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Sustainability Literacy: Assessment of Knowingness, Attitude and Behavior Regarding Sustainable Development among Students in China

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Abstract: Education is critical to achieving the world's sustainable development (SD). Assessment or measurement is a means to help an education system to accelerate integrating SD content. To have a perception of the gap in relation to the SD action goals, a basic understanding of current students' knowledge, attitudes and behaviors (KAB) needs to be established. The study applied a survey to assess Chinses students' knowingness, attitude and behavior regarding SD. Data were collected from students from all parts of China via an online survey tool, which consists of 887 primary-school students and 1661 secondary-school students. The results indicate a high level of KAB regarding SD among Chinese students, while this sustainability literacy is mainly embodied in the environmental dimension. In general, the results showed the better KAB of primary-school students than secondary-school students, while there was almost no difference between male and female students. Moreover, knowingness and attitude have significant and positive correlations with behaviors. These results constitute a general sketch of Chinese students' sustainable knowledge, attitudes and behavior, which could be employed to monitor China's efforts on education for sustainable development and also to foster curriculum developments and innovations in China.

Keywords: sustainability-literacy assessment; sustainable development goals; education for sustainable development; online survey; Chinese students

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1. Introduction

Long-term sustainable development (SD) has increasingly become a key issue worldwide regarding future environmental, political, social and economic development. Despite the huge progress made by many societies, challenges such as poverty, biodiversity loss and climate change still exist, leaving many areas where actions can be taken. For individuals, the current generation needs to develop new capacities regarding SD. Despite the divergence in the usage of different concepts—such as abilities, competencies, and consciousness—generally speaking, an individual's SD qualities are the knowledge, mindset and skills that allow individuals to become deeply committed to building a sustainable future and assisting in making informed and effective decisions to this end [1]. A change in individuals' knowledge, attitudes and behavior (KAB) is essential to accomplish SD [2].

Students take on an extraordinarily crucial role, since they are the primary objects of formal education and change agents of SD through actions and decision making. The past two decades have witnessed increasing recognition and political agreement over the role of education as a major agent to transform the current society into a more sustainable, equitable and socially just one. Education for sustainable development (ESD) is not only one of the 17 sustainable development goals (SDGs), but is also a means to reach other SDGs. Goal 4 in the SDGs, in particular, targets the role of ESD in this respect. The development of adequate knowledge, right attitudes and proficient skills is an important dimension

of ESD. With regard to this, many activities are underway related to the ESD policies [3]. In May 2021, the UNESCO World Conference on Education for Sustainable Development was held in Berlin (online). The conference stressed that, in response to various challenges in the field of SD, ESD supports efforts to equip learners with the knowledge, skills, values and attitudes needed to contribute to a more sustainable world [4]. Although ESD policies and practices are abundant, the monitoring and evaluation of ESD achievements are still weak. UNESCO suggested that it is important to accelerate the improvement of monitoring and evaluation, to provide evidence to support investments in ESD and accelerate the process of ESD.

Measuring people's knowledge, awareness or behavior should always be a first step in the development or evaluation of any kind of program or intervention [5]. To have a perception of the gap in relation to the SD action goals, a basic understanding of current students' KAB needs to be established. Identifying indicators to monitor KAB that are needed to promote SD is challenging work. An important reason for the difficulty in assessment is that there are very few relevant student-assessment surveys and it is difficult to develop survey items that are culturally relevant but not culturally biased [6]. To our knowledge, there is limited research in China concerning the KAB of students concerning SD, especially considering all three content dimensions, which are environmental sustainability, social sustainability and economic sustainability (which is interpreted as the planet, people and prosperity content domain in the SDGs). Typically, studies that delve into the field have a focus on the environmental dimension, which addresses more narrow frameworks such as sustainable consumption [7], pro-environmental behaviors [8], etc. In recent years, a few studies have moved on from the environmental dimension to the integrated concept of SD which incorporates the environmental, economic and social dimensions [5,9]. There is still a need for studies focusing on students' psychometric constructs within the broader context of SD, including all the environmental, social and economic dimensions.

This study focuses on an important issue, which is describing Chinese students' sustainability literacy. To the best of our knowledge, this is the first study to investigate and evaluate Chinese primary- and secondary-school students' KAB regarding the environmental, social and economic dimensions of SD. To achieve that, we developed a culturally unbiased and contextually applicable questionnaire. The underlying idea of ESD is to empower students with SD competences through content with a holistic, interdisciplinary perspective. The study has taken a holistic view of SD into account, rather than separating them into polarities, which was also emphasized in United Nations (UN) documents. Through the assessment, we could obtain a general sketch of Chinese students' sustainable KAB, which could be employed to monitor China's progress on ESD efforts, and also foster curriculum developments and innovations in China. Moreover, the evaluation methods and indicators adopted by us can also provide reference for other countries and regions to access the implementation effects of ESD.

2. Literature Review

It is difficult to study SD without an account of the UN's SD framework. The UN's goals and targets will still stimulate action over the next ten years and are of critical importance for humanity and the planet [10]. In addition, "sustainability literacy" is the combination of knowledge, attitudes and behavior, which is closely related to the UN's SDGs and is also the result of ESD. The 17 SDGs put forward more specific requirements for future development, which means SD has changed from a concept to measurable indicators [11]. In this case, the content of ESD has become specific, and it is necessary to establish comparable indicators to monitor and evaluate the achievements of ESD. Regarding the assessment of KAB related to SD, there are scales or surveys measuring students' competences that are based on UNESCO documents [12–15].

Understanding global issues (such as peace, poverty, migration, globalization and climate change), events and institutions is essential for developing sustainability literacy [16]. The knowledge system of sustainability literacy includes relevant knowledge of social,

environmental and economic sustainability. To help learners prepare for the uncertainty of the future, they should be helped to acquire relevant knowledge. A lack of knowledge or having the wrong knowledge may limit pro-SD behaviors. Studies have shown that publics have limited knowledge about SD and its goals. A study conducted by GlobeScan (2016) found that only 28% of people across 13 countries, including India, the UK, and Germany, expressed that they have some or a lot of awareness of SDGs [17]. While, in China, awareness of the SDGs is lower than that of the Millennium Development Goals in 2007 [17]. Guan et al. (2019) surveyed more than 4000 residents in five cities in China; the results also indicated that knowledge about the SDGs was scarce [18]. However, on the other hand, the public's growing awareness of SD is being proven by the fact that youth show higher knowledge than the public average [19]. However, the knowledge varies by area. Michalos et al. (2015) revealed that students' knowledge of the social and environmental dimensions of sustainability appears to be stronger than that of the economic dimensions [20].

Knowledge is not the only factor affecting students' sustainability ability, affective factors also affect their daily behavior decisions [21]. Attitudes can help individuals adapt to the environment faster. Attitudes may change over time, and susceptibility to attitude change is greater during adolescence [22]. Therefore, attitudes can be cultivated through education; changing attitudes or forming supportive attitudes are important content of ESD. Many international policies and national practices have been implemented to promote students' sustainable attitudes, such as the UNESCO Education for Sustainable Development Goals: Learning Objectives [23]. It is not only because attitudes can be changed through education that it is essential to accomplish SD [2]. Students' supportive attitudes vary in different aspects of SD content [24]. Liu et al. (2020) found that students of a vocational college in China had the most-favorable attitudes towards the educational dimension and the least-favorable attitudes towards the social dimension [25]. There are also some gender differences in attitudes toward SD. Male students hold stronger anthropocentric values while biocentric values are more common among female students [25,26]. Some empirical studies revealed positive associations between sustainability knowingness and sustainability attitudes [27]. Liang et al. (2018) found that a high level of environmental knowledge was required if environmental attitude is to be strong [28]. However, attitudes are not necessarily related to objective knowledge. A gap between knowledge and attitudes implies that a better-informed public is not necessarily a public that holds supportive attitudes [18].

In addition to knowledge and attitudes, behavior has received the most attention from researchers. Behavior is critical, as only changes in behavior can lead to the achievement of SDGs, and the ultimate goal of ESD is to empower students to make sustainable decisions. Previous studies were inconclusive about the factors robustly associated with behaviors regarding SD or some aspects of SD. The relationship between knowingness/knowledge, attitudes and behavior differs between studies. For example, the correlation between environmental knowledge and behavioral intention was extremely weak for Taiwanese university students [8]. Michalos et al. (2015) indicated that the correlation between sustainability-related levels of knowledge and choices favorable to sustainability is likely to increase with exposure to ESD [20]. Strengthening the knowledge base itself contributes to the adoption of more sustainable choices and actions. However, sustainability behavior may only be related to knowingness (knowledge) and attitudes in limited content dimensions [8,29], and the correlation between attitude and behavior may be enhanced when attitudes are directed to specific sustainable behavior [30,31].

For the content domain, environmental sustainability has received the most attention. Although SD policies have been implemented all over the world for decades, people still consider that SD is closely related to the environment or nature resources. There is a dearth of study on students' KAB beyond environmental aspects of sustainability, which view SD as a holistic concept.

3. Data and Methodology

This study is based on a quantitative approach to investigate the SD knowingness, attitudes and behaviors of Chinese students. Students from primary schools and secondary schools took part in an online survey in March 2021. The study framework, the questionnaire, and the sample description are described in detail in the following sections.

3.1. Study Framework

Many studies were devoted to individuals' knowledge, beliefs, and behaviors regarding SD. Some defined knowledge, attitudes, values, behaviors, etc., as a holistic and integrative concept, such as Olsson et al. (2016), which applied sustainable consciousness to represent a holistic view of SD [21]. While there were others that measured KAB separately. Although these studies often interpreted KAB as various subcategories, such as concerns, awareness, intentions and willingness, the three building blocks—knowledge, attitude and behavior—are almost always present [12], as individual's qualities, knowledge, attitudes and behaviors must interact with each other. However the relationships between the three are ambiguous, and various studies obtain different results. Hence, we performed the assessment separately. For this purpose, a KAB survey was conducted.

The questionnaire items varied between different instruments, which implied that these studies focused on specific contexts. However, in the literature, there is an emphasis on encouraging holism and pluralism for SD [32]. Our study focused on more general individual qualities regarding SD, rather than specific topics. In this regard, UNESCO documents have become the benchmark [21]. The literature was also anchored by the UNESCO definitions. It is necessary to take these benchmarks as our point of departure.

As stated above, studies in the realm have a focus on the environment dimension of SD. Moving from environmental dimension to all fields, there are studies that attempted the development of measurement and assessment tools [7,12,13]. In search of potential items that might be included in standardized measures of KAB concerning SD, we were aware that SD was an open-textured concept and it was impossible to incorporate all the issues in the field. In the construction of assessment tools, there are generally two strategies to formulate assessment questionnaire. One is to form an item pool and make a final list of items for use. Another one is to modify assessment tools that already exist, to make it more consistent with the purpose of the present study. We choose the second one, because it is more convincing to develop our questionnaire based on previous sound studies.

Gericke et al. (2019) applied knowingness to the measurement of students' sustainability consciousness rather than using knowledge [12]. Knowingness could be regarded as recognition of the fundamentals of SD [12], and it includes many similarities with awareness, for it probes individuals' wakefulness and perceptions. They argued that the term knowledge is associated with objective truth. Knowledge is a complex concept that can be expressed in a variety of forms, not only in the form of truths [21]. In addition, knowledge is not always in line with the concept of SD, in which the solution of sustainability issues is complex and context-dependent [33]. Although awareness of the problem and recognizing the sustainability issue is the prerequisite for actions, factual knowledge alone cannot make individuals committed to sustainable lifestyles. Affective factors are also very important to empower decision making in everyday life. In studies where two validated scales—the new ecological paradigm (NEP) and the connectedness with nature scale (CNS)—are included, the more effective CNS appears to more strongly predict environmental behavior than the more reflective and cognitive NEP [34]. There are so many facts about SD and SDGs, we find it is difficult to cover all the topics in the field and include sufficiently comprehensive items, without bias, in one questionnaire. However, the concept of knowingness is more suitable to the study since we do not intend to probe factual knowledge about environmental, economic and social issues, but an affective-based knowingness [35].

Attitude represents a summary evaluation of a psychological object captured in such attribute dimensions as good–bad, harmful–beneficial, pleasant–unpleasant, and likable–dislikable [36]. Attitudes refers to judgments or evaluations regarding ideas, per-

sons, objects, events, situations, and/or relationships [15]. There is no consensus on the definition of sustainable attitude. In addition, it is possible for people to hold different attitudes in specific context at the same time, sometimes even contradictory attitudes. Due to the presence of multiple context-dependent attitudes toward social targets, correct responses are not required. Most scholars use self-report scales to measure attitude, which requires the subjects to evaluate something with scores. The implicit assumption of self-reporting scale is that individuals are willing and able to accurately express their attitudes, but this assumption is sometimes not valid. Many scholars have noted that there is a widespread social-desirability bias in self-reported attitude scales [37]. Therefore, in theory, it is difficult to measure individuals' attitudes to SD accurately with self-reporting scales. According to the definition of UNESCO, sustainable behavior is the actions and practices that can promote human wellbeing and SD. Behavior is reflected in many aspects, such as individual consumption and lifestyle, participation in policy making, etc.

3.2. Survey Instrument

Knowledge, attitude and practice (KAP) surveys (or their offshoots) have long history in describing qualities of populations of interest, and have been extensively used to measure public's knowledge, attitude and behaviors related to issues such as environment protection, etc. A survey based on three subconstructs, which were SD knowingness, SD attitudes and SD behaviors, were used. In addition, there was also a set of standard demographic questions concerning gender, age, and so on, at the beginning of the questionnaire. Each item in the questionnaire relates to a specific subtheme within the UNESCO definition of the planet (environment), people (society) and prosperity (economy) aspects of SD.

We carefully studied the items of knowingness and attitudes in the Sustainability Consciousness Questionnaire (SCQ) that Gericke et al. (2019) compiled [12]. The questionnaire has been validated extensively in the study of sustainability consciousness. In order for the item content to include full range of SDGs, we made some modifications to SCQ-Knowingness, which, generally, were removing or adding items to the original version. When adding items, we kept a consistent narrative. The Knowingness subsection has a four-point format, ranging from Strongly agree to Strongly disagree, and a Don't know option, for it is possible students were not entirely sure about the knowingness items. PISA 2018 showed that global mindedness was a good predictor of attitude [38]. There were six questions in the students' self-report questionnaire—global mindedness in PISA 2018, and we adapted four of them to measure attitudes. In addition, we developed five questions to measure students' attitudes towards environmental and social issues. These items were derived from the SDGS and the learning objectives of ESD. The attitude sub-section has a four-point format, ranging from Strongly agree to Strongly disagree. Items are provided in the following Results section.

It is hard to observe the real behavior in students' life. For this reason, we measured students' willingness to take actions rather than their real actions. PISA 2018 assessed students' willingness to take actions using a series of eight yes-or-no statements [38]. The items were set for measuring students' global competency through their practices in social activities, international affairs and environmental conservation. Those aspects are consistent with the demand of SD. Hence, we adapted these questions in order to make them more realistic to Chinese students, and added items with the same narrative form to ensure they cover all the SDGs. However, it is important to note that prosustainable behavior is too diverse to measure in a brief self-report scale.

In addition, as an important factor affecting sustainable behavior, we also conducted a survey of self-efficacy among students (since answering these questions required certain knowledge and understanding, only secondary-school students were asked to answer these questions). The 2016 International Civic and Citizenship Education Study (ICCS) divided the behavior of civic literacy into three parts: dispositions, behavioral intentions, and civic participation. Behavioral intentions included individuals' interest and self-efficacy [15].

According to ICCS, self-efficacy could affect individual's decision making and effort level when completing tasks. Self-efficacy was also an important part of PISA's global competence assessment [38]. PISA 2018 asked students to what extent they think they can complete tasks related to global issues, and the options include: they cannot do it, they have difficulty in doing it, they can do it with a little effort, and they can do it easily. We adapted these questions from PISA 2018 into the questionnaire, and added an item about COVID-19 to evaluate students' self-efficacy. Figure 1 shows the framework of our survey and questionnaire.

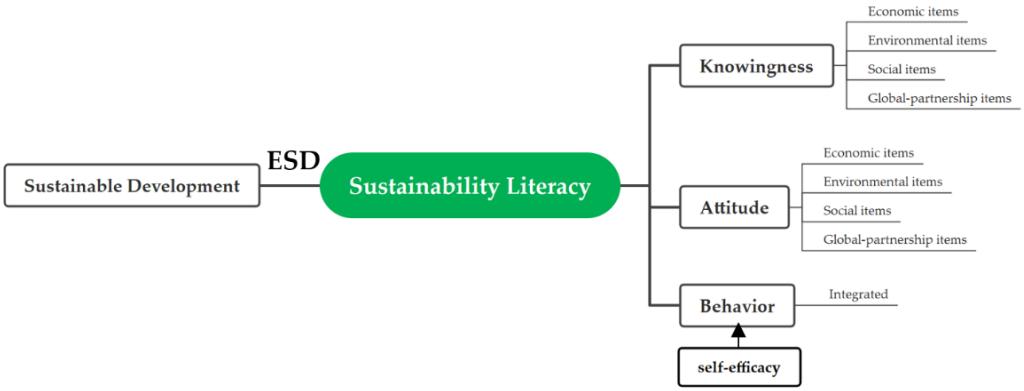

Figure 1. Framework of survey and questionnaire.

We first translated the questionnaire that was for secondary-school students into Chinese. Based on this version of the questionnaire, before collection of primary school data, we improved the language for better understanding for primary-school students. The research team transformed the narrative of the questionnaire into simple statements. After that, five primary school Chinese teachers modified the questionnaire to make it suitable for the reading level of primary-school students. Throughout the process, we kept meaning of the questions as constant as possible. Two versions of the questionnaire were eventually made: one for primary-school students and one for secondary-school students. In addition, a few sentences were worded negatively for the purpose of identifying careless respondents and the responses were reverse coded during the analysis.

The survey is valid and reliable. As stated above, the items of each construct were from valid questionnaire. Results from the reliability analysis for the scales of knowingness and attitudes constructs and self-efficacy are provided in terms of Cronbach's α. The analysis indicated sufficient reliability of the instrument, with the separate alphas being 0.82, 0.82, and 0.79, which were all above 0.7.

3.3. Sampling and Data Collection

The analysis included two main groups of students. One from primary school and one from secondary school. Students entered the study by completing an online questionnaire. The questionnaires were distributed in March 2021 through the professional and influential online survey platform "Questionnaire Star", which is widely used in China. The platform generated a link to our questionnaire and invited qualified samples in its sample pool to fill out the questionnaire. Only when finishing all the questions (which means that for every question, students must choose an option or fill the blank) could students submit the questionnaire. Due to this setting, there are no missing values in the final data we collected. However, this may have led to another problem, which is that students choose any answer although they did not feel that way, in order to finish and submit the survey sheet.

Due to the low possibility of owning a cell phone, it was difficult to reach primary-school students directly through the Internet. For this reason, we randomly distributed the online questionnaire in three primary school in Beijing with the help of school administrators. Since a certain level of literacy and comprehension is required to fill out the questionnaire, the sample of primary-school students in this survey was composed

of students in grades 3–6. However, using the convenience sample may contribute to the larger proportion of urban students of primary school.

Although we assured their anonymity and requested them to answer the questions by their own, there was still possibility that parents were the real respondents. In addition, there may be carelessly invalid respondents. Overall, a total of 64 nonvalid respondents or inattentive respondents were identified through response time, response length restrictions, and whether consecutive questions gave identical responses.

The final data consists of 2548 students, including 887 primary-school students, 278 middle-school students, and 1383 high-school students (a total of 1661 secondary-school students), as detailed in Table 1. In addition, the number of male and female students in the study's sample was approximately equal, but the majority of students lived in urban areas. A reason for this may be that online questionnaire distribution results in barriers for students from rural areas, as detailed in Figure 2.

Table 1. Description of sample characteristics.

	Number of Samples	Proportion (%)
School level		
Primary school	887	34.81
Secondary school	1661	65.19
Middle school	278	10.91
High school	1383	54.28
Gender		
Male	1204	47.25
Female	1344	52.75
Household type		
Rural	513	20.13
Urban	2035	79.87

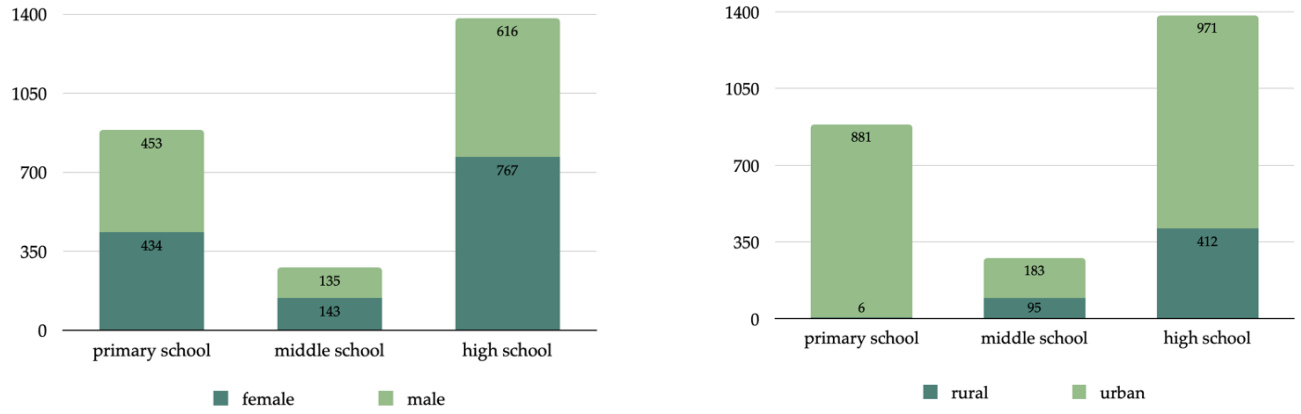

Figure 2. Description of sample by school level. (**a**) Gender by school level; (**b**) household type by school level.

4. Results

A five-point format was used for all the questions in the knowingness subsection, and a four-point format was used in attitude subsection. Hence, it is not appropriate to simply add the scores. We present here the percentage of responses of the strongly agreeing and the total percentage of favorable responses. However, a fair amount of information is lost when neglecting the responses that are unfavorable or neutral [20]. Therefore, we also treat the degree as if they were cardinal numbers so that we can obtain mean scores as summary

measures of the responses. The mean scores are calculated as the degree of all response divided by the number of the responses, with 1 being highest and 4 being lowest.

4.1. Knowingness

We present students' knowingness of SD both with the means and standard deviations and with the frequencies of the items, in Table 2. To every question, there are students who chosen the Don't know option. Due to it being hardly possible to assign a reliable value to it, the Don't know answers were excluded when calculating the mean values. Since the items are either SDGs or paraphrases of SDGs, the results indicate that students have a good knowingness of SD. The mean values of each item are all less than 2 (1 to 4), meaning that most of the students recognized what it takes to achieve sustainable development. Of these eight items, six items gained more than 90% of agreement or strong agreement. Item number K8 had the lowest mean value and, correspondingly, received the highest level (99%, n = 2548) of agreement or strong agreement.

Table 2. Students' knowingness regarding sustainable development.

		Mean (SD)	N Valid Entries	Strongly Agree and Agree	Strongly Agree
No.	**Item**	**(1)**	**(2)**	**(3)**	**(4)**
Economic items					
K2	Sustainable development requires ending hunger and malnutrition in all its forms.	1.72 (0.77)	2420	0.85	0.45
K3	End poverty is necessary for sustainable development.	1.47 (0.58)	2497	0.96	0.57
K5	Building resilient infrastructure is necessary for sustainable development.	1.40 (0.53)	2496	0.98	0.62
Environmental items					
K6	Sustainable development requires a shift to renewable natural resources.	1.41 (0.57)	2488	0.97	0.63
K7	Marine pollution and overfishing are threats to sustainable development.	1.30 (0.53)	2506	0.98	0.72
Social items					
K1	For sustainable development, major infectious diseases such as HIV/AIDS and malaria must be stopped.	1.64 (0.72)	2364	0.89	0.49
K4	Reinforcing girls' and women's rights and increasing equality is necessary for sustainable development.	1.41 (0.58)	2480	0.97	0.63
Global-partnership items					
K8	Sustainable development requires global partnership.	1.27 (0.48)	2494	0.99	0.75

Note: For the convenience of presentation, the narrative of questions shown in the table are the questionnaire for secondary-school students and the questionnaire for primary-school students was modified by teachers. The valid entries excluded respondents who chose don't know option; the valid entries are group-calculated mean values. The entries of the percentages in columns 3 and 4 are the full sample.

In addition to that, the results show that, generally, students have better knowingness of the planet content domain than the people or prosperity content domains. For item K6 and K7, which are from the planet domain, 72% and 63% of the students strongly agree with the statement separately. As for the items from the other two domain, for example, item K1 and K2, only 49% and 45% of the students gave the strongly agree answer, and these two were also the questions that most students expressed that they do not know. There were 184 and 128 students expressed that they do not know whether these two items were the content of SD.

4.2. Attitude

Results in Table 3 show that students held favorable attitudes towards SD. The mean values of the attitude items are less than 2 and more than 90% of the students agree or strongly agree with the items except one inverted item, A2. Almost all students (99%, n = 2548) have affirmative attitude (agree and strongly agree) towards item A1, A9, A7 and A8, and, correspondingly, the mean values of these items are, separately, the lowest. The same with knowingness, two out of four (A8, A9) of these items were the issues in the planet domain. However, in general, students show a positive attitude towards SD, the differences only varied within the agree section.

Table 3. Students attitudes regarding sustainable development.

		Mean (SD)	Strongly Agree and Agree	Strongly Agree
No.	**Item**	**(1)**	**(2)**	**(3)**
Economic items				
A3	When I see the poor conditions that some people in the world live under, I feel a responsibility to do something about it.	1.59 (0.60)	0.96	0.46
A4	I think it is right to boycott companies that are known to provide poor workplace conditions for their employees.	1.46 (0.61)	0.96	0.59
Environmental items				
A8	I think that it is important to take measures problems which have to do with climate change.	1.34 (0.52)	0.99	0.68
A9	I think destruction of the environment is a threat to biodiversity.	1.27 (0.48)	0.99	0.74
Social items				
A1	I think everyone must have the access to clean drinking water.	1.25 (0.46)	0.99	0.76
A6	I think floating people should have all the same rights as the local people.	1.50 (0.59)	0.96	0.55
A7	I think good education is important to everyone.	1.28 (0.50)	0.99	0.74
Global-partnership items				
A2	I think my behavior have *no* impact on people from other countries.	2.16 (0.96)	0.62	0.31
A5	I can do something about the problems of the world.	1.70 (0.64)	0.92	0.40

There are some ceiling effects related to the attitude items, due to social desirability bias, which results in deviation from the true results. The presence of ceiling effects in attitude measurements has been discussed in several studies [39]. Therefore, the frequencies of strongly agree may present a more realistic result. Only 55% (n = 2548) strongly agree that floating people should have all the same rights as the local people. It is contradictory to the result that 74% (n = 2548) strongly agree that good education is important to everyone.

For the negative item A2, only 38% (n = 2548) of the students thought their behavior had an impact on people from other countries. This indicates how students reflect on their own role in global society. Most students did not see themselves as connected to the global community nor feel a sense of responsibility for others [40]. We also think that the result is partially because of students not reading the questions carefully, perhaps even unconsciously ticking.

4.3. Behavior

Results in Table 4 show that students were most likely to report that they take actions concerning environmental protection. Emissions-reducing behaviors were almost the most important aspects of individual environmentalism. Similar to the findings of knowingness and attitude, the top three most common actions (B7, B1, B9) are still related to environmental issues.

Table 4. Students behaviors regarding sustainable development.

No.	Item	Yes (%)	No (%)	N
B1	I reduce the energy I use at home (e.g., by turning the heating down or turning the air conditioning up or down or by turning off the lights when leaving a room) to protect the environment.	2489 (97.68)	59 (2.32)	2548
B2	I choose certain products for ethical or environmental reasons, even if they are a bit more expensive.	1969 (77.28)	579 (22.72)	2548
B3	I report environment and social issues to mayor's hotline, or on government websites and internet.	813 (48.95)	848 (51.05)	1661
B4	I keep myself informed about world events via TikTok or Weibo.	2355 (92.43)	193 (7.57)	2548
B5	I would *not* boycott products or companies for political, ethical or environmental reasons.	1150 (45.13)	1398 (54.87)	2548
B6	I participate in activities promoting equality between men and women.	2385 (93.60)	163 (6.40)	2548
B7	I participate in activities in favor of environmental protection.	2504 (98.27)	44 (1.73)	2548
B8	I regularly read websites on international social issues (e.g., poverty, human rights).	1867 (73.27)	681 (26.73)	2548
B9	Where possible, I choose to cycle or walk when I'm going somewhere, instead of travelling by motor vehicle.	2361 (92.66)	187 (7.34)	2548
B10	I advise others to make lifestyle choices which are good for their health.	2286 (89.72)	262 (10.28)	2548
B11	Where possible, I order takeout without disposable cutlery	2278 (89.40)	270 (10.60)	2548

Note: Sample size of B3 was 1661 as that item B3 was designed for secondary-school students only; primary-school students did not need to answer this question.

In addition, above 90% students reported Yes to B6 (93%) and B4 (92%). Including item B7, B1 and B9, above, these actions are those that are either the easiest and most common actions (such as B1), or those that investigated the willingness to take rather than the real behavior. This is perhaps the reason why these items have higher participation rates.

The least common action among students was B3 (49%) (only for secondary-school students). The least common action is what requires active participation or involves forms of active citizenship that adolescents may not be familiar with or that require time and effort. In addition, the results of B2 and B5 indicate that, when regarding financial commitments, students' willingness to take action reduced.

4.4. Self-Efficacy

When students have greater confidence in successfully completing a task, they are more likely to set difficult and challenging targets, put in more effort, and are more likely to persevere in face of failure. Conversely, students who lack self-efficacy may perceive that putting more effort into a task is a waste, which, in turn, may reduce their motivation to persevere and make them less likely to succeed.

Figure 3 showed the self-efficacy of secondary-school students. Self-efficacy questions require students to master environmental, social and economic knowledge. Students may be more familiar with topics widely covered by the media or ongoing events, such as carbon dioxide and global warming, as well as the impact of the COVID-19, than the topics that require specific knowledge. Of course, these questions only reflect the self-

efficacy of students, but do not really reflect their knowledge reserves or problem-solving competences. For example, although a high proportion of students thought they could explain the impact of carbon emissions on global warming, how they explained it and how deeply they explained it were not reflected by the questions.

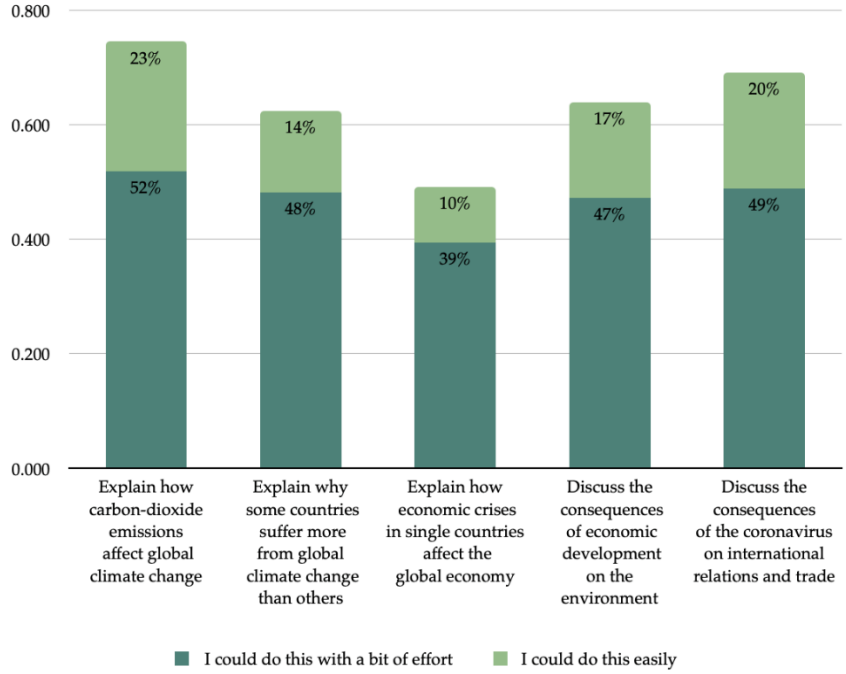

Figure 3. Self-efficacy of secondary-school students.

4.5. Heterogeneity Analysis

In addition, we tried to describe the KAB of students at different school ages and whether there were differences in those of students by gender, as emphasized in the literature. Since the items in the behavior subsection for primary-school students had one less than for secondary-school students (B3), we used the percentage of the number of completed behaviors. As indicated in Figure 4, primary students showed relatively better sustainability literacy. Their mean values of knowingness and attitude were lower than middle-school students and high-school students, and they completed more behavior items. However, the difference between middle-school and high-school students is not that obvious.

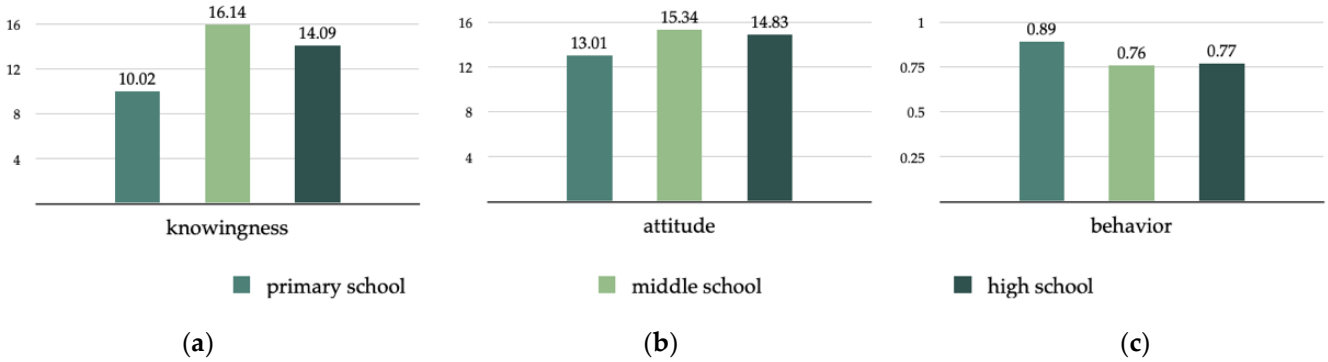

Figure 4. Students' knowingness, attitude and behavior of different school level. (**a**) Students' knowingness of different school level; (**b**) Students' attitude of different school level; (**c**) Students' behavior of different school level.

We also similarly described the differences between students of different genders, as presented in Figure 5 and Table 5. In general, male and female students did not show significant differences in sustainability literacy. However, the results of our analysis showed that there were significant differences in the responses of male and female students on some items. For example, in the Knowingness dimension, male students were more aware of the role of ending hunger (K2) and poverty (K3) in SD ($p < 0.01$ and $p = 0.04$). While, for item K4, female students scored significantly lower than males ($p = 0.01$). In the Attitude dimension, in terms of "planet" and "global partnership", female students had more positive attitudes than male students. From the specific items, regarding the rights of individuals to obtain clean drinking water (A1) and good education (A7), the overall attitude of female students was "strongly agree", and the score was significantly lower than that of male students ($p = 0.02$ and $p = 0.01$). In items of climate and biodiversity (A8, A9), the attitudes of female students were also more positive than that of male students ($p = 0.02$ and $p = 0.07$). In the behavior dimension, male students may be more concerned about social issues, where more male students reported that they keep themselves informed about world events (B4).

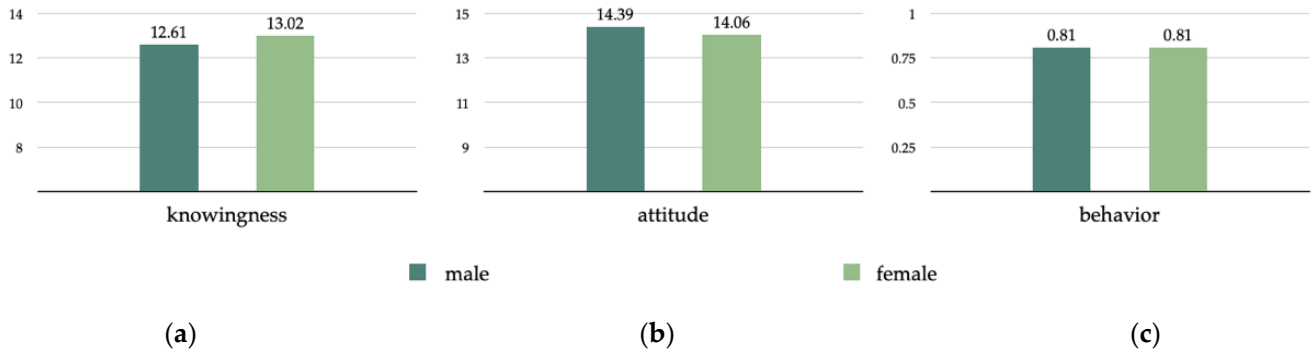

Figure 5. Knowingness, attitude and behavior of male students and female students. (**a**) Knowingness of male students and female students; (**b**) attitude of male students and female students; (**c**) behavior of male students and female students.

Table 5. The differences in knowingness, attitude and behavior of male students and female students.

	(1) Female		(2) Male		(1)–(2)	
	Mean	**N**	**Mean**	**N**	**Mean Difference**	***p*-Value**
Knowingness						
K1	1.72	1239	1.55	1125	0.17	<0.01
K2	1.79	1264	1.64	1156	0.15	<0.01
K3	1.50	1312	1.45	1185	0.05	0.04
K4	1.38	1315	1.44	1165	−0.06	0.01
K5	1.40	1320	1.39	1176	0.01	0.69
K6	1.42	1309	1.39	1179	0.04	0.10
K7	1.27	1324	1.34	1182	−0.06	<0.01
K8	1.26	1311	1.28	1183	−0.02	0.27
Attitude						
A1	1.23	1344	1.28	1204	−0.04	0.02
A2	2.25	1344	2.06	1204	0.19	<0.01
A3	1.59	1344	1.59	1204	−0.01	0.77
A4	1.46	1344	1.45	1204	0.01	0.70
A5	1.70	1344	1.69	1204	0.00	0.94
A6	1.51	1344	1.49	1204	0.02	0.34
A7	1.26	1344	1.31	1204	−0.05	0.01
A8	1.32	1344	1.37	1204	−0.05	0.02
A9	1.25	1344	1.29	1204	−0.03	0.07

Table 5. *Cont.*

	(1) Female		(2) Male		(1)–(2)	
	Mean	**N**	**Mean**	**N**	**Mean Difference**	***p*-Value**
Behavior						
B1	0.97	1344	0.98	1204	−0.00	0.45
B2	0.76	1344	0.79	1204	−0.03	0.08
B3	0.46	910	0.52	751	−0.06	0.02
B4	0.93	1344	0.91	1204	0.02	0.08
B5	0.42	1344	0.48	1204	−0.06	<0.01
B6	0.95	1344	0.92	1204	0.02	0.02
B7	0.99	1344	0.97	1204	0.02	<0.01
B8	0.71	1344	0.76	1204	−0.05	0.01
B9	0.92	1344	0.93	1204	−0.01	0.15
B10	0.89	1344	0.90	1204	−0.01	0.45
B11	0.88	1344	0.91	1204	−0.02	0.04

4.6. Relationships between Knowingness, Attitudes and Behaviors

Based on the findings of the three subsections of knowingness, attitudes and behavior, and using the data from the present study, we made an attempt to explore the relationships and the factors that related students' SD behaviors. We added up the scores of each respondent in the three subsections, and used OLS regression to roughly investigate the relationships between knowingness, attitudes and behavior. As mentioned above, adding up respondents' scores was not the best approach, but it could give us some evidence of correlations between variables. In the regressions, we also included some control variables obtained in the survey, including *gender* (dummy, 1 if female), *hukou* (household type; dummy, 1 if urban), and *medu* (highest education of mother; dummy, 1 if bachelor's degree or above). The regression results are shown in Table 6. In Table 7, we examined the above correlations by school level.

Table 6. Factors related to behaviors regarding sustainable development.

Variable	**(1)**	**(2)**	**(3)**	**(4)**
Knowingness	−0.065 ***		−0.035 ***	−0.028 ***
	(0.005)		(0.006)	(0.006)
Attitudes		−0.127 ***	−0.095 ***	−0.093 ***
		(0.008)	(0.009)	(0.009)
gender				−0.025
				(0.047)
hukou				0.085
				(0.062)
medu				0.222 ***
				(0.055)
c	9.441 ***	10.506 ***	10.398 ***	10.163 ***
	(0.067)	(0.119)	(0.118)	(0.141)

Note: *** $p < 0.01$; standard errors are reported in parentheses.

Table 6 shows that, when no control variables are included, results show that knowingness and attitudes are correlated with behavior at the 1% significance level. The results are robust after adding control variables. The findings support the conclusion that there is a correlation between SD behaviors and SD knowingness and SD attitudes. In addition, the estimated coefficients of control variables indicate that the higher the mother's education level, the better the individual's SD behavior. Table 7 shows that there is a stronger correlation between primary-school students' SD knowingness and SD behavior (the absolute values of the *knowingness* in columns 3 and 4 are significantly larger than those in columns 7 and 8), and there is a stronger correlation between secondary-school students' SD attitude and SD behavior (the absolute value of the *attitude* in column 6 is greater than that in column 2,

and the *attitude* coefficients in columns 7 and 8 are significant, while the coefficients in columns 3 and 4 are not significant).

Table 7. Factors related to behaviors regarding sustainable development grouped by school level.

Variable	Primary School				Secondary School			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Knowingness	−0.049 ***		−0.044 ***	−0.040 ***	−0.053 ***		−0.024 ***	−0.023 ***
	(0.009)		(0.012)	(0.012)	(0.007)		(0.007)	(0.007)
Attitudes		−0.049 ***	−0.009	−0.011		−0.131 ***	−0.114 ***	−0.113 ***
		(0.127)	(0.016)	(0.016)		(0.011)	(0.012)	(0.012)
gender				−0.099 *				0.009
				(0.058)				(0.066)
hukou				0.956 ***				0.012
				(0.370)				(0.072)
medu				0.067				0.266 *
				(0.060)				(0.101)
c	9.432 ***	9.584 ***	9.509 ***	8.548 ***	9.165 ***	10.352 ***	10.444 ***	10.378 ***
	(0.094)	(0.168)	(0.168)	(0.406)	(0.103)	(0.169)	(0.171)	(0.189)

Note: * $p < 0.1$, *** $p < 0.01$; standard errors are reported in parentheses.

5. Discussions and Conclusions

5.1. Sustainability Literacy

The study indicates that environment issues still receive more attention from students than the social and economic domains. Top-ranked responses were to statements directly or indirectly related to the environmental dimension. In the Chinese context where the study was conducted, it is no surprise that students showed a high level of SD concerns, since environmental education and sustainability education had a long history in the Chinese education system. The initial education for SD in China was generally equivalent to environmental education. Since 1996, Green School has been developed in most areas of China [41]. Even not in China, for many education systems, there is little or no difference between ESD and environmental education [9], where students are taught lessons related to energy conservation and nature protection. Even if environmental education is not the main cause, there are normative influences that shape students' attitudes and behaviors. Conservation is a virtue of the Chinese people. In addition, the Chinese traditionally attach great importance to the harmony between man and nature in culture; hence, protecting the environment has always been advocated. Students also might interpret SD as an environment-related concept [6]. However, this is not to imply that the increased focus on environmental issues is unique to Chinese students. Previous studies also found similar results across countries and areas. Concern for the environment is also strongly emphasized in western European societies [6].

In addition, we observed individualistic tendencies among the students. For the top-ranked item A1 and item A7, we use everyone in both sentences to demonstrate that it is the right for everyone to have the access to clean drinking water or good education. The issues involve everyone, especially the students themselves. We assume the commonality of the two items led to the similarly high positive answers. More evidence appears when comparing with item A6. Since, in China, education resources and medical care is unequal among urban residents and migrant workers, it is important to ensure that floating people have the same access to good education. The result is contradictory, as most of the students agreed that good education is important for everyone. The one possible reason is that, when its comes to issues that involved the respondent his/herself, they might give the more affirmative answer. In addition, a significant number of students did not seen their influence on other people around the world. Individuals with a greater sense of personal responsibility are more likely to have engaged in sustainability-responsible behavior [42]. Otherwise, they may have little faith about their behavior making a change to the world, causing barriers to motivating actions.

5.2. Differences in School Level and Gender

As the results indicated, primary-school students were a little better at sustainability literacy than secondary-school students. One speculation is that secondary-school students are more cautious and prefer to use very strong expressions (e.g., strongly agree) less, compared to primary-school students, for the reason that the differences are not between agreement and disagreement, but the degree of agreement (disagreement). In addition, for behaviors, the yes–no options which led social-desirable answers may have more impact on primary-school students than secondary-school students. However, it is important to be aware that there are still possibilities that individuals may become less enthusiastic about SD with age. This decline may come from their more selfish thinking and more realistic constraints, which also means that ESD needs to be strengthened at all ages, especially at the level of lifelong learning.

The results of the differences between male students and female students suggest that, in general, male students gave more credit to the social domain and female students care more about environmental issues. These are consistent with previous studies [25,26]. However, not all the responses support the conclusion, which means the gender differences in the KAB of SD in the previous literature were context dependent.

5.3. Relationships between Knowingness, Attitudes and Behaviors

The existing studies hardly support the existence of causal relationships between SD knowledge, attitudes and behaviors. Increases in knowledge and awareness do not necessarily lead to sustainable behaviors. Individuals may acquire knowledge, understanding and skills but still lack the disposition to use them. A strong environmental concern can be overcome by stronger desires and needs [43]. To cease the gap between attitude and behavior, it is important to unravel what causes the gap. Apart from that, many factors not included in this study presumably play important roles. Fang et al. (2018) questioned the focus on knowledge transfer in education as the only way to increase environmental action [8]. Individuals may also be hindered by psychological barriers that impede behavioral choices, such as limited cognition about the problem, and positive but inadequate behavior change [44]. Ignorance can be a barrier to action in two general ways: not knowing a problem exists and not knowing what to do. In the present study, a few respondents chosen the "don't know" option of the question in the subsection of knowingness, and there are possibilities that these students care less about SD.

It does not mean that behaviors can only be changed through personal efforts. Gifford (2011) expounded that there were structural behavioral barriers beyond an individual's reasonable control [44]. Ensconced habits do not change without a substantial push; even attitude change often does not lead to behavioral change. Social and institutional constraints can prevent individuals from acting sustainably [45]. For example, many proenvironmental behaviors can only take place if the necessary infrastructure is provided (e.g., recycling, taking public transportation) [43]. Economic incentives can also influence individuals' behavioral decisions. However, it is important to note that economic factors are intertwined with social, infrastructural, and psychological factors [43]. Ways to lower behavioral barriers include education which gives students knowledge of issues and knowledge of action strategies, and gives students more opportunities to develop behavioral habits, etc. Norms are also cited as a potential force for progress in SD issues. However, some internal factors cannot be changed. Issues related to sustainable development are so complex, which calls for more research to be carried out.

5.4. Limitations

The present study has certain limitations. First, the sample in our study is not representative of Chinese students. In addition, as previously mentioned, the data we collected were from a self-report questionnaire. However, the basic individual's tendency to present oneself in the best possible light, which is known as the social desirability bias, can significantly distort results [37]. Respondents measure themselves against a social norm,

and, therefore, answers generally contain a component of social desirability which makes respondents agree to a greater extent than is the case for their actual beings.

In addition, the attitudes measured in this study were much broader in scope than the behaviors measured. This may result in the weak correlation between attitudes and behaviors among students. However, it is difficult to make choices of whether research should be applied more narrowly to target attitude measurements, since this may lose information when measure attitudes toward particular issues. After the study was carried out, we found that there were inconsistencies in the narrative of the items in the attitude construct. This inconsistency may result in not all the items perfectly measuring attitudes regarding SD. For example, item A5 seems to also measure self-efficacy, and the variance between responses can be explained by this, to some extent.

Experimental studies have shown that people may engage in behaviors for limited times. We measured whether respondents have performed those acts, but what has not been solved is the mystery of the frequency and intensity of the behaviors. In addition, this made our findings about behaviors less convincing. Future research could focus on the frequency of behaviors and more accurately measure individual behaviors of SD.

On the other hand, the questionnaire content is of great relevance when performing studies. The items we have chosen in the KAB questionnaire were relatively broad. Research in the future could also focus on more specific and targeted issues, for instance, types of pro-environmental behaviors (e.g., environmental activism, consumer behaviors, non-activist political behaviors, etc.).

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