant impacts on their information literacy?

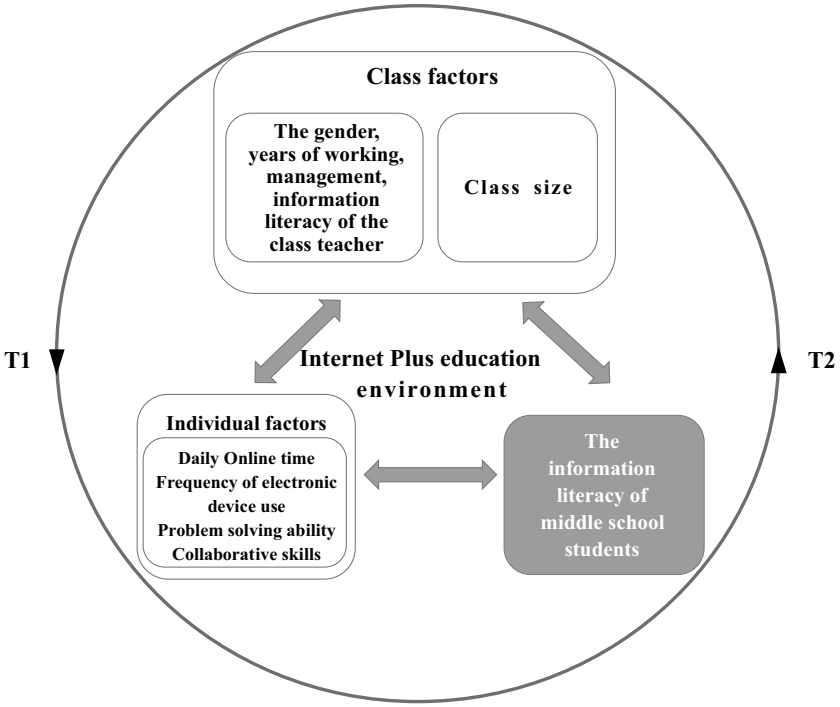

Fig. 1 Model of factors affecting middle school students'information literacy in the Internet Plus education environment

Research design

Measures

The students' information literacy questionnaire was developed with reference to the International Computer Information Literacy Study proposed by the International Association for the Evaluation of Educational Achievement (Fraillon et al., 2019). The problem-solving ability was measured by the PISA 2003 problem-solving ability test revised by Yang and Zhang (2017). The collaborative skills was measured by the collaborative skills scale (Yu et al., 2011). Class teachers' information literacy scale was developed using the framework proposed by Ma et al. (2019), which consists of 18 test questions, with six first-level indicators of understanding ICT, curriculum and assessment, pedagogy, ICT use, organization and management, and teacher professional learning. Class teachers' management methods were grouped into three types based on self-assessment or the opinions of two school administrators: authoritative leadership, democratic leadership, and informative leadership.

The present study takes Cronbach's alpha as the measure of internal consistency for collaborative skills scale ($\alpha = .91$) and teachers' information literacy scale ($\alpha = .92$).

Data analysis

This study collects data on students' information literacy over two academic years and compares them twice longitudinally to investigate whether the Internet Plus environment has an impact on students' information literacy. The study was approved by the Academic Ethics Committee of Faculty of Education, Southwest University in China. The analysis of the impact was conducted using a two-level linear model. The hierarchical analysis aims to discern the distinctions between first-level students and second-level classes, as there exists a distinct hierarchical relationship and nested structure between class and student influences, known as the class-student hierarchy (Liu & Meng, 2002). Data statistics and analysis tools were SPSS 25.0 and HLM 6.08.

Data sources

This study took a middle school from Northwestern part of China as an example to track the development of students' information literacy. The school serves as a model for the implementation of Internet Plus Education, which is widely referred to as the merger of internet technology and education. This school has a gigabit campus network as well as the infrastructure environment. The participants completed the questionnaire for the first, second, and third years of the school year through stratified sampling. The first round data are the information literacy of 1073 students at the beginning and the end of the first school year, and the second round data are that of 1011 students at the beginning and the end of the second school year, and the distribution of the data in the first and second rounds is shown in Table 1. The third school year data pertain to the class teachers of 21 classes with a total of 1103 students.

As shown in Table 2, the teachers who participated in the survey were all classroom teachers from the sampled students' classrooms, a total of 21, with 13 female classroom teachers and 8 male classroom teachers accounting for 61.9% and 38.1%, respectively. Classroom teachers' management styles were authoritative

Table 1 Distribution of students' information literacy

Time	Grade	*N*	Fall semester		Spring semester	
			M	SD	M	SD
First year	Grade 7	378	13.19	3.383	14.05	3.518
	Grade 8	353	13.99	3.183	14.93	3.429
	Grade 9	342	14.49	3.394	16.25	3.600
Total		1073	13.87	3.362	15.04	3.627
Second year	Grade 7	174	13.39	3.81	15.90	3.629
	Grade 8	336	13.67	3.889	17.24	3.669
	Grade 9	501	14.28	3.849	17.77	3.733
Total		1011	13.92	3.869	17.27	3.751

Table 2 Variable statistics and coding

Variable	Code	*n*	%
Information literacy	Student' information score	1103	100
Problem-solving ability	Scale score	1103	100
Collaborative skills	Scale score	1103	100
Frequency of electronic device use	1 = 0–1 time/month	108	9.80
	2 = 2–3 times/month	97	8.80
	3 = 1 time/week	222	2.10
	4 = 2–3 times/week	404	36.60
	5 = 4–5 times/week	272	24.70
Daily online time	1 = never online	111	1.10
	2 = 0–1 h	511	46.30
	3 = 1–2 h	335	3.40
	4 = 2–3 h	82	7.40
	5 = At least 3 h	64	5.80
Class teachers' gender	0 = Female	13	61.90
	1 = Male	8	38.10
Class teachers' years of working	Working years of each class teacher	21	100
Class teachers' management style	− 1 = Authoritative leadership	2	9.50
	0 = Democratic leadership	8	38.10
	1 = Instructive leadership	11	52.40
Class teachers' information literacy	Scale score	21	100
Class problem-solving ability	Class average	21	100
Class collaborative skills	Class average	21	100
Class frequency of electronic device use	Class average	21	100
Class daily online time	Class average	21	100

(2 teachers), democratic (8 teachers), and instructive (11 teachers), accounting for 9.5%, 38.1%, and 52.4%, respectively.

Data analysis

The variables were counted and coded before data analysis, and the results are shown in Table 2. In the process of multi-layer linear modeling, the first step was to build and run the empty model, then set up and run each model separately.

The random coefficient regression model 1 was used to judge whether technology had a significant effect on information literacy of middle school students.

$$\begin{aligned}\text{Model 1}:\ \text{Level 1}Y_{\text{ij}} &= beta_{0j} + \beta_{0j}(\text{Average daily online time}) \\ &+ \beta_{1j}(\text{Frequency of use of electronic devices}) + \varepsilon_{ij}\varepsilon_{ij} \sim N(0,\ \sigma^2)\end{aligned} \tag{1}$$

$$\text{Level 2}:\ \beta_{0j} = \Gamma_{00} + \mu_{oj}\mu_{0j} \sim N(0,\ \tau) \tag{2}$$

$$\beta_{1j} = \Gamma_{10} \tag{3}$$

$$\beta_{2j} = \Gamma_{20} \tag{4}$$

The random coefficient regression model 2 was used to determine whether core competence had a significant effect on information literacy of middle school students.

$$\begin{aligned} \text{Model 2}: \text{Level 1}: Y_{ij} =& \beta_{0j} + \beta_{1j}(\text{problem solving ability}) \\ &+ \beta(\text{collaborative skills}) + \varepsilon_{ij}\,\varepsilon_{ij} \sim N\left(0,\ \sigma^2\right) \end{aligned} \tag{5}$$

$$\text{Level 2}: \beta_{0j} = \Gamma_{00} + \mu_{0j}\mu_{0j} \sim N(0,\ \tau) \tag{6}$$

$$\beta_{1j} = \Gamma_{10} \tag{7}$$

$$\beta_{1j} = \Gamma_{20} \tag{8}$$

The intercept model 3 was used to determine whether the class teacher had a significant effect on the information literacy of middle school students.

$$\text{Model 3}: \text{Level 1}: Y_{ij} = \beta_{0j} + \varepsilon_{ij},\ \varepsilon_{ij} \sim N(0,\ \sigma^2) \tag{9}$$

$$\begin{aligned} \text{Level 2}: \beta_{0j} =& \Gamma_{00} + \Gamma_{01}(\text{gender}) + \Gamma_{02}(\text{Years of working}) \\ &+ \Gamma_{03}(\text{management style}) + \Gamma_{04}(\text{information literacy}) \\ &+ \mu_{0j},\ \mu_{0j} \sim N(0,\ \tau) \end{aligned} \tag{10}$$

The intercept model 4 was used to determine whether the class size had a significant effect on information literacy of middle school students.

$$\text{Model 4}: \text{Level 1}: Y_{ij} = \beta_{0j} + \varepsilon_{ij}\,\varepsilon_{ij} \sim N(0,\ \sigma^2) \tag{11}$$

$$\text{Level 2}: \beta_{0j} = \Gamma_{00} + \Gamma_{01}(\text{class size}) + \mu_{0j},\ \mu_{0j} \sim N(0,\ \tau) \tag{12}$$

Finally, possible mediating effects were tested by 2-2-1, 2-1-1, and 1-1-1 (Fang et al., 2010; Wen & Ye, 2014).

Results

The factors influencing information literacy of middle school students in the Internet Plus education environment were investigated using the independent sample test and the analysis of the empty model, random model, intercept model, and model with mediating variables.

Table 3 Results of the independent sample test of middle school students' information literacy

Variable	Time	*M*	*SD*	*t*	*p*
Information literacy	First year	13.87	3.362	− 7.796	.000***
	Second year	15.04	3.627		
	Second year	15.04	3.627	− 13.765	.000s
	Third year	17.27	3.751		

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

According to Table 1, the average level of students' information literacy increased from 13.87 to 15.04 in the first school year and from 13.92 to 17.27 in the second school year, indicating that the average level of students' information literacy in the school was improved each year. According to Table 3, the independent sample t-test of information literacy of all students in the schools found a significant increase at the end of the first school year compared to the beginning of the first school year, and a significant increase at the end of the second school year compared to the end of the first school year, indicating that middle school students' information literacy was improved under the Internet Plus education environment.

The results of linear model

Table 4 shows the results of the empty model runs, where the model estimates a variance of 3.71657 in class and 1.46446 between classes ($p < .001$), with an inter-class correlation coefficient of ICC = 1.46446/ (1.46446 + 3.71657) = .283, indicating that students' information literacy varies with inter-class differences and about 28.3% variance is caused by inter-class differences. Therefore, a multi-layer linear model analysis of students' information literacy is necessary to explain this part of the variation. According to the results of Model 3, the class teacher's gender, years of working, management style, and information literacy had no effect on students' information literacy at the class level ($p > .05$). The results of Model 4 showed that class size had no significant effect on students' information literacy ($p > .05$).

According to the Model 1 in Table 4, the daily online time ($B = -.379$, $p < .001$), and frequency of electronic device use ($B = .369$, $p < .001$) of middle school students have significant effects on their information literacy. It shows that the more time students spend online, the worse their information literacy, and the more students surf the Internet, the better their information literacy. However, combined with the results of students' information literacy in Table 1, the relationship between the students' information literacy and the frequency of electronic devices use is not linear. When the frequency exceeds a certain limit (about 1–3 times a week), the information literacy level declines, however, within a certain range, an increase in the frequency will help to improve students' information literacy. Model 2 shows that middle school students' problem-solving ability ($B = .082$, $p < .001$), and

Table 4 Results of linear model running

Fixed effect		Coefficient	standard error	t	Degrees of freedom	p
Model 1	Average intercept, γ_{00}	16.564	.552	29.986	20	.000***
	Daily online time, γ_{10}	− .379	.115	− 3.305	1100	.001***
	Frequency of electronic device use, γ_{20}	.369	.108	3.405	1100	.001***
Model 2	Average intercept, γ_{00}	16.924	.330	51.233	20	.000***
	Problem-solving ability, γ_{10}	.082	.010	7.891	1100	.000***
	Collaborative skills, γ_{20}	.025	.008	3.279	1100	.001***
Model 3	Intercept, β_0					
	Average intercept, γ_{00}	16.218	.408	39.754	16	.000***
	Class teacher's gender, γ_{01}	.843	.781	1.078	16	.297
	years of working, γ_{02}	.053	.038	1.382	16	.186
	Management style, γ_{03}	.902	.456	1.98	16	.065
	Information literacy, γ_{04}	− .133	.427	− .311	16	.760
Model 4	Intercept, β_0					
	Average intercept, γ_{00}	11.963	3.93	3.044	15	.009**
	Class size, γ_{01}	.105	.056	1.879	19	.075

Random effect	Variance component	Share of the total variance (%)	Degrees of freedom	x^2	p
Level-2 effect (inter-class)	1.464	28.30	20	19.134	.000***
Level-1 effect (intra-class)	3.717	71.70			

*$p<0.05$, ** $p<0.01$, *** $p<0.001$

collaborative skills ($B=.025$, $p<.001$) have significant effects on their information literacy. It demonstrates that enhanced problem-solving and collaborative skills contribute to the improvement of middle school students' information literacy.

The results of mediation model

According to Table 5, when class size was used as the independent variable, the direct effects of class level ability and technical behaviors were not statistically significant ($p>.05$). However, the existence of a mediating effect could not be directly inferred, so the mediating effect path was tested based on suppressing effects. First, when class problem-solving ability mediated the effect of class size on students' information literacy, the influence coefficients $c'=.076$ ($p<.05$) and $b=.381$ ($p<.001$) were significant, the direct effect of class size on students' information literacy was significant, and ab and c' were positive. Therefore, the mediating effect was $ab=.03$. Second, when class collaborative skills were used as a mediating effect of class size on students' information literacy, the influence coefficients $c'=.141$ ($p<.01$) and $b=.211$ ($p<.001$) were both significant, the

Table 5 2-2-1 Mediation model

Formulation effect	Fixed effect	Coefficient	Standard error	*t*	Degrees of freedom	*p*
Class size—Class problem-solving ability(a)	Intercept, β_0					
	Average intercept, γ_{00}	75.158	.717	104.786	19	.000***
	Class size, $\gamma 0_1$	.078	.126	.622	19	.541
Class size—Class problem-solving ability—students' information literacy(c′, b)	Intercept, β_0					
	Average intercept, γ_{00}	16.918	.179	94.692	18	.000
	Class size, γ_{01}	.076	.032	2.389	18	.028*
	Problem-solving ability, γ_{02}	.381	.058	6.606	18	.000***
Class size—Class collaborative skills(a)	Intercept, β_0					
	Average intercept, γ_{00}	113.468	1.081	104.992	19	.000***
	Class size, γ_{01}	− .165	.190	− .867	19	0.397
Class size—Class collaborative skills—students' information literacy(c′, b)	Intercept, β_0					
	Average intercept, γ_{00}	16.919	.234	72.258	18	.000***
	Class size, γ_{01}	.141	.042	3.359	18	.004**
	Collaborative skills, γ_{02}	.211	.050	4.184	18	.001***
Class size—Class Internet Frequency(a)	Intercept, β_0					
	Average intercept, γ_{00}	3.574	.066	53.881	19	.000***
	Class size, γ_{01}	.003	.012	.280	19	.782
Class size—Class Internet frequency—students' information literacy(c′, b)	Intercept, β_0					
	Average intercept, γ_{00}	16.918	.317	53.374	18	.000***
	Class size, γ_{01}	.109	.055	1.963	18	.065
	Internet frequency, γ_{02}	− 1.228	1.098	− 1.118	18	.279
Class size—Class online time(a)	Intercept, β_0					
	Average intercept, γ_{00}	2.530	.048	52.872	19	.000***
	Class size, γ_{01}	− .006	.008	− .745	19	.465

Table 5 (continued)

Formulation effect	Fixed effect	Coefficient	Standard error	t	Degrees of freedom	p
Class size—Class online time—students' information literacy(c′, b)	Intercept, β_0					
	Average intercept, γ_{00}	16.918	.316	53.534	18	.000***
	Class size, γ_{01}	.094	.056	1.684	18	.109
	Online time, γ_{02}	− 1.793	1.529	− 1.173	18	.257

*$p<0.05$, ** $p<0.01$, *** $p<0.001$

direct effect of class size on students' information literacy was significant, ab was different from c′, and the mediating effect is $ab = -.03$. Third, when class equipment use is used as a mediating effect of class size on students' information literacy, the influence coefficients $c' = .109$ ($p > .05$) and $b = -1.228$ ($p > .05$) were both significant. However, because the coefficient value b was greater than 1, this mediating effect was excluded. Fourth, when class online time was used as a mediating effect of class size in students' information literacy, the influence coefficients $c' = .094$ ($p > .05$) and $b = -1.793$ ($p > .05$) were not statistically significant, this effect was excluded since the coefficient value b was greater than 1. Add the first mediating effect coefficients to the second, the result was 0, which may explain why the effect of class size on students' information literacy was significant. The influence paths of class size, class level mediators, and information literacy of middle school students in the Internet Plus education environment were obtained as shown in Fig. 2.

According to Table 6, which verified the relationship between variables at the student level, collaborative skills and problem-solving ability have significant effects on students' online time, with $B = -.005$, $p < .001$ and $B = -.007$, $p < .001$, respectively. It showed that the stronger the students' collaborative skills or problem-solving ability, the better to control the students' online time. The between-group variation of collaborative skills a2 ($p < .05$) and the within-group variation of students' Internet frequency b1 ($p < .001$) were significant, it can be inferred that class collaborative skills, students' Internet frequency, and students' information literacy met the conditions of the 2-1-1 model, so the relationship was verified. According to Table 7, the three regression coefficients $a = -.027$ ($p < .05$), $b = .238$ ($p < .05$), and $c = .176$ ($p < .05$) were all significant when students' Internet frequency was used as a mediating effect, and the test of the regression coefficient c′ ($p < .01$) also reached a significant level, indicating that students' Internet frequency was a mediating effect of student information literacy.

According to Table 7, first, when students' problem-solving ability was used as a mediating effect of class size on students' information literacy, the regression coefficients $b = .105$ ($p < .001$), $c' = .076$ ($p < .05$), $\Gamma = .381$ ($p < .001$), and the direct effect c′ was significant, indicating the possible presence of other mediators and ab and c′ were positive, and the mediating effect was $ab = .008$. Second, when students'

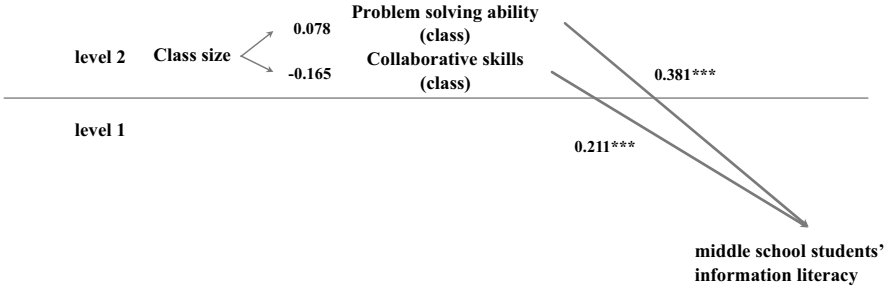

Fig. 2 Influence pathway of class size on middle school students' information literacy at class level

Table 6 1-1-1 Mediation model

Formulation effect	Fixed effect	Coefficient	Standard error	*t*	Degrees of freedom	*p*
Students' collaborative skills—Students' information literacy (c2, c1)	Intercept, β_0					
	Average intercept, γ_{00}	− 2.977	6.955	− .428	19	.673
	Class collaborative skills, γ_{01}	.175	.061	2.864	19	.010**
	Students' collaborative skills, β_1					
	γ_{10}	.061	.005	12.128	1100	.000***
Students' collaborative skills—Students' Internet frequency (a1)	Intercept, β_0					
	Average intercept, γ_{00}	6.658	1.423	4.679	19	.000***
	Class collaborative skills, γ_{01}	− .027	.013	− 2.169	19	.043*
	Students' collaborative skills, β_1					
	γ_{10}	− .003	.002	− 1.588	1100	.112
Students' collaborative skills—Students' Internet frequency—Students' information literacy (b2, c′2, b1,c′1)	Intercept, β_0					
	Average intercept, γ_{00}	− 4.656	1.493	− .444	18	.662
	Class Internet frequency, γ_{01}	.253	1.151	.220	18	.829
	Class collaborative skills, γ_{02}	.182	.070	2.592	18	.019*
	Students' Internet frequency, β_1					
	γ_{10}	.291	.088	3.306	1098	.001***
	Students' collaborative skills, β_2					
	γ_{20}	.062	.005	12.329	1098	.000***
Students' collaborative skills—Students' online time (a2, a1)	Intercept, β_0					
	Average intercept, γ_{00}	4.455	1.072	4.154	19	.001***
	Class collaborative skills, γ_{01}	− .017	.009	− 1.798	19	.088
	Students' collaborative skills, β_1					
	γ_{10}	− .005	.001	− 3.396	1100	.001***

Table 6 (continued)

Formulation effect	Fixed effect	Coefficient	Standard error	*t*	Degrees of freedom	*p*
Students' collaborative skills—Students' online time—Students' information literacy (b2, c′2, b1, c′1)	Intercept, β_0					
	Average intercept, γ_{00}	.644	9.824	.066	18	.949
	Class online time, γ_{01}	− .812	1.528	− .532	18	.601
	Class collaborative skills, γ_{02}	.162	.068	2.391	18	.028*
	Students' online time, β_1					
	γ_{10}	− .018	.111	− .159	1098	.874
	Students' collaborative skills, β_2					
	γ_{20}	.061	.005	12.042	1098	.000***
Students' problem-solving ability—Students' information literacy (c2, c1)	Intercept, β_0					
	Average intercept, γ_{00}	− 13.154	4.787	− 2.748	19	.013*
	Class problem-solving ability, γ_{01}	.400	.064	6.292	19	.000***
	Students' problem-solving ability, β_1					
	γ_{10}	.105	.007	14.643	1100	.000***
Students' problem-solving ability—Students' Internet frequency (a2, a1)	Intercept, β_0					
	Average intercept, γ_{00}	5.975	1.501	3.98	19	.001***
	Class problem-solving ability, γ_{01}	− .032	.02	− 1.6	19	.126
	Students' problem-solving ability, β_1					
	γ_{10}	− .001	.003	− .500	1100	.617

Table 6 (continued)

Formulation effect	Fixed effect	Coefficient	Standard error	*t*	Degrees of freedom	*p*
Students' problem-solving ability—Students' Internet frequency—Students' information literacy (b2, c′2, b1, c′1)	Intercept, β_0					
	Average intercept, γ_{00}	− 15.657	6.592	− 2.375	18	.029*
	Class Internet frequency, γ_{01}	.420	.743	.565	18	.579
	Class problem-solving ability, γ_{02}	.414	.069	5.994	18	.000***
	Students' Internet frequency, β_1					
	γ_{10}	.258	.086	3.01	1098	.003**
	Students' problem-solving ability, β_2					
	γ_{20}	.106	.007	14.741	1098	.000***
Students' problem-solving ability—Students' online time (a2, a1)	Intercept, β_0					
	Average intercept, γ_{00}	4.635	1.063	4.361	19	.000***
	Class problem-solving ability, γ_{01}	− .028	.014	− 1.984	19	.062
	Students' problem-solving ability, β_1					
	γ_{10}	− .007	.002	− 3.591	1100	.001***
Students' problem-solving ability—Students' online time—Students' information literacy (b2, c′2, b1, c′1)	Intercept, β_0					
	Average intercept, γ_{00}	− 14.409	6.957	− 2.071	18	.053
	Class online time, γ_{01}	.271	1.065	.255	18	.802
	Class problem-solving ability, γ_{02}	.408	.072	5.685	18	.000***
	Students' online time, β_1					
	γ_{10}	.016	.108	.149	1098	.882
	Students' problem-solving ability, β_2					
	γ_{20}	.106	.007	14.741	1098	.000***

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7 2-1-1 intermediary model

Formulation effect	Fixed effect	Coefficient	Standard error	t	Degrees of freedom	p
Class collaborative skills—Students' Internet frequency (a)	Intercept, β_0					
	Average intercept, γ_{00}	3.573	.060	59.954	19	.000***
	Collaborative skills, γ_{01}	− .027	.013	− 2.169	19	.043*
Students' Internet frequency—Students' information literacy (b)	Slope of Internet frequency, β_1					
	γ_{10}	.238	.094	2.543	1100	.011*
Class collaborative skills—Students' information literacy (c′)	Intercept, β_0					
	Average intercept, γ_{00}	16.932	.290	58.395	19	.000***
	Class collaborative skills, γ_{01}	.176	.061	2.868	19	.010**
Class size—Students' problem-solving ability—Students' information literacy (c′, b)	Intercept, β_0					
	Average intercept, γ_{00}	12.934	1.675	7.722	18	.000***
	Class size, γ_{01}	.076	.032	2.402	18	.027*
	Class problem-solving ability, γ_{02}	.381	.058	6.61	18	.000***
	Students' problem-solving ability, β_1					
	γ_{10}	.105	.007	14.644	1099	.000***
Class size—Students' collaborative skills—Students' information literacy (c′, b)	Intercept, β_0					
	Average intercept, γ_{00}	9.528	2.213	4.306	18	.000***
	Class size, γ_{01}	.141	.042	3.366	18	.004**
	Class collaborative skills, γ_{02}	.211	.050	4.184	18	.001***
	Students' collaborative skills, β_1					
	γ_{10}	.061	.005	12.129	1099	.000***

Table 7 (continued)

Formulation effect	Fixed effect	Coefficient	Standard error	t	Degrees of freedom	p
Class size—Students' Internet frequency—Students' information literacy (c′, b)	Intercept, β_0					
	Average intercept, γ_{00}	15.583	4.744	3.285	18	.005**
	Class size, γ_{01}	.109	.055	1.964	18	.065
	Class Internet frequency, γ_{02}	− 1.228	1.098	− 1.117	18	.279
	Students' Internet frequency, β_1					
	γ_{10}	.238	.094	2.543	1099	.011*
Class size—Students' online time—Students' information literacy (c′, b)	Intercept, β_0					
	Average intercept, γ_{00}	16.507	5.234	3.154	18	.006**
	Class size, γ_{01}	.094	.056	1.684	18	.109
	Class online time, γ_{02}	− 1.793	1.529	− 1.173	18	.257
	Students' online time, β_1					
	γ_{10}	− .155	.118	− 1.318	1099	.188

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

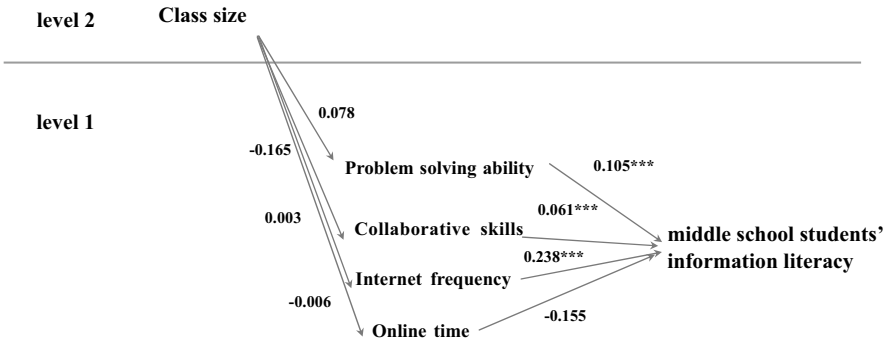

Fig. 3 Influence pathways of class size on middle school students' information literacy at student level

collaborative skills were used as a mediating effect of class size effect on students' information literacy, regression coefficients b = .061 ($p < .001$), $c' = .141$ ($p < .01$), and $\Gamma = .211$ ($p < .001$), the direct effect c′ is significant, indicating that there may be other mediators and ab is different from c′, with $ab = -.01$. Third, when frequency of device use was used as a mediating effect of class size on students' information literacy, the regression coefficient $b = .238$ ($p < .05$), $c' = .109$ ($p > .05$), $\Gamma = -1.228$ ($p > .05$), and the mediating effect is $ab = .0007$. Fourth, when students' online time was used as a mediating effect of class size on students' information literacy, the regression coefficients $b = -.155$ ($p > .05$), $c' = .094$ ($p > .05$), $\Gamma = -1.793$ ($p > .05$), and the mediating effect is $ab = .0009$. The four mediating effect values add up to a value of 0, which may explain why the effect of class size on students' information literacy is not significant. The influence paths of class size, student-level mediators, and information literacy level of middle school students in the Internet Plus education environment can be obtained as shown in Fig. 3.

In summary, the factors affecting the information literacy of middle school students in the Internet Plus education environment are summarized in Fig. 4.

Discussion

In light of the critical nature of enhancing the information literacy of middle school students, this study investigated the key factors affecting students' information literacy by longitudinally tracking the changes of students' information literacy in one school. First, comparing 2 years of data revealed that students' information literacy was improved significantly as a result of their practice in the Internet Plus education environment. Second, after analyzing the relationship between students' core competencies and information literacy, we found students' technology behaviors and core competencies had significant effects on their information literacy. Next, the results of the empty model showed that 28.3% of the differences in middle school

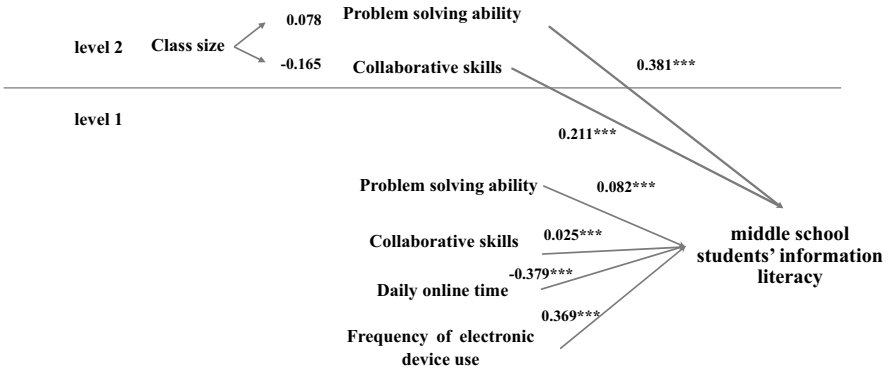

Fig. 4 Class-level and student-level factors affecting middle school students' information literacy

students' information literacy were due to class level. Although researchers have explored the influence of teachers on students' information literacy, little research has focused on the key role of class teachers and the relationship between class size and students' information literacy. The results indicated that class teacher's age, years of working, information literacy, and management style did not have significant effects on students' information literacy, and that class size may affect students' information literacy by affecting class collaborative skills and problem-solving ability, and that larger class size is not conducive to improving class collaborative skills but has a positive effect on class problem-solving ability. Finally, the study also found that improving students' core competencies helped control students' online behavior, thus improve their information literacy.

The effect of school factors

The present study showed that middle school students' information literacy was improved significantly in the Internet Plus education environment. "Internet Plus teaching" is not simply the networking and digitization of teaching but rather a teaching ecological environment that deeply integrates Internet thinking and technology with all elements of the teaching process (Li & Lin, 2018). It has both external space and equipment conditions, as well as the support of tools and resources.

For schools, first of all, they should comprehensively apply emerging information technologies such as artificial intelligence, big data, and Internet of Things, build a good information-based education environment, and construct a technical support ecology that integrates online and offline, so that students can conveniently participate in education and teaching activities under the Internet Plus education environment. Secondly, they can promote the deep integration of information technology and education teaching, innovate education teaching mode, and carry out independent, inquiry and cooperative learning practices under the Internet Plus education environment, so as to enhance information literacy in a subtle way. Finally, schools should update the information technology curriculum content system, strengthen the application of information technology skills, design practical

projects combined with the actual learning and living of secondary school students, and cultivate students' ability to apply information technology to solve practical problems, so as to enhance information literacy.

The effect of class factors

It was found that class size had a positive effect on class problem-solving ability, which had a significant positive effect on middle school students' information literacy. This finding suggests that it is important to use the group dynamics of the class to develop students' logical thinking as much as possible and to develop students' problem awareness with the help of tools, which is to improve students' information literacy in large classes. Some empirical studies have shown that large classes have a significant impact on students' creative thinking (Zheng, 2020). The larger class size stimulate students' competitiveness and promote students' creativity and motivation (Yu et al., 2022). Classroom collaborative skills have a significant positive effect on middle school students' information literacy, while class size had a negative impact on students' collaborative skills. This finding indicates that the method used to improve the information literacy of middle school students in small classes should maximize the benefits of small-class instruction by fostering collaboration among students. Many studies have found that smaller class sizes are beneficial in promoting students' non-cognitive skills, especially in the elementary school (Finn & Achilles, 1999). Other studies comparing class sizes in international schools have found that smaller class sizes help regulate students' behaviors and enhance their emotional interaction skills (Yao et al., 2021). The impact of differences in class size on students' growth may vary depending on their grade and the location of the school (Zheng & Yang, 2018). Therefore, schools need to consider the goals of the curriculum when setting class sizes. Courses that develop students' thinking logic and hands-on skills can be implemented in large classes, while courses that promote students' collaboration and communication skills can be conducted in small classes.

Classroom teacher variables, such as classroom teacher's gender, years of participation, management style, and information literacy, had no significant effect on middle school students' information literacy, which were consistent with the studies of Wu et al. (2022), Lucas et al. (2021), and Tondeur et al. (2008). There was no significant effect of classroom teacher variables on students' information literacy. However, the classroom teacher is the organizer, educator, and leader of the classroom group, responsible for all students in the class, educating, managing, and guiding students in a holistic manner, and having a significant impact on students' growth. Therefore, classroom teachers can play an important role in the development of students' abilities as well as in the control of technical behaviors. They can organize class activities to develop students' abilities, instruct students how to use Internet tools, help students establish rules for accessing the Internet, and coordinate with parents to strictly control and supervise the length and frequency of students' access to the Internet.

The effect of student factors

The study found that the daily online time and the frequency of electronic device use have significant effects on middle school students' information literacy under the Internet Plus education environment, which shows that information literacy decreases when students spend more time online per day and increases when students use electronic devices more frequently. The study also revealed that the optimal daily online time for middle school students should be controlled within 1 h, and the frequency should be limited to 1–3 times per week.

This finding shows that appropriate amount of Internet access will have a positive effect on students' information literacy, and when the Internet access goes beyond a certain limit, it will have a negative effect instead. Other studies also revealed that an appropriate amount of online surfing made positive effects on students' information literacy (Wang & Gu, 2019). Students frequently utilize information technology to complete learning activities in the Internet Plus education environment. Proficiency in information technology usage leads to improved learning efficiency, confidence, and information literacy. Conversely, excessive information technology usage results in diminished time management abilities, Internet addiction, and the challenge of coordinating multiple tasks in an unbalanced manner (Salomon & Kolikant, 2016). Therefore, teachers and parents can help students make plans for information technology use, coordinate and control study and recreation time, and form good information technology use habits through a combination of external discipline and self-monitoring.

The research revealed that problem-solving and collaborative skills have significant effects on the information literacy of middle school students in the Internet Plus education environment. The greater the collaborative skills and the problem-solving ability, the better the students' information literacy, which fully indicates that the students' abilities largely influence each other. It has been demonstrated that problem-solving ability and information literacy are positively correlated (Voogt & Roblin, 2012), and students with better problem-solving abilities are more likely to be successful in using information technology to solve problems and gain successful experiences. Meanwhile, information literacy itself emphasizes the exchange and sharing of information, and when students have stronger collaborative skills, their ability to share information will be stronger and their information literacy level will rise. In addition, the study revealed that when students' core competencies, such as problem-solving ability and collaborative skills, are enhanced, they will significantly control their online time, which indicated that enhancing students' competencies will simultaneously improve students' learning efficiency in the Internet Plus education environment. Based on this, enhancing students' core competencies can effectively develop information literacy. Teachers should actively implement the integration of the problem-based teaching model (PBL) and information technology subjects. They should adhere to the principle of problem orientation, meticulously design learning tasks, offer ample resources and technical support, and guide students in enhancing their problem awareness by resolving inadequately constructed problems in the Internet Plus education environment. This approach aims to collaboratively cultivate students' problem-solving abilities and information literacy. It is imperative

that teachers provide students with additional chances to engage in communication and practice beyond the classroom setting. They should also proactively coordinate research learning activities that utilize the Internet and online education platforms, motivate students to apply their knowledge and skills of information technology in practical situations, and foster the growth of their problem-solving, higher-order thinking, and collaborative capabilities.

Conclusion

The Internet Plus education environment provides students with opportunities to develop their abilities and literacy, and it is important to explore how to improve students' information literacy in an efficient and targeted way in the twenty-first century. This study constructed a model of the factors affecting middle school students' information literacy in the Internet Plus education environment at both the class and student levels, and the results showed that the middle school students' information literacy was improved year by year. Students' information literacy was significantly influenced by the class problem-solving ability, class collaborative skills, and students' problem-solving and collaborative skills. Students' daily online time and frequency of electronic device use had significant effects on their information literacy. The analysis of the mediation model revealed that class size may have an impact on students' information literacy via the various mediating factors. In addition, students' core competencies such as collaborative skills and problem-solving can significantly control students' daily online time to some extent.

There are also some limitations in this study. First, in terms of the influencing factor model, only the influence of students and class teachers was taken into account, and neither the time series nor school level factors were considered. Second, this study only considered classroom teacher factors, while other factors at the class level were not sufficiently considered. Third, the sample for this study was from only one middle school and caution should be exercised when extrapolating the findings to other populations. Future studies could enlarge the sample size, explore the influence of school factors and other class factors, and combine qualitative study instruments such as field surveys and interviews to explore the effects of various factors in a multidimensional and in-depth way.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics declarations

Conflict of interest The authors have no conflict of interest to declare that are relevant to the content of this article.

Ethical approval We hereby declare that this manuscript is the result of our independent creation under the reviewers' comments. Except for the quoted contents, this manuscript does not contain any research achievements that have been published or written by any individuals or groups. We are the only manuscript authors. The legal responsibility for this statement should be borne by us.

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Liang Yu is a professor of educational technology at Southwest University. His research interests cover online and distance education, computer supported collaborative learning and digital learning resources.

Yuanyuan Zhang is a graduate student at Southwest University, where she studies learning science and technology and online and distance education.

Meiqi Sun is a graduate student at Southwest University and her research centers on technology enhanced learning.