

Development and validation of internet literacy scale for high school students

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Abstract

The paper aims to develop and validate an internet literacy scale for high school students. The study emphasizes the importance of internet literacy, especially for adolescents who need sufficient internet literacy to gain self-development and live their whole lives in this information age. The study has recruited 744 high school students and provided a validated scale consisting of thirty items in eight dimensions: (1) self-management, (2) self-image construction, (3) damage control, (4) information processing, (5) critical thinking, (6) cooperation, (7) consciousness of morality, and (8) consciousness of security. The current developed scale can reflect the latest, abundant meaning of internet literacy. This study fulfills the need to build up a validated, comprehensive internet literacy scale for adolescents such as high school students. The study also suggests potential applications of the scale in the pedagogical context.

Keywords Internet literacy \cdot Scale development \cdot Validity \cdot Reliability \cdot Media in education

1 Introduction

According to World Bank's investigation (Individuals using the Internet, 2021), the number of internet users has exceeded 4.6 billion, which means the global internet penetration rate has reached 60%. In Meeker's worldwide investigation (2019), the number of internet users is still increasing by 7% per year. In developing countries, internet users' growth is even more noticeable, and people aged 10–19 contribute greatly to the increase. For instance, in 2022, the China Internet Network Information Center (CNNIC) reported that 142 million (13.5%) of the whole country's internet

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users were aged from 10 to 19 years old. In addition, 45% of newly added netizens (40 million) in 2021 were also 10 to 19 years old (CNNIC, 2022).

High school students are one of the most crucial groups of internet users. They belong to the 10–19 age group and account for a large proportion of internet users. High school students gain more independent internet use experience when compared with primary school and middle school students. These adolescents' use of the internet may shape the online media environment. Although high school students gain more independence in internet use, they may not have enough internet literacy to educate themselves on how to use the internet effectively.

Therefore, it is worthwhile to clarify the definition of internet literacy, develop a new scale, and help high school students to learn how to use the internet. Crucial reasons are listed here: First, high school students nowadays (Generation Z) need more advanced internet literacy, while previous literacy scales could not fully assess. For instance, some students have internet addiction problems (Kwak et al., 2018), lack information integration ability (Breakstone et al., 2018), expression ability (Weninger, 2017), as well as the consciousness of safety and morality (Vandoninck et al., 2010). A well-established internet literacy scale can help students identify their shortcomings in internet use, and then indirectly encourage them to seek related knowledge and practice. Second, according to the cognitive development theory (Inhelder & Piaget, 1958), children (or adolescents) begin to form abstract thinking and scientific reasoning abilities no earlier than 12 years old, and the formation process could last into adulthood. Therefore, the three years of high school age is a very early and crucial time to teach students abstract and comprehensive concepts such as internet literacy. Third, up-to-date internet literacy can indirectly help develop a country or region's information and communication technology (ICT). The secondary gross enrolment ratio (which includes high school education) is one of the crucial factors of ICT development, which indicates that the more people are educated, the more development of ICT skills (see the webpage of the ICT Development Index). If high school education specifically encompasses internet literacy, it could contribute more to the development of this highly technologydependent society (Lau & Yuen, 2014).

Internet literacy combines two perspectives: internet skill literacy and internet information literacy (e.g., understanding/analyzing/evaluating/producing online information, Harrison, 2018; Kim & Yang, 2016). This combination brings difficulties in developing the internet literacy scale. According to the previous literature, some different scales (named as new media, computer, information, or digital literacy) were related to internet literacy, but could be either only partly overlapping or too broad. For instance, some scales focused on internet tool use; some focused on critically evaluating information and cooperating online, while others focused on the broad picture of technics, cognition, and socio-emotion on all digital media (e.g., Ng, 2012; Lau & Yuen, 2014; Van Deursen et al., 2016). Part of those scales even did not pass the reliability and validity test (Mahmood, 2017). Therefore, the current study chose internet literacy which was neither too

broad nor too specific, aimed to clarify the definition of internet literacy, and developed a reliable internet literacy scale for high school students.

2 Literature review

2.1 The theoretical framework of internet literacy

As mentioned above, internet literacy combines two perspectives, starting with internet skill literacy and later including internet information literacy. Internet skill relates mainly to the basic skills required to use Internet technology, including the ability to navigate hypermedia environments. Internet information refers to one's ability to sift through information to achieve certain needs. It often involves searching, collecting, understanding, and evaluating content (Kim & Yang, 2016).

The definition of internet literacy appeared at the end of the twentieth century and focused on internet skills. In 1994, McClure proposed network literacy and defined it as specific skills and knowledge in a networked computer environment. The word "network" literally has a broader meaning than "internet," for instance, offline interaction among friends is also a type of network. However, McClure's network literacy focuses on the use of internet. For the sake of consistency, the current study named network literacy the same as internet literacy. In the beginning, internet literacy emphasized the property of internet skills. For instance, McClure proposed that the internet was a neutral tool, and users should be able to manipulate online information, be aware of the range of available global internet, and use the information in daily problem-solving activities (McClure, 1994, 2001). Influenced by the internet skill properties, researchers developed detailed internet literacy scales for students to improve their internet-using skills because they exhibited little concern for the authority of the textual and graphical information (Hirsh, 1999). More widely, computer utilization skills like reading news, sending e-mails, listening to music, and the consciousness of computer use were also considered essential parts of internet literacy (Hargittai, 2005; Ozkul & Kaya, 2009). Even in recent studies, internet skills property still has important implications (Lau & Yuen, 2016).

Along with decades of technological development, the internet went beyond a tool and became more like a medium providing the public sphere with diverse opinions (Papacharissi, 2002). Therefore, internet literacy not only refers to internet skills, but also expands its definition to internet information literacy, such as understanding/analyzing/evaluating/producing online information (Kim & Yang, 2016). Considering the expanded definition, internet literacy was more related to digital literacy, and had two models to clarify what kinds of internet information literacy people needed in their daily lives.

First, the *protectionism model* describes that the internet bombarded its users with individuals and organizations which cloak their true intentions (Breakstone et al., 2018). Therefore, people should have enough literacy to prevent themselves from being harmed by the internet. Led by the protectionism model, some studies

proposed that internet literacy should encourage individuals to make independent judgments about media consumption, be aware of the media impact on individuals and society, develop strategies to analyze and discuss media messages, and provide insight into the media content and culture (Silverblatt et al., 2014). More specifically, protectionism model studies mainly focused on self-controlling, information processing, critical thinking, information ethics, and internet security. For instance, Hobbs (2010) suggested that internet literacy contained aspects such as critical thinking, analysis & evaluation, information gathering & editing, and morality. Some other related studies are also concerned much about ethics, security protection, and critical thinking (Elmborg, 2006; Lee et al., 2015; Lin, 2011). In addition, internet addiction was also related to internet literacy. Some studies developed scales and designed courses to help students appropriately consume online games, social media and gain self-control under the temptation of the internet (Young, 1998, 2004; Leung & Lee, 2012; Wasiński & Tomczyk, 2015).

The protectionism model was also widely used in internet literacy education. Singaporeans emphasized that students should learn how to "analyze the underlying meaning of visual messages, offer interpretive judgment, and question and evaluate what is read from a variety of sources" (Ministry of Education, 2008, p. 34). While in China, internet literacy courses taught students that the over-consumption of social media would negatively affect their academic performance (Gan et al., 2015). To sum up, the protectionism model significantly influences the development of internet literacy scale and literacy education. The dimensions in previous scales such as critical thinking, information processing, security & morality still contribute to the new scale.

Second, the empowerment model (Mao & Li, 2005) emphasized having more initiative to understand/analyze/evaluate/produce online information. This model is concerned more with advanced information processing, impression management, active critical thinking, and cooperation online. In the digital age, media literacy is meant to gain control of media (Potter, 2012). In other words, internet users should have a more positive attitude to learn critical thinking and gain self-development. Accordingly, some traditional dimensions are endowed with new definitions. For instance, information processing not only meant using the search engine but meant resolving the inconsistency across multiple resources and solving problems sustainably and creatively (Goldman & Scardamalia, 2013; Jenkins, 2006). The purpose of critical thinking not only meant survival in the digital age but also meant transitioning from analysis to action (Harrison, 2018). Moreover, impression management became part of internet literacy. Huang (2015) designed an impression management scale, including self-image construction and damage control dimensions. For adolescents, researchers proposed that using social media to present oneself was necessary and possible (Kim & Yang, 2016), and students should learn how to use media to express themselves in a diverse, multicultural environment (Weninger, 2017). In addition, with the development of education technology and instructional design, problem-based learning and resource-based learning in the E-learning environment also became popular (Pérez-Nordtvedt et al., 2010; Jumari et al., 2016). Those new methods in pedagogies encouraged students to work together and share knowledge online. To some extent, they promoted ideas like cooperation and participation Nowadays, high school students are much more familiar with the internet than their parents and siblings. Because they will live their whole life in a digitalized society, internet literacy education becomes more urgent and crucial to them. For instance, American schools emphasized the importance of cooperation, responsibility, and open-mind in internet literacy courses (Li & Li, 2012). In addition, internet literacy education in the UK put forward the idea of "beyond protectionism" (Buck-ingham, 1998). Australian schools were concerned about multicultural convergence (Pan, 2010). They all proposed that students should not only behave as critical viewers but also as creators and producers online. Although those courses' evaluation was not steady enough, ideas like information integration, independent judgment, cooperation, and self-expression were accepted in pedagogical contexts. Scholars and teachers from the US, Australia and some regions of Latin America and Asia are gradually accepting the empowerment model, expanding the definition of internet literacy and applying it to course design (De Azevedo, 2015; Gillett-Swan & Sargeant, 2018; Kim & Yang, 2016; Spring, 2018).

To sum up, the definition of internet literacy is supported by three pillars, from the internet skill use model to the protectionism model and empowerment model. However, it does not mean the latter model totally replaces the former. On the contrary, the current research suggests that internet literacy should combine internet skill literacy and internet information literacy (including protectionism and empowerment models). Therefore, researchers define internet literacy as a combination of rational tool use, appropriate caution to the internet, and active internet consumption.

2.2 Design dimensions of the internet literacy scale

Over the past ten years, researchers developed many scales that only related to a part of the internet literacy concept (e.g.,Huang, 2015; Lee et al., 2015; Leung & Lee, 2012; Ozkul & Kaya, 2009; Rheingold, 2011). However, those scales did not combine internet skills and the understanding of internet information together (e.g., Jenkins, 2006; Kim & Yang, 2016; McClure, 1994; Rheingold, 2011). Therefore, the current study has aimed to develop an internet literacy scale that learned widely from existing scales and combined the skill use, protectionism, and empowerment models.

Previous studies have proposed several dimensions for each model to construct the concept of "internet literacy." For instance, the internet skill use model emphasized the tool use of internet; the protectionism model emphasized self-management, consciousness of morality and security; the empowerment model emphasized cooperation, self-image construction, and damage control on social media. In addition, protectionism and empowerment models emphasized critical thinking, and

all three models emphasized information processing. The current study reviewed relevant literature to summarize eight dimensions of internet literacy that could cover most of the previously proposed dimensions: self-management, self-image construction, damage control, information processing, critical thinking, cooperation, consciousness of morality, and consciousness of security.

Table 1 summarizes the theoretical framework of internet literacy and proposes the definition and eight dimensions constructed in the current study. The eight dimensions are:

(1) Self-management dimension focuses on individuals' self-control on timeconsuming, emotional connections online, health and peer interactions. The current study used Young's internet addiction scale (1998), Chen's internet addiction scale (2003), Li's media literacy scale (see Cai et al., 2005), and Ouyang et al.'s internet usage and self-control scale (2013) for reference. (2) Self-image construction dimension focuses on people's ability to build positive online figures such as friendly, appreciative and concerned about others. We used Huang's impression management scale as an essential reference (2015); the reliability and validity of the scale were acceptable. (3) Damage control construction dimension emphasizes people's ability to reduce negative effects and willingness of apologies. We also used Huang's scale for reference (2015). (4) Information processing dimension emphasizes individuals' keywords for information seeking, perception of source credibility, and the ability to combine different information sources. This dimension also considers some computer and internet tool use. This study used Ozkul and Kaya (2009), Lin (2011), Wu et al. (2011), and Van Deursen et al.'s (2016) scales for reference. Some items from the previous scales, like "using different types of information sources such as encyclopedias, journals, references, annuals," were paraphrased to the new scale. Some items were transformed for China's reality (for example, using Baidu and Zhihu to represent Google and Quora). However, some items, such as "use keywords in search engine" or "ask somebody for help online," were outdated. Our new scale does not include those items. (5) In the critical thinking dimension, the current study has used Potter's critical thinking examples (2012) and PISA reading tests (Soule & Warrick, 2015) for reference. (6) In the cooperation dimension, the current study emphasizes the ability to join interest groups, finish tasks online, and share knowledge (Rheingold, 2011). This study also used Ahonen's team working scale (2014) for reference. (7) The consciousness of morality dimension focuses on individuals' concerns about cyber manhunt, online bullying, and spreading rumors. This study used Ozkul & Kaya's scale for reference (2009). (8) The consciousness of security dimension focuses on individuals' privacy protection and copyright awareness online. This study also used Ozkul & Kaya's scale for reference (2009). Items such as "preparing reference lists from different types of references" is paraphrased to the new scale. However, privacy protection measures need to catch up with the current internet environment, such as mobile payment, free Wi-Fi, and social media accounts.

Previous scales were helpful for our new scale development but needed to paraphrase and reorganized. The first reason is that previous scales were mainly developed under different contents, which might not be fully applied to high school students. For instance, Lin (2011) developed a scale for students in

Table 1 Theoretical fran	nework of internet literacy	
Model	Definition	Dimensions
Internet skill use model (start from 1990s)	Specific skills and knowledge in a networked computer environment (McClure, 1994)	E.g.1: Manipulate online information, be aware of the range of available global internet, use the information in problem-solving (McClure, 1994, 2001) E.g.2: Read news, send e-mails, listen to music, the consciousness of computer use (Hargittai, 2005; Ozkul & Kaya, 2009)
Protectionism model (start from 2000s)	Prevent people from being harmed by the internet (Breakstone et al., 2018)	 E.g.1: Performance, appropriation, multitasking, collective intelligence (Jenkins, 2006) E.g.2: Media exposure, critical thinking, analysis and evaluation, information gathering & editing, morality (Hobbs, 2010) E.g.3: Ethics, security protection, critical thinking (Elmborg, 2006; Lee et al., 2015; Lin, 2011) E.g.4: Appropriately consume online games & social media, gain self-control of the internet (Young, 1998; Leung & Lee, 2012; Wasiński &
Empowerment model (start from 2000s)	Gain control of media and develop people themselves. (Mao & Li, 2005; Potter, 2012)	 Tomczyk, 2015) E.g. 1: Information processing (Goldman & Scardamalia, 2013) E.g. 2: Critical thinking (Harrison, 2018) E.g. 3: Self-image construction, damage control, manipulation, ingratiation (Huang, 2015) E.g. 4: Impression management (Kim & Yang, 2016; Weninger, 2017) E.g. 5: Cooperation and participation online (Rheingold, 2011; Li & Li, 2012; Marzal & Borges, 2017)
A combined model (Current study)	Rational tool use, appropriate caution to the internet, and active con- sumption of the internet	Self-management, self-image construction, damage control, information processing, critical thinking, cooperation, consciousness of morality, consciousness of security

nursing school. Some of Lin's items were quite useful for the new scale, while some other items might too narrow for nursing students. Secondly, some scales overemphasized skills like "design a website" or "install apps" which were out of date (Ainley et al., 2016; Koc & Barut, 2016; Van Deursen et al., 2016). Moreover, with the development of the mobile internet, some measurements of people's abilities were also outdated. For instance, previous scales used time length and internet access frequencies to measure people's self-management ability. However, people nowadays can be "always online" with their smartphones and Tablet PCs, which indicates that time length and frequency of use cannot accurately reflect self-management ability. That is why the current study would like to apply new items, such as arousal of emotions and withdrawal reactions, to measure selfmanagement. To sum up, the current study summarized eight dimensions from literature, but paraphrased and reorganized some items in order to develop a sufficient, stable internet literacy scale for high school students. The scale is important because 1) high school teachers and students can use this scale as a tool for curriculum design and self-evaluation, and 2) policymakers and government institutions can use this tool to evaluate ICT development in different regions.

The current study has explained the paraphrasing and reorganizing steps in detail: We took the relevant scale items for reference, and re-edited them in order to fit the current internet environment (e.g., some search engines are not popular anymore) and the language difference (e.g., for some of the scales written in English, we need to translate them to Chinese). To be more specific, one professional expert in English-Chinese translation translated the English scales into Chinese. In addition, other researchers with adequate English reading ability read the translated Chinese version and discussed it with the professional translator to keep the consistent meaning. Furthermore, all researchers re-edited the translated Chinese scales and other original Chinese scales to fit the current internet environment.



Fig. 1 Work flow of the study

Table 2 Paradigms and spe	cific focuses addressed in l	previous research			
Previous research	Number of Samples (N)	Respondents identity	Data collection region	Theory paradigm	Specific focuses
Young (1998)	496	General people	NS	Protectionism	Internet addiction; Self-management
Ozkul and Kaya (2009)	432	Nursing students	Turkey	Skill use	Information processing
Lin (2011)	453	Nursing students	Taiwan	Protectionism	Information processing; Ethics and security
Wu et al. (2011)	60	University students	China Mainland	Protectionism	Information processing Critical thinking; Cooperation; Ethics and security
Rheingold (2011)	NA	General people	NA	Empowerment	Cooperation; Critical thinking; Qualitative study
Ouyang et al. (2013)	1165	University students	China Mainland	Protectionism	Self-management
Leung and Lee (2012)	716	Age 9–19	Hong Kong	Protectionism	Self-management
Lee et al. (2015)	574	Age 10–17	Singapore	Protectionism	Information processing Critical thinking; Cooperation
Huang (2015)	1549	High school students	China Mainland	Empowerment	Self-image construction; Damage control
Koc and Barut (2016)	1226	University students	Turkey	Skill use	Information processing Critical thinking; Cooperation; Ethics and security
Van Deursen et al. (2016)	1337	General people	Europe	Skill use	Self-image construction; Information processing; Cooperation; Ethics and security
Harrison (2018)	NA	Fifth-grader	UK	Empowerment	Critical thinking; Cooperation; Qualitative study

We provide a workflow figure to summarize the study's design better (Fig. 1). Furthermore, we also provide a table summarizing current dimensions addressed in previous scales (Table 2).

3 Methods

3.1 Item development

The current study needs to define high school students. They mainly included senior high school students and vocational school students aged 15 to 18 years old.

This study conducted an item generation process for internet literacy scale with the guidance of the adopted theoretical framework of internet literacy (Kim & Yang, 2016; Mao & Li, 2005; McClure, 1994; Silverblatt et al., 2014), literature review of previous measures on internet literacy (e.g., Koc & Barut, 2016; Lin, 2011; Ozkul & Kaya, 2009; Van Deursen et al., 2016; Young, 1998) and our focus group discussions.

Each item was constructed in three steps. First, we examined theoretical explanations of different dimensions and got a conceptual understanding of internet literacy construction. Second, we discussed potential items that could represent those dimensions. In this step, previous English version items were translated into Chinese by professional experts and then discussed by scholars with adequate English skills to maintain a consistent meaning. Then four researchers with adequate education and communication research experience discussed and wrote adaptable candidate statements for this study in Chinese. The candidate statements did not need full support from all four scholars but only needed to get more than two of them. Third, we examined these candidate statements with careful reviews to eliminate typos, complex and illogical expressions. The original item pool contained 67 items measured on a 5-point Likert-type scale. Sample items included "I cannot have meals or go to bed on time when I surf the internet" or "I like to press 'like' on social media to encourage my friends to share their stories with me."

3.2 Participants and procedure for study

The current study did a pilot survey to modify the scale. Researchers collected 120 samples (in 2016.2) from three schools, of which 92 were valid. The samples included 53.3% male students and 46.7% female students; 16.3% grade one students, 14.1% grade two students, 22.8% grade three students from senior high school and 23.9% first-year students, 22.8% sophomores from the vocational school. After filling in the survey, researchers interviewed participants, asked for suggestions from scholars, and then deleted seven ambiguous or lacked discrimination items. As a result, the updated scale included 60 items, and 13 of them were reversely coded. The scale used a five-point Likert scale. For each item, 1 meant strongly disagree, 2 meant disagree, 3 meant neutral, 4 meant agree, and 5 meant strongly agree.

Then the current study conducted a field survey. Researchers sampled three classes in each grade of the senior high school and six classes in each vocational school grade. Because the vocational school had fewer students in each class, this sampling method helped get a more equivalenced population between senior high school and vocational school.

This study recruited 744 valid samples from 1026 participants (in 2016.4 and 2019.11), including 45.0% of students from senior high school and 55.0% of vocational school students. All the students were recruited from a major city in Northeast China; all participants received an RMB5 (Chinese dollar) compensation, and the survey was distributed in paper form. Participants were all voluntary and could leave the investigation at any time. All answers are confidential, can only be used for academic purposes, and all identifying information will be kept anonymous. Of the sample (N=744), 61.2% were male, and 38.6% were female students. Then we used even and odd serial numbers to select 372 samples (167 via high school and 205 via vocational school) into exploratory factor analysis (EFA) and correspondently put 372 samples (168 via high school and 204 via vocational school) into confirmatory factor analysis (CFA). Finally, we used the whole 744 samples to test the reliability and validity.

This study adopted SPSS22.0 and Amos 22.0 to analyze the data. The reason for doing EFA is that it is a newly developed scale, so we need to use EFA to establish a model with good model fits, then use CFA to identify that the model is solid with good model fits.

3.3 Contextual information about schools for investigation

All three high schools represent high-school-level students very well. These high schools include students from urban and rural areas and include students who plan to apply to universities (usually called senior high school students) and students who plan to apply to technical colleges (usually called vocational school students). Most of the high schools in China still follow a traditional, offline, and teacher-centered teaching style (iResearch Inc., 2022). During data collection (before COVID), high schools seldom offered online courses and seldom had online assignments. Some high schools may have online channels, such as smart classrooms, Tencent chat groups, Wechat groups, or emails, to support family-school communication or student clubs. But it only played a secondary role in teaching and communication. During the COVID pandemic, high schools developed many online courses and got used to online communications. However, these are, by all means, temporary policies. As China is rapidly exiting from the strict public health policy in the winter of 2022, high schools will return to offline-dominated courses and campus life again.

Although online teaching and learning activities are not prevalent in Chinese high schools, the National Curriculum of China has stipulated that high school students must take computer courses (Information technology curriculum standards, 2020). To be more specific, these courses are offered in computer laboratories on campus at least once a week, and students must pass the final exam for graduation. Internet literacy is considered one principle of computer course teaching, but it still lacks detailed guidelines to illustrate what literacy is and what content should be taught. Again, the current situation of China's high schools indicates that developing an internet literacy scale is necessary.

4 Results

4.1 Establishing the primary scale of high school students' internet literacy

The current study assessed the suitability of EFA. Several missing values (0.52% of the total data points) were estimated by the series mean method. Because the missing values were randomly distributed and the number was relatively small compared to the large sample size, the researchers assumed the missing values did not have a distortion effect (Mertler & Vannatta, 2005). The normality assumption was also supported because the skewness and kurtosis absolute values were not highly biased. See Table 3 for details.

The Kaiser–Meyer–Olkin (KMO) measurement coefficient was 0.814, exceeding the recommended value of 0.60. Barlett's Test of Sphericity was statistically significant (p < 0.001), indicating the data was suitable for EFA (Pallant, 2007). The EFA sample size (N=372) was acceptable because the number of cases from 100 to 400 was considered suitable for factor analysis (Hair et al., 2010).

The study examined Anti-image correlation matrix (MSA) to delete low-correlation items (< 0.5). Then the study examined commonalities and deleted items whose coefficients were lower than 0.4. Communalities must be examined once again after deleting each item. Afterward, the study inspected structure matrix to: (1) delete items that had similar cross-loadings (the difference was less than 0.10), (2) delete items with a factor loading lower than 0.40, as well as (3) delete dimensions that had less than three items (Hair et al., 2010).

Finally, the primary scale retained 30 qualified items. The MSA correlation ranged from 0.737 to 0.929, and most of the correlation was higher than 0.8. In addition, the communalities coefficients were in good condition because all of these coefficients were higher than 0.4, and most of them were higher than 0.5.

Table 4 lists all the items of the internet literacy scale.

The EFA results were basically consistent with the construct defined by the literature. The scale generated eight common factors and explained 63.68% of the total variance, which was acceptable in social science. Combined with the results of EFA and previous theoretical explorations, the current study defined the internet literacy scale with eight dimensions:

Factor 1: Self-management. The contribution rate was up to 19.40%, including five items.

Table 3 Means, skewness, andkurtosis of internet literacy scale	Item	Mean	Std. Deviation	Skewness	Kurtosis
items in EFA ($N=372$)	1	3.833	1.1697	860	096
	2	4.022	1.1584	-1.057	.202
	3	3.857	1.2540	881	304
	4	3.997	1.2076	-1.001	095
	5	4.311	1.0782	-1.631	1.888
	6	4.032	1.1948	-1.111	.192
	7	3.984	1.2152	-1.020	041
	8	3.394	1.4355	428	-1.152
	9	3.989	1.2131	-1.054	.087
	10	2.862	1.4444	.059	-1.387
	11	3.106	1.3245	077	-1.099
	12	4.189	1.1571	-1.393	.951
	13	3.016	1.3417	.011	-1.102
	14	3.011	1.3478	046	-1.109
	15	3.238	1.4491	246	-1.299
	16	3.109	1.3830	080	-1.235
	17	3.149	1.3802	166	-1.225
	18	3.065	1.4354	142	-1.286
	19	3.035	1.3994	122	-1.262
	20	3.098	1.3974	177	-1.205
	21	1.930	1.1681	1.158	.455
	22	4.208	1.2076	-1.485	1.126
	23	2.359	1.3425	.566	892
	24	3.418	1.3640	486	953
	25	3.024	1.3938	038	-1.238
	26	3.245	1.3821	269	-1.133
	27	3.892	1.2565	967	158
	28	3.603	1.2633	509	846
	29	3.480	1.3519	565	876
	30	3.655	1.2152	682	441
	31	3.797	1.1059	888	.176
	32	2.400	1.2118	.500	659
	33	3.859	1.1046	829	010
	34	3.873	1.1411	877	047
	35	3.639	1.1970	478	595
	36	3.577	1.1823	490	480
	37	3.162	1.3341	088	-1.174
	38	3.339	1.2682	340	820
	39	3.635	1.2820	527	786
	40	2.931	1.3084	.096	-1.030
	41	3.734	1.1914	675	400
	42	3.298	1.2350	160	869
	43	2.852	1.4055	.166	-1.246

Item	Mean	Std. Deviation	Skewness	Kurtosis
44	3.016	1.3478	010	-1.180
45	3.054	1.4265	123	-1.315
46	2.771	1.4252	.207	-1.292
47	2.439	1.3886	.551	959
48	2.754	1.3910	.279	-1.158
49	2.202	1.4198	.861	628
50	3.365	1.4159	413	-1.137
51	3.418	1.3521	423	963
52	3.884	1.2198	798	381
53	3.935	1.2658	904	363
54	4.314	1.0910	-1.475	1.191
55	2.092	1.3326	.875	555
56	3.799	1.3105	822	465
57	3.668	1.3053	601	769
58	3.689	1.3531	714	672
59	3.477	1.2912	444	841
60	3.342	1.3946	293	-1.160

The scale adopted a five-point Likert scale; each item's minimum value is 1, and the maximum value is 5

Factor 2: Self-image construction. The contribution rate was up to 12.52%, including three items.

Factor 3: Damage control. The contribution rate was up to 7.99%, including three items.

Factor 4: Information processing. The contribution rate was up to 6.42%, including four items.

Factor 5: Critical thinking. The contribution rate was up to 5.33%, including four items.

Factor 6: Cooperation. The contribution rate was up to 4.59%, including four items.

Factor 7: Consciousness of morality. The contribution rate was up to 4.19%, including three items.

Factor 8: Consciousness of security. The contribution rate was up to 3.23%, including four items.

Table 5 shows the results of EFA in detail.

4.2 Establishing the final scale of high school students' internet literacy

The current study assessed the suitability of CFA. Several missing values (0.48% of the total data points) were estimated by series mean method. Because the missing values were randomly distributed and the number was relatively small compared to the large sample size, the researchers assumed the missing values did not have

Table 3 (continued)

Serial number	Item
A1	I cannot have meals or go to bed on time when I surf the internet
A2	I lose my emotional control when I surf the internet
A3	Even though I know some behaviors are wrong; I still do them on the internet
A4	When I surf the internet, I behave impulsively
A5	When I surf the internet, I forget everything else in the real world
B1	I like to press 'like' on social media in order to encourage my friends to share their stories with me
B2	I like to praise my friends on social media to make them feel that I am friendly
B3	I pay close attention to my friends' activities on social media to make them feel that I am concerned about their life
C1	I apologize to my friends on social media if I hurt their feeling
C2	I apologize to my friends on social media if I do something wrong
C3	In order to maintain a positive image among my friends, I tend to explain the details if I am involved in some negative events
D1	I can use several simple keywords to summarize the information that I need to search
D2	I am familiar with several information sources: portal web, forum, blog, internet ency- clopedia (such as Baidu Encyclopedia), social media, and digital library
D3	When I face difficulties in searching for information on the internet, I will ask for help from the following media: Zhihu, Douban, Baidu Encyclopedia, and Forum
D4	The following factors can affect my judgment of information credibility: the media's authority, information source's authority, information channel's authority, and personal experience
E1	I think public figures have consistent behaviors both on the internet and in their daily life
E2	If someone I like faces criticism on the internet, I think the criticism is baleful
E3	Before I buy digital products, I only watch the products' advertisements for information
E4	Internet media's reports on crime make me feel that the crime rate in society is increas- ing
F1	I like to share my successful experiences with others
F2	When netizens ask for help, I would like to give suggestions
F3	I participate in discussions on the forum and express my opinion
F4	I share my reading notes with friends on the internet
G1	Cyber manhunt is a reasonable way to bring the truth to light
G2	I used to curse other people on forums or social media
G3	I pretended to be someone else for online activities
H1	I support internet legislation, and I am willing to accept legal supervision
H2	If I transmit others' original works, I will mention that I cite this from others and provide its original source
H3	I use privacy settings on social media
H4	I consider others' daily schedules when I use the internet to connect with them

Table 4 Internet literacy scale factors selected for EFA

The original scale was conducted in Chinese, while researchers translated the scale to English in this table

Item	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Commu- nalities
A1	.672								.477
A2	.719								.540
A3	.705								.533
A4	.684								.578
A5	.662								.477
B1		.687							.680
B2		.810							.773
B3		.721							.704
C1			.861						.846
C2			.936						.882
C3			.534						.619
D1				.698					.677
D2				.844					.704
D3				.669					.566
D4				.569					.531
E1					.563				.463
E2					.646				.577
E3					.691				.562
E4					.690				.557
F1						.748			.671
F2						.864			.779
F3						.810			.757
F4						.834			.708
G1							.703		.602
G2							.757		.676
G3							.797		.737
H1								.773	.625
H2								.764	.657
H3								.745	.596
H4								.690	.550
Cronbach's alpha	0.747	0.822	0.845	0.732	0.630	0.872	0.746	0.761	
Variance explained (%)	19.40%	12.52%	7.99%	6.42%	5.33%	4.59%	4.19%	3.23%	
Eigen-value	5.820	3.756	2.397	1.925	1.600	1.376	1.256	0.973	

 Table 5
 The results of EFA in developing the internet literacy scale

a distortion effect (Mertler & Vannatta, 2005). The normality assumption was also supported because the skewness and kurtosis absolute values were not highly biased. See Table 6 for details.

Table 6 Means, skewness, andkurtosis of internet literacy scale	Item	Mean	Std. Deviation	Skewness	Kurtosis
items in CFA ($N=372$)	A1	4.024	1.2073	-1.165	.349
	A2	3.880	1.2661	871	354
	A3	4.00	1.216	990	152
	A4	4.269	1.1379	-1.626	1.759
	A5	3.88	1.287	903	381
	B1	3.28	1.378	326	-1.138
	B2	3.02	1.322	028	-1.121
	B3	3.05	1.277	109	995
	C1	3.09	1.361	169	-1.171
	C2	3.02	1.393	093	-1.265
	C3	3.12	1.395	176	-1.197
	D1	3.88	1.190	970	.040
	D2	3.56	1.197	434	750
	D3	3.44	1.340	445	-1.017
	D4	3.68	1.167	758	137
	E1	3.69	1.142	608	305
	E2	3.556	1.1340	501	389
	E3	3.02	1.318	.064	-1.139
	E4	3.36	1.239	317	804
	F1	2.84	1.341	.109	-1.157
	F2	3.00	1.342	061	-1.152
	F3	2.85	1.350	.095	-1.164
	F4	2.69	1.331	.275	-1.076
	G1	4.02	1.210	-1.074	.178
	G2	4.08	1.240	-1.141	.079
	G3	4.43	1.057	-1.871	2.553
	H1	3.70	1.370	748	649
	H2	3.747	1.3218	778	515
	H3	3.695	1.3523	739	667
	H4	3.55	1.301	591	724

The scale adopted a five-point Likert scale; each item's minimum value is 1, and the maximum value is 5

Then the study illustrated the measurement model of the final scale with standardized factor loadings. See Fig. 2 and Table 7 for details.

The standardized factor loading of each item was statistically significant (p < 0.01) and most of the items (29 of 30) were not less than the recommended factor loading value of 0.50 (Hair et al., 2010), ranging from 0.534 to 0.891. Because the only exception item (factor loading value = 0.471) also significantly contributed to the factor, this model's standardized parameter was still acceptable. In addition, each item was loaded only on its respective factor in the model, which indicated that the model was well-designed (Kline, 2005).



Fig. 2 The measurement model of internet literacy

Then the current study analyzed the goodness-of-fit of model.

According to Table 8, the χ^2/df =1.88, RMSEA=0.049, GFI=0.889, AGFI=0.863, CFI=0.915, TLI=0.902, and IFI=0.916. The χ^2/df value is recommended to be less than 3 (Kline, 2005), the RMSEA value is recommended to be no more than 0.05 (Schumacker & Lomax, 2004), the GFI & AGFI values should be greater than 0.8 (Doll et al., 1994; MacCallum & Hong, 1997), and the CFI, TLI, & IFI values should be greater than 0.90 (Brown, 2006; Hair et al., 2010; Huang, 2007). The coefficients in this model fit the threshold, which reflected that this goodness-of-fit was in good condition. The final scale of high school students' internet literacy was acceptable.

In conclusion, the 30 items of High school students' internet literacy scale presented good fitness both in EFA and CFA.

4.3 Reliability and validity analysis of high school students' internet literacy scale

4.3.1 Internal reliability

The Cronbach' α coefficient of the whole internet literacy scale was 0.794. As for the eight dimensions, seven of them ranged from 0.702 to 0.853 except the Critical thinking's coefficient equaled 0.628, which was also acceptable (Ursachi et al., 2015) (Table 9).

4.3.2 Split-half reliability

Split-half Reliability is one of the most common methods to test reliability, reflecting the consistency of content. Researchers divided items of high school students' internet literacy scale into two sections by odd or even numbers. Then, researchers calculated the correlations between the two sections mentioned above. The Spearman-Brown coefficient of this scale was 0.892 (Table 10).

	Self-management	Self-image construction	Damage control	Information processing	Critical thinking	Cooperation	Morality
Self-image construction	-0.13						
Damage control	-0.05	0.61^{***}					
Information processing	0.09^{**}	0.28^{***}	0.28^{***}				
Critical thinking	0.19^{***}	-0.17***	-0.15**	-0.04			
Cooperation	-0.05	0.40^{***}	0.49^{***}	0.34^{***}	-0.16**		
Morality	0.27^{***}	-0.10^{**}	-0.19***	0.04	0.19^{***}	-0.14**	
Security	0.10^{*}	0.21^{***}	0.27^{***}	0.27^{***}	0.08	0.20^{***}	0.09^{*}
p < 0.05, p < 0.01, p < 0.01, p < 0.01	001						

tion between dimensions	
Correlat	
Table 7	

Table 8 Goodness-of-fit of the internet literacy scale model	Absolute Fit Measures	χ^2 degrees of freedom	707.734 377
		Probability level	< 0.0001
		RMSEA	0.049
		GFI	0.889
		AGFI	0.863
	Relative Fit Measures	TLI	0.902
		CFI	0.915
		IFI	0.916

RMSEA=root mean square error of approximation; GFI=goodness of fit index; AGFI=adjusted goodness of fit index; TLI=Tucker-Lewis index; CFI=comparative fit index; IFI=incremental fit index

Table 9 Cronbach's α coefficients of the internet literacy scale	Dimension	Item	Internal Consist- ency
	Self-management	3	0.777
	Self-image Construction	3	0.827
	Damage Control	3	0.849
	Information Processing	4	0.761
	Critical Thinking	4	0.628
	Cooperation	4	0.853
	Consciousness of Morality	3	0.702
	Consciousness of Security	4	0.759
	Total	30	0.794

Table 10 Split-half reliability of the internet literacy scale

Cronbach Alpha	First Section	number	.632
		Items numbers	15
	Second Section	number	.611
		Items numbers	15
			30
Correlation of report forms	Total number of items		.806
Spearman-Brown coefficient	Equal length		.893
	Unequal length		.893
Guttman Split-half reliability coefficient			.892

4.3.3 Content validity

Content validity aimed to test if the content in this scale adequately reflected the real definition of high school students' internet literacy. In the process of establishing the

scale, researchers used existing internet literacy questionnaires and scales from the US, Australia, Singapore, Mainland China and Hong Kong for reference. In addition, researchers discussed with experts, undergraduates, senior high school students, and vocational students to make sure the content adequately described high school students' internet literacy.

After identifying the thirty items for the final version of the internet literacy scale, the current study sent consultation questionnaires to four experts. These four experts are professors (two full professors and two assistant professors) with research and teaching experience in media literacy, with Doctoral degrees majoring in Education or Communication. In the consultation questionnaire of content validity evaluation, experts were asked to choose the relevance of each item to the corresponding content dimension. The relevance score has four levels: 1 = irrelevant, 2 = weak correlation, 3 = relatively strong correlation, and 4 = very strong correlation. Based on the experts' scores, the current study calculated its I-CVI (item level content validity index) and S-CVI (scale level content validity index, universal agreement). For the I-CVI, 24 of the 30 items were rated "good", four items were "acceptable", and two items were "not good" (Polit et al., 2007). The overall scale's S-CVI was 0.8, indicating good content validity (Davis, 1992). Considering the two CVIs comprehensively, as well as expert suggestions during the questionnaire design period, the current study kept the 30 items for the final version of internet literacy scale. This procedure showed the good validity of the content, and see Table 11 in detail.

Item	Expert rating				I-CVI	Item	Expert rating				I-CVI
	A	В	С	D			A	В	С	D	
1	4	4	4	3	1.00	16	4	4	4	2	0.75
2	4	2	2	1	0.25	17	4	4	4	3	1.00
3	3	4	4	3	1.00	18	3	4	4	3	1.00
4	3	4	3	3	1.00	19	3	4	4	3	1.00
5	3	4	2	4	0.75	20	4	4	4	4	1.00
6	4	4	4	4	1.00	21	3	4	4	4	1.00
7	4	3	4	4	1.00	22	4	4	4	4	1.00
8	4	4	4	4	1.00	23	3	4	4	4	1.00
9	4	3	3	4	1.00	24	4	3	4	3	1.00
10	4	3	3	4	1.00	25	4	4	4	2	0.75
11	4	3	3	4	1.00	26	3	4	4	3	1.00
12	3	4	4	4	1.00	27	3	4	4	4	1.00
13	3	4	4	4	1.00	28	3	2	4	4	0.75
14	4	4	4	4	1.00	29	4	4	4	4	1.00
15	4	4	4	4	1.00	30	3	3	2	1	0.50
S-CVI (universal agreement) $= 24/30 = 0.8$											

Table 11Experts ratings andcalculation of I-CVI and S-CVI

4.3.4 Construct validity

This study used 744 samples from senior high schools and vocational schools to test the construct validity. The KMO equaled 0.841, and the result of Bartlett's test was p < 0.001, which was fit for the threshold. The scale used principal component analysis extraction method to get scale items' factor loading. According to the EFA results, this scale adopted principal axis factor analysis and selected eight factors. Those factors could explain 63.06% of the total variance, which was acceptable.

By using the principal component analysis method, the following results were concluded. The first factor was 'Self-management'(including 5 items), and the variance rate was 19.25%; the second factor was 'Self-image construction'(including 3 items), and the variance rate was 12.76%; the third factor was 'Damage control'(including 3 items), and the variance rate was 7.49%; the fourth factor was 'Information processing' (including 4 items), and the variance rate was 5.21%; the sixth factor was 'Cooperation' (including 4 items), and the variance rate was 4.65%; the seventh factor was 'Consciousness of morality' (including 3 items), and the variance rate was 4.65%; the seventh factor was 'Consciousness of security' (including 4 items), and the variance rate was 4.14%; the eighth factor was 'Consciousness of security' (including 4 items), and the variance rate was 3.50%. In conclusion, the factors in this construct validity test were consistent with the scale design. The scale's construct validity was acceptable.

5 Discussion and conclusion

The current study recruits 744 samples from senior high schools and vocational schools to develop an internet literacy scale for students. After EFA and CFA, the current study proposes the high school students' internet literacy scale (30 items) with acceptable goodness-of-fit, reliability, and validity. The study summarizes the results here: (1) The coefficient of internal consistency of high school students' network literacy scale is 0.794, and its split-half reliability is 0.893, which reflects that this scale has pretty good reliability. (2) This scale is reliable in content and qualified in construct validity that the KMO coefficient is 0.841, and the Bartlett test is significant (p < 0.001). (3) The scale has eight dimensions, including self-management, self-image construction, damage control, information processing, critical thinking, cooperation, consciousness of morality, and consciousness of security, which accumulatively explains 63.06% of the variance rate.

5.1 Theoretical implication

The current study proposes some theoretical implications for developing the internet literacy scale. First of all, some items in the traditional scales need to keep up with the internet's current condition. This study has updated those items. For instance, scholars tended to use the time length of the internet use to measure people's ability of self-management, because spending all day long in an internet café or in front of a desktop computer at home was a signal of squeezing out other necessary tasks in daily life (Chen et al., 2003). However, the wide application of mobile internet makes people connect to the internet anytime and anywhere, and the time length is not a proper measurement for self-management nowadays. Therefore, researchers should take other items, such as users' addictive behavior, "I cannot have meals or go to bed on time when I surf the internet," into consideration. Furthermore, the current study has summarized three models that guided internet literacy research and education, proposed that the three need not be exclusive, and specifically designed the scale guided by a combination of the three models. Although the empowerment model is the latest constructed, and the protectionism model and skill use model are formed in the early days of the internet, each one is still influential nowadays. For instance, the empowerment model includes online cooperation skills and selfimage construction to emphasize the theoretical concerns of proactively embracing the internet instead of passively receiving protection. However, it does not mean that the idea of critical thinking in the protectionism model or the up-to-date information-processing skills in the skill use model is no longer necessary. To sum up, this internet literacy scale is designed to fit the development of internet technology and reflects recent theory concerns.

5.2 Practical implication

The updated internet literacy scale has promising practical implications in education and nationwide investigations. First of all, educators can apply the scale for instructional design. To use the scale for the pre-test, teachers can identify students' initial level of internet literacy in different dimensions. Thus, based on students' performance on the scale, teachers could design more targeted courses for the class. For instance, if the scale shows students are more proficient in information processing skills but relatively lack experience in online cooperation, teachers may consider designing more problem-based learning tasks or resource-based learning tasks to practice teamwork. According to Gagne's model of instruction, the final steps of a course should provide feedback and assess the performance of students (Gagné et al., 1992). Thus, using the scale as a post-test could help measure the class's effectiveness, and students can also get feedback about their progress. In addition, the scale could be used as a part of social investigation. The twenty-first century is the age of information, and the internet coexists with people. Getting a panorama of internet literacy on Generation Z will help future policy-making on education and information-communication technologies (ICTs). For instance, there are obvious differences in education and ICTs funds between China's east and west, urban and rural areas. The internet literacy scale could be used as empirical evidence to monitor education resource inequality and the digital divide, thus may contribute to better policy-making and social development.

Moreover, the COVID-19 pandemic has profoundly reshaped the way people communicate with each other and elementary education's model of instruction. Whether from daily life or education perspective, the pandemic pushes adolescents to learn more advanced internet literacy to deal with the challenges from misinformation, digital learning, and social interactions. Therefore, this scale is even more necessary for teachers and students, to use it as a tool to evaluate and improve internet literacy. Furthermore, this scale can even be updated with more advanced network theories, such as connectivity theory for MOOCs, six degrees of separation, and weak ties. Those theories seem too hard for high school students to understand, but when the pandemic accelerates activities moving from offline to online, students may need those skills in the near future.

5.3 Limitations and future studies

This study has several limitations. First, the findings' generalizability is limited to Chinese high schools because participants are all recruited from China. Since internet application in different countries is quite different, the result may be biased if generalized to all adolescents worldwide. In addition, partly influenced by the increasingly skewed sex ratio in China's vocational schools, this study samples more males (around 60%) than females (around 40%), which may also cause relatively biased results. Second, due to the new items in the scale, the survey only shows acceptable reliability and validity, but not perfect. Especially, the cumulative variation explanation rate and internal consistency of some dimensions still need improvement. Third, researchers proposed some items to test people's knowledge of network theory, such as small-world theory, the recommended algorithm, basic principles of databases, and switches. However, our pilot test found that students knew very little about that knowledge. Therefore, the item discrimination was quite low. According to scholars' suggestions, the current study did not include those items, even though the network theory knowledge might be necessary for the young generation. In addition, the pilot study was conducted in 2016.2, and the first round of the main study was conducted in 2016.4. The first round of data collection got 463 valid samples. Researchers had to wait until the new session of students (three grades) were promoted to high school in 2019. In 2019.11, researchers collected the second round of data. Overall, we got 744 valid samples. It may be a shortcoming that the data collection procedure lasted for a long time. But the research team has really tried their best. It is very hard for researchers to get permitted by high school teachers and students, so the researchers have to rely on the three high schools which have long-term cooperation.

Further studies will focus on three questions: First, how can the scale be generalized to students in different regions or different ages? Second, how can the scale be used as an evaluation tool and apply it in pedagogical contexts? Third, pay attention to new developments in internet theory and technology and renew the scale in time.

To sum up, the internet plays a significant role in people's daily life. Internet literacy should become an inevitable ability for people in the information age, which deserves more attention, discussion, and practice in the future.

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

Declarations

Conflict of interest The authors declare that there is no conflict of interest.

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