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Article

Research on interdisciplinary project-based geography fieldwork in education for sustainable development

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Abstract: The ability to solve real-world problems for a sustainable future has become a worldwide consensus, and interdisciplinary competencies and project-based learning (PBL) have become the focus of curriculum reform in China. This study investigates the effectiveness of interdisciplinary PBL fieldwork in geography education for sustainable development, focusing on the perceptions of students from a junior high school in Chongming, Shanghai, of the interdisciplinary effectiveness of PBL fieldwork. Over a one-month pilot program, the results suggest that the new fieldwork approach did not achieve the expected benefits. The significant gains of students can be grouped into four perspectives, namely, understanding of nature and classroom knowledge; problem-solving skills and environmental action; scientific spirit, environmental awareness, and interest in geography; and understanding of local needs and sustainable development issues, which increased their interest in learning. The students generally accepted the ability to collect information and data and the thinking ability of circular development. The influencing factors of activity effectiveness include the time and difficulty of the activity, cognitive and knowledge levels, learning habits of students, student participation, and teaching experience of teachers. The study offers valuable insights for improving fieldwork in other regions and for future research.

Keywords: junior high school; empirical research; PBL

1. Introduction

Societies across the globe are facing new challenges that are emerging from quickly advancing technology and globalization. To achieve a sustainable future, individuals need to learn how to understand the complex world in which information from several disciplines must be integrated [1].

Interdisciplinarity is a key solution and approach to sustainable development (SD) [2,3] in the scientific sustainability community, which only focuses on the environmental pillar. As an area of study, geography is more suitable for sustainability education because it encompasses the social and economic pillars of sustainability [4]. A widespread recognition of the major contribution of geography teaching to education for sustainable development (ESD) exists [5–7] as stemming from the human-environment relationship [8,9] and the interdisciplinary nature of the discipline [8,10–12], which stresses synthesis [13].

Importantly, fieldwork as a pedagogy in geography is imperative for sustainability education [14], because it fully corresponds to the facets of ESD [10]. Local fieldwork helps students understand SD better [15]. Fieldwork provides many opportunities for ESD, enabling students to see the real world in a more

comprehensive and holistic way and to actively participate in and influence the environment [14].

However, a lack of awareness exists about inter-subject integration among secondary school teachers in China, and cross-learning exchanges among teachers from different disciplines are rarely conducted [16]. In addition, interdisciplinary geographic fieldwork and research on ESD is scarce due to the influence of security, COVID-2019, and other factors. In the new round of curriculum standard revision in China, the Compulsory Education Curriculum Plan stipulates that each discipline should use no less than 10% of its total class hours to conduct interdisciplinary theme learning (fieldwork) activities [17]. At the same time, the geography standard suggests that project-based learning (PBL) should be utilized in conducting fieldwork, proactively breaking down disciplinary barriers, designing and organizing geography practice activities based on discipline integration as much as possible, and improving the ability of students to learn multidisciplinary knowledge and solve problems in the real world [18]. This aspect provides geography with increased opportunities for developing fieldwork for SD.

Interdisciplinary PBL, as a new method of fieldwork in China, remains unclear in terms of the type of knowledge learners obtained or the changes in their attitudes through this mode of fieldwork. Although the perception of usefulness is important for students in opting to study a subject further [19].

Shanghai Chongming Island is rich in ecological resources. Taking a junior high school in Chongming District, Shanghai, as an example, this study has a representation of junior high schools in rural areas of Shanghai. The study was taken in 2022. It investigates the current status of the existing geography fieldwork, helps improve and design teaching models, and conducts exploratory experiments. This study pays special attention to the perceptions of students of the effectiveness of interdisciplinary PBL fieldwork. Specifically, it intends to answer two questions by exploring the views and attitudes of students toward interdisciplinary PBL fieldwork as follows.

1) What are the achievements and problems of geography fieldwork in the pilot school?
2) What are the perceptions of the students about the usefulness of interdisciplinary PBL fieldwork?

Following this introduction, the study briefly discusses theories and the research status of PBL that informed the pedagogy design. The authors then describe the context of regional sustainability and introduce the evolution of the project design, including investigation, project duration, and process. After the geographical fieldwork, the Q-methodology, which was used for assessment, was used to investigate the gains and existing problems of the students and to analyze the reasons and factors that influence the effectiveness of the activity. Finally, the authors provide results and discussions that highlight opportunities and suggestions for interdisciplinary PBL fieldwork.

2. Literature review

Interdisciplinarity is not a new phenomenon, as it dates back at least to the

1950s [20]. Mansilla [21] defines interdisciplinary learning as a process by which "learners integrate information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines to craft products, explain phenomena, or solve problems in ways that would have been unlikely through single-disciplinary means."

The value of interdisciplinarity in ESD is largely taken for granted due to the inherent complexity and uncertainty of SD issues [21–26] and the recognition that a single way of knowing is insufficient for understanding the complexity of the world. Interdisciplinary student teams are superior to mono-disciplinary programs [27,28].

The subject of geography is more willing to draw on concepts and techniques from neighboring disciplines, which lends itself to interdisciplinary learning. Geographers are more open to interdisciplinary work compared with those from other disciplines because they more readily absorb ideas and techniques from neighboring intellectual territories [29].

Moreover, ESD should be taught through fieldwork in geography, which goes well with ESD [14] in terms of inquiry-based pedagogy [10] and enables an observation of nuanced real-world solutions [4]. Fieldwork reflects the pedagogical concepts of learning by doing and learning from experience, inspired by the work of John Dewey and Jean Piaget, among others [30,31].

Numerous studies suggest that students benefit from fieldwork across dimensions [4,32–44], such as practical skills, transferable and social skills [44], independence [45], connection of knowledge inside and outside the classroom, opportunities for solving problems, interest in other local topics, improved attitudes of students toward geography, and increased self-confidence. However, several barriers to fieldwork influence the conduct of fieldwork, including difficulty in assessing student learning [46].

In the centralized curriculum in China, fieldwork has remained underdeveloped over the past decades. A few fieldworks have been conducted prior to 2000, and the majority of secondary schools lacked fieldwork or conducted only one or two off-campus fieldwork during secondary education [15]. However, geographic practice has become one of the four core competencies after the revision of the curriculum standards for geography in high school. Meanwhile, an increasing number of schools have developed top-level geographic fieldwork and achieved corresponding research results due to the national emphasis on travel study. From 2015 to 2022, as many as 3412 papers in China were searched using the keywords geography and fieldwork in China National Knowledge Infrastructure. Those papers explore the strategies for developing practical power and case design from the perspective of geography [47–51].

Although different methods, such as field excursion, field research, and inquiry-based fieldwork, are used to support sustainability education [52], few middle schools in China organize fieldwork. Many of these fieldworks were conducted as teacher-led projects or Cook's tours, as classified by Kent et al. [53]. For this reason, students are not deeply engaged in fieldwork.

As a project approach for engaging students in hearty and purposeful activities, Kilpatrick [54] first introduced PBL, which was further developed by Blumenfeld et al. [55]. The authors define PBL as a pedagogy that entails two components: "a

question or problem that serves to organize and drive activities; and these activities result in a series of artifacts [56] or products that culminate in a final product that addresses the driving question" [55]. Compared with problem-based learning, the uniqueness of PBL lies in the construction of an end product [55], which represents the new understanding, knowledge, and attitude of students regarding the issue under investigation. These issues are frequently presented using videos, photographs, sketches, reports, models, and other collected artifacts [57] and multimedia mini-documentaries [58].

PBL is an active student-centered pedagogical method [59] that has been used from basic to higher education [60]. As fieldwork, PBL has been called an action-oriented strategy for fostering environmental and sustainability competencies [61–63]. A few studies conclude that PBL is less demanding than traditional teaching, can be implemented using a few resources, and is within the allocated time for studying particular topics [64].

The majority of PBL in ESD studies focus on higher education, such as engineering education [65]. A few studies suggest that PBL holds the potential to help students in different aspects [66], such as the development of critical thinking [67], collaboration skills [68], argumentation skills [69] and construction of knowledge [70], interest in learning [71], motivation [72], positive attitudes toward the subject [73], effective benefits [64], and academic achievement [74,75]. Alternatively, poor management, lack of supervisory support, and ineffective communication are typical barriers to PBL [76].

PBL is also used at the basic education level, such as concept maps [77], technology or online platforms [63,69,78], and qualitative and quantitative tools [72]. However, it lacks application to SD. Other scholars argue that PBL is seemingly suitable for classroom assignments related to SD [12] and that the majority of PBL is in classroom teaching. However, project-based fieldwork is more difficult not only because it is time-consuming and difficult to supervise but also because of associated resourcing problems, such as lack of equipment, and the impact of COVID-2019.

In China, certain papers and dissertations are beginning to focus on the application of PBL in geography fieldwork in secondary schools [79–87] (**Table 1**). However, the majority of graduate theses are conceived only at the theoretical level and are not implemented; thus, the effects of teaching methods are not verified. Research on implementation [88] is mostly conducted by secondary school teachers and presents an insufficient theoretical basis. Moreover, it mainly focuses on knowledge and skills related to the geography subject and establishes an insufficient connection to other subjects. As such, meeting the requirements of the current concept of interdisciplinary learning in geography in junior high school is difficult. Although studies focus on interdisciplinary implementation [16,87–90], research and practice mainly emphasize high school students and allocate few activities for middle school students.

Table 1. Advantages and disadvantages of research done about PBL in geography fieldwork.

Author (Year)	Advantages	Disadvantages
Zhang et al. (2022)	* The theory of the application of PBL in geography fieldwork in secondary schools is discussed in depth.	* They stay at the theoretical level and lacks practical implementation and there is a lack of validation of teaching effectiveness.
Huang (2018)	* PBL in geography fieldwork is implemented in secondary schools.	* Instructional design is not sufficiently connected to other disciplines and does not meet interdisciplinary requirements.
Zhai et al. (2018)	* An interdisciplinary implementation of PBL in geography fieldwork is carried out.	* They focus on high school students and neglect middle school students.

In conclusion, geographical fieldwork can be effective in supporting the goals of ESD. Currently, fieldwork, PBL, and interdisciplinary research in ESD at home and abroad are mostly concentrated in higher education and mainly highlight classroom teaching. Consequently, fieldwork in geography is missing in secondary schools, especially in junior high schools. PBL fieldwork in geography is rare and lacks interdisciplinary content, and relatively little research is conducted on the effectiveness of fieldwork models from the perspective of students [53].

3. Materials and methods

3.1. Background

Located at the mouth of the Yangtze River, Chongming Island is the world's largest alluvial island. As a low-urbanization area within the metropolitan area, Shanghai plans to transform Chongming Island into a world-class ecological island and to gradually form an ecological education system with regional characteristics.

Over the past decade, the pilot school has organized annual fieldwork trips for students, visiting sites such as Changxing Island Country Park, Chongming Dongtan Wetland, Chongming Institute of Eco-Chongming, and Dishui Lake. Affected by COVID-2019, only a few students could be facilitated in conducting fieldwork in recent years.

3.2. Materials and methods

First, through a literature review, the study aims to enhance the understanding of the current status of fieldwork, PBL, and interdisciplinary methods in ESD as well as the existing problems.

Second, the author invited junior high school students who had participated in fieldwork to provide feedback on the learning experience and prepare them for progression to a new mode of fieldwork (Appendix A). The study recruited a total of 100 junior high school students (male: 48%; female: 52%). They all participated in the fieldwork, out of which 45% participated more than three times.

The interdisciplinary PBL fieldwork is designed according to the result of the survey. Affected by COVID-2019, the study randomly selected 17 junior high students in the pilot school to organize fieldwork twice during daily teaching. The entire activity lasted for one month, and each fieldwork lasted for approximately 2 h.

At the end of the fieldwork, the 13 students were subjected to a survey designed using the Q-methodology (**Figure 1**). This survey evaluated the perceptions of the

students of the value of the activities. Q-methodology is a research technique that quantifies subjective perspectives, allowing for the identification of distinct viewpoints on a topic. The process involves participants sorting a set of statements (Q-set) according to their personal agreement or disagreement. Factor analysis is then used to reveal common perspectives among the group. Key steps include selecting relevant statements, conducting concourse sorting with participants, and interpreting the resulting factors to understand shared viewpoints. This method is particularly useful for capturing the complexity of human opinions in empirical research.

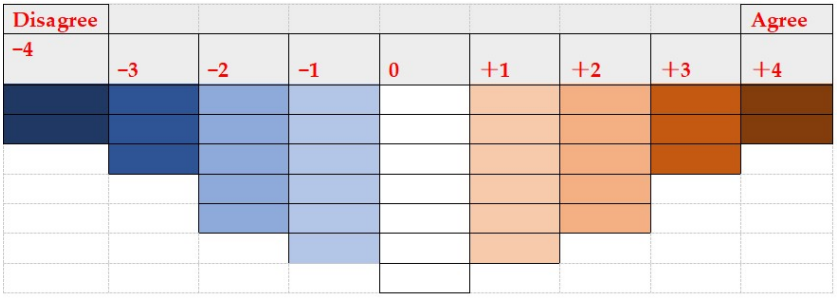

Figure 1. Q-score sheet.

In this experiment, the majority of Q statements (Appendix B) were derived from publications and assessment metrics such as the questionnaires of Kempa and Orion [91] and Chew [32]. The study supplemented only a few viewpoints by canvassing additional comments from the participants after the fieldwork. After initially eliminating statements with similar meanings, experts and peers reviewed the sample viewpoints to ensure clarity of language and that they were sufficiently comprehensive in representing the possible range of opinions. After Q sorting, the authors conducted interviews; audio data were then transcribed into word documents.

All procedures were performed in compliance with the Declaration of Helsinki and its subsequent amendments. The ethics committee of East China Normal University approved the study protocol.

4. Research analysis and design improvement

4.1. The value of geographical fieldwork is widely recognized

In general, the majority of students have basically recognized the previous fieldwork. Fieldwork can enable students to acquire substantial knowledge that is unavailable in books (Question 12), cultivate the quality to bear hardships and hard work (Question 9), and promote the cultivation of the sense of innovation and ability of students (Question 13). In addition, as shown in **Figure 2**, the biggest gain for students is the happiness of teamwork, which accounts for 27% (Question 14).

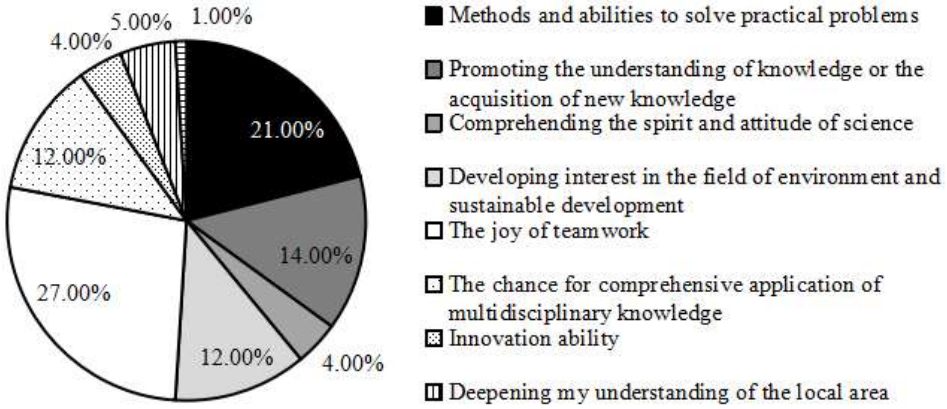

Figure 2. The most impressive advantages of fieldwork activities for students.

4.2. It significantly improves SD literacy, but economic and social themes are lacking

Through experience, 97% of the students reported that fieldwork enhanced their understanding of the relationship between humans and the natural environment (Question 11). As shown in **Figure 3**, extracurricular activities are the most important method for students to acquire knowledge about SD, which accounts for 33% (Question 18). This finding highlights the significant role of geography fieldwork in ESD.

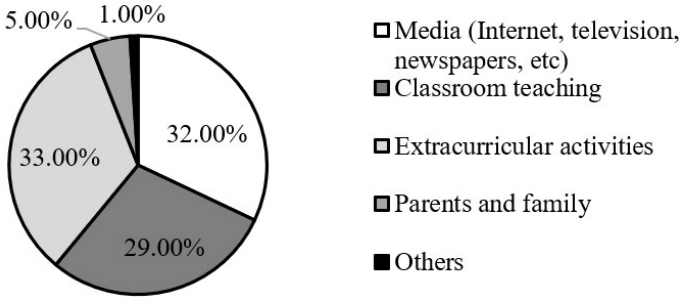

Figure 3. The main sources of knowledge about SD.

However, most SD issues are related to the ecological dimension of SD rather than the social and economic dimensions. As shown in **Figure 4**, the circular economy only accounts for 4% (Question 17). This finding indicates students who remain unable to develop a holistic understanding of the dimensions of SD or a superficial understanding of concepts beyond the environment [92,93].

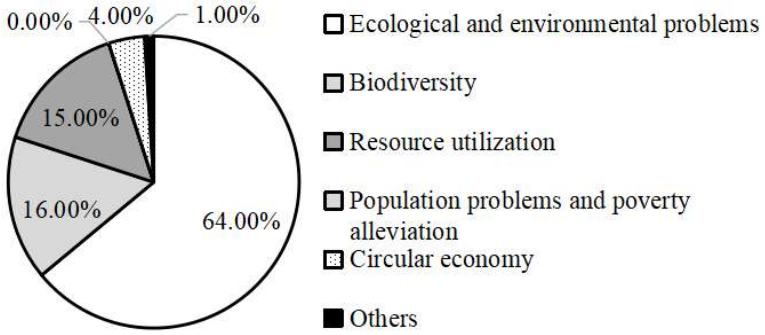

Figure 4. The issue of SD in fieldwork.

4.3. It is not closely related to classroom teaching and does not have sufficient interdisciplinary character

This aspect differs from the previous study in that examination is a factor that influences the development of fieldwork in junior high school [44]. In Question 19, the majority of students believe that fieldwork will promote the improvement of test scores (**Figure 5**). The reason may be that students only participate in fieldwork that improves their learning interest.

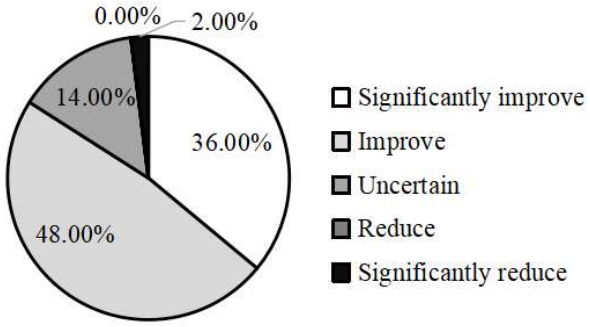

Figure 5. The influence of fieldwork on exam scores.

This is also reflected in Question 5, where approximately 15% of the students do not consider fieldwork as related to classroom content. This finding suggests that a tendency may exist to ignore classroom knowledge in fieldwork. In addition, 11% of the students remain unsure whether or not to apply knowledge from other subjects (Question 6), which indicates that the interdisciplinary content of previous geography fieldwork requires further improvement.

4.4. A room remains for further improvement in the design and methods of fieldwork teaching

Through the analysis of Question 21 using Word Cloud, we summarized the suggestions of students for improving fieldwork under the following four aspects, namely, increasing the activity and autonomy of students, innovating a method for pioneering practice activities, increasing the time and frequency of field practice, and providing more combinations of book content.

After years of fieldwork, the students recognized the advantages of geography fieldwork. However, there is still room for improvement.

a) The theme of the activity is environmental education, and more social and economic topics require discussion;
b) increasing student autonomy and the proportion of student-centered learning;
c) increasing the activity and activity time of the students; and
d) combining more class teaching contents, including those from different disciplines.

5. Improvements

Based on the abovementioned problems, the study presents the following improvement and optimization.

First, we selected an agricultural circular economy as the theme to enhance the

understanding of students about the social and economic dimensions of SD.

Second, teaching methods were improved, and the autonomy of students was increased. Prior to the fieldwork, the authors understand the existing cognitive levels of students about circular agriculture and encourage them to consult materials and select a location for fieldwork. Under the guidance of the teacher, the students finally decided to visit the Dongtan Low-Carbon Agricultural Park and the digital breeding base with fishing and light complementary in Puye Town. These two places are mainly based on the cycle process of carbon elements, which provided students with the experience of the transformation of material and energy and understanding the internal and industrial digital cycle modes in the circular economy. According to the principle of "students first" (heterogeneous within the group and homogeneous between the groups), each group consists of three to five students. They were allowed to name their groups, such as the Sunbird Team and the Kingfisher Team. Then, they are exposed to the basic situation of fieldwork through preliminary visits, family interviews, telephone interviews, and online searches.

Third, according to standards and textbooks, which are centered on geography, a geography teacher discusses with teachers from other disciplines and integrates the knowledge and thinking methods of biology, chemistry, and other disciplines in junior high school into activities (**Table 2**). The comprehensiveness of geography enables students to better understand the terrain, climate, transportation, science and technology, market, national policies, and other regional factors of the circular economy.

Table 2. The design of interdisciplinary fieldwork.

Location of fieldwork	Investigation content	Subject	Knowledge	Content standard
Dongtan Low-Carbon Agricultural Park	Traditional rice and wheat farming Traditional fruit growing Modern fruit growing Traditional irrigated agriculture Modern micro-drip irrigation agriculture Modern vegetable farming Wind-solar complementary power supply system Steam, heat, water, and fertilizer combined production system	Geography	Geographical landscape	Discuss the differences in geographical landscapes.
			Agriculture	Collect graphic and textual information on the development status of a certain industrial sector in China and emphasize the application of high and new technology in industrial development.
			Transport	Use maps to determine traffic lines and transportation hubs and discuss the relationship between the distribution of transportation network and regional economic development.
		Biology	Green plants in the biosphere	Green plants can use solar energy, synthesize carbon dioxide and water into energy-storing organic matter, and release oxygen. Plants provide many resources available to human beings.
			Humans in the biosphere	Illustrate the impact of humans on the biosphere.
			Biotechnology	Fermentation technology utilizes the characteristics of microorganisms to produce corresponding products through a certain operation process.
		Physics	Conversion and transfer of energy	Different forms of energy can be converted into each other.
		Chemistry	The air around us	Learn about the oxygen cycle and the carbon cycle in nature.
The digital breeding base with fishing and light complementary in Puye Town	Fishing and light complementary landscape Investigate the development history of Chongming Island Ecological breeding base Chongming Island meteorological disaster and its effect on fishery production.	Geography	Geographical landscape	Discuss the differences in geographical landscapes
			Industry	Present the characteristics of different industries (photovoltaic power generation) and analyze their development conditions.
			Transport	Use maps to identify transportation routes and transportation hubs and discuss the relationship between the distribution of transportation networks and regional economic development
			Environmental problems and environmental protection	Conduct practical activities on an environmental problem. Change the adverse impact of traditional aquaculture on the environment
			Natural resources and production and life	Measures for utilizing and protecting water resources
			Land and resources	A large population and less land is a basic national condition of our country
			Weather and climate	Impact of climate on agricultural production
		Biology	The survival of living things depends on a certain environment.	Provide students with information and discuss the effects of temperature, air, light, and other factors on biological life.
			People in the biosphere	Illustrate the impact of humans on the biosphere
		Physics	Transformation and transfer of energy	Different forms of energy can be converted into each other.

Fourth, the authors designed the PBL fieldwork (**Figure 6**) based on the model of PBL [94].

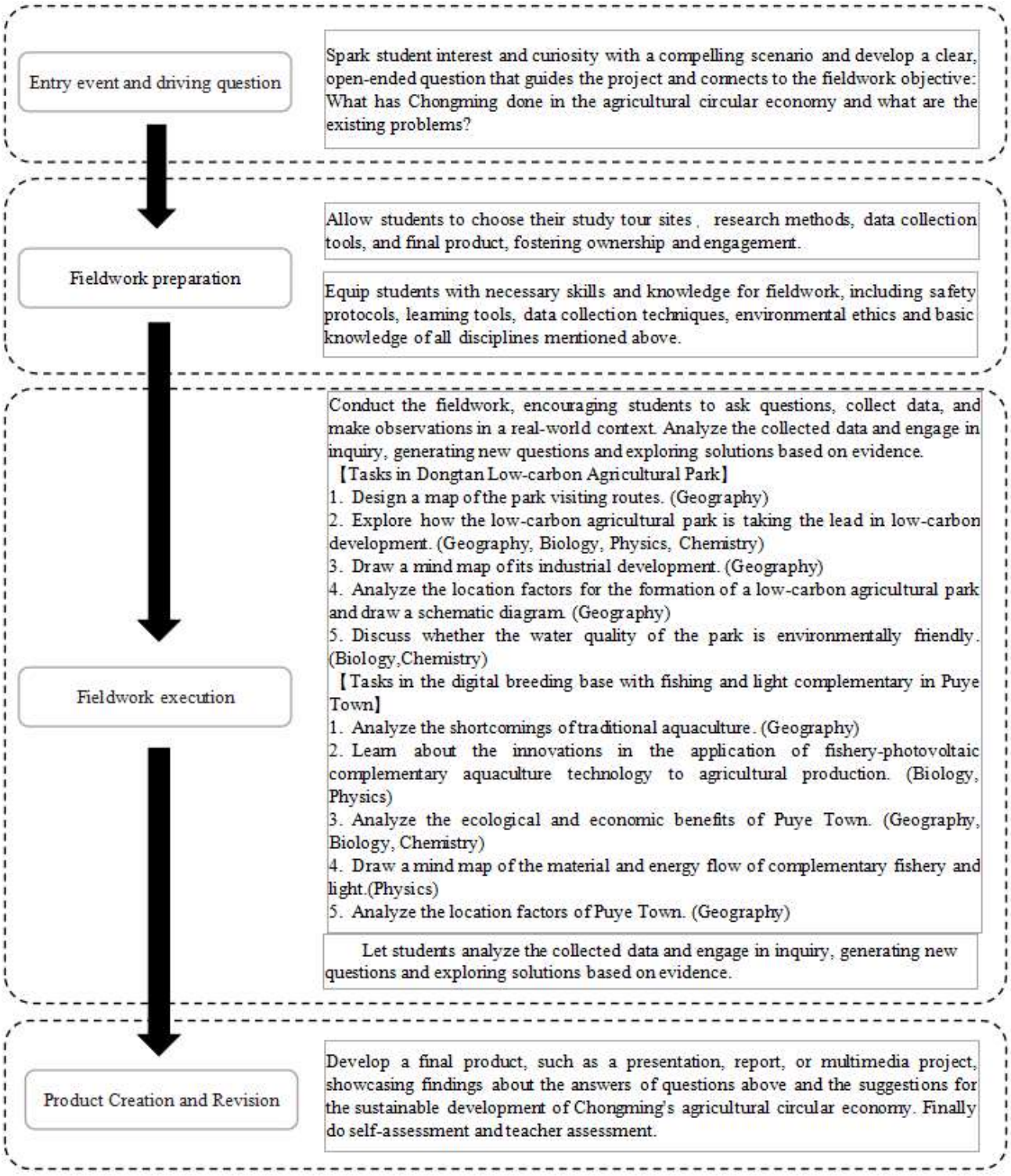

Figure 6. The design of PBL fieldwork.

Finally, students draw a mind map of the circular economy and compose an investigation report, including suggestions.

Getting started—This theme is about orienting students, that is, motivating them

to well consider the project well before they begin, providing them with a rubric that clearly explains what they are expected to search for and accomplish, and jointly agreeing on the grading criteria.

6. Results

6.1. It deepened my understanding of nature, classroom knowledge, and sustainability, but did little for high-level thinking

Four students supported this idea and displayed high levels of recognition of the value of fieldwork and its relationship with SD (**Table 3**). They believed that fieldwork brought them better appreciation of and closer to nature (Statements 2 and 3) and enabled them to gain an initial understanding of an unfamiliar landscape through careful observation. This finding is consistent with the value of geography as a discipline that tends to inspire a life-long passion for the countryside in people of all ages, an understanding of the interconnectedness of the world, and the need for the sustainable management of resources.

"Fieldwork can enable me to acquire knowledge and skills through experiments, imitation, and planting. It also increases my curiosity about everything in the world and gives me a sense of protecting nature. In outdoor practice." (Student 1)

Table 3. Top ranked statements for Viewpoint 1.

No.	Statement	Normalized factor scores	*Z*-Score
3	Better appreciate and value the beauty, delicacy of nature	+4	1.971
2	Increase my curiosity about nature	+4	1.941
4	Improve my ability to collect information and data	+3	1.451
10	Deepen my understanding of classroom knowledge	+3	1.403
18	Better understanding of the relationship among ecology, society, and economy	+3	1.230
37	By comparison, classroom teaching is more important.	−4	−2.076
28	Become aware of a few prejudices	−4	−1.551
23	Improve the integrated ability to solve local practical problems	−3	−1.409
32	The progress and development of a region should not be shelved under the pretext of protecting a few birds/animals.	−3	−1.371
31	The so-called ecological crisis facing mankind has been greatly exaggerated, and nature will be balanced over time	−3	−1.206

At the same time, students agreed with the value of fieldwork [35], which provided them with the opportunity to link knowledge in textbooks with knowledge in everyday life (Statements 37 and 10). This aspect enabled them to better understand classroom knowledge. This finding suggested that this activity can solve the problem of the insufficient application of classroom knowledge during fieldwork.

"Classroom teaching is only an objective understanding of the principle, while fieldwork is to discover the principle by hand, and both are indispensable... Fieldwork experience can effectively solute difficult problems in the classroom." (Student 2).

Statements 18, 31, and 32 clearly indicated that the activities promoted a

comprehensive understanding of SD, that is, understanding not only the consequence of the ecological environment but also the link among ecology, society, and economy from the perspective of the economic and social dimensions.

However, the students expressed that the activities did not sufficiently improve high-level thinking skills. For example, they reported no improvement in their problem-solving skills and awareness of their biases (Statements 28 and 23). This result did not fully achieve critical thinking in PBL [67]. One of the reasons is that the problem provided may be beyond the current cognitive and knowledge levels of middle school students, such as the factors of the geographic location. Another reason may be that the role of students in the group was primarily in problem-solving.

"I can only find the reason and point out where the problem is, but cannot solve it." (Student 4).

6.2. I gained a lot in terms of problem-solving skills and environmental action and a high level of acceptance of the new fieldwork approach

The students who held this viewpoint exhibited high levels of approval of the new fieldwork mode (**Table 4**). They believed that it would directly influence future behaviors such as willingness to participate in field trips and environmental activities (Statements 36–38).

"It can enhance my practical ability and broaden my horizons. At the same time, it can help me make more friends and enhance my interpersonal skills. At the same time, I can learn more extracurricular knowledge... I was really interested in this activity, but I did not realize all kinds of potential characteristics of myself... I do not think I can contribute to that, and I do not really understand it." (Student 6)

Table 4. Top ranked statements for Viewpoint 2.

No.	Statement	Normalized Factor Scores	*Z*-Score
38	I am willing to continue to participate in such field activities.	+4	2.112
36	I will actively participate in environmental activities.	+4	2.005
32	The progress and development of a region should not be shelved under the pretext of protecting a few birds/animals.	+3	1.477
23	Improve the integrated ability to solve local practical problems	+3	1.262
24	Improve my ability to cooperate and communicate with others	+3	1.262
37	By comparison, classroom teaching is more important	−4	−1.790
17	Conscious of their interests and abilities in the field of environment and sustainable development	−4	−1.477
31	The so-called ecological crisis facing mankind has been greatly exaggerated, and nature will be balanced over time	−3	−1.469
6	Improve the ability to use graphic expression	−3	−1.369
16	Improve knowledge and ability in chemistry, biology, information, and other disciplines	−3	−1.270

The students believed that practical activities can improve integrated problem and collaboration competencies (Statements 23 and 24). Both are particularly important key competencies in ESD [95]. This result demonstrated that PBL holds the potential to help students develop collaboration skills [68]. According to the

observation of the teacher, the students held this viewpoint and were more active in the problem-solving process of group cooperation.

However, the perception of students of SD in fieldwork was insufficient because they did not realize their awareness and abilities in relation to SD from the activities (Statement 17). Moreover, their understanding of SD was not holistic and required improvement (Statement 32).

Although we focused on interdisciplinary learning, students exhibited the lowest recognition of the activities in terms of enhancing their knowledge of different disciplines (Statement 16) and graphic expression skills (Statement 6). The main reason may be their inexperience in interdisciplinary teaching and learning.

"This activity shows me the ecology of Chongming, various animals, and plants. The teacher introduced many characteristics of them, but I do not think they have many relationships with the subject, especially chemistry and information, because now the breeding basically does use pesticides instead of the greenhouse. And I think biology is mainly to observe some plants." (Student 5)

6.3. I gained scientific spirit, environmental awareness, and interest in geography, but not much recognition of the teaching method

Three students expressed this viewpoint (**Table 5**); although they agreed with the fieldwork (Statement 38), they expressed negative statements about the new fieldwork mode (Statement 39). The reason may be that they felt that this teaching mode was time-consuming and insufficiently connected to classroom knowledge and learning (Statements 9 and 10). In a high culture of accountability and performance, curriculum time was frequently and exclusively focused on exam preparation. Thus, the students observed less practical values from such field practice in relation to learning during class hours.

Table 5. Top ranked statements for Viewpoint 3.

No.	Statement	Normalized Factor Scores	*Z*-Score
8	Comprehend the scientific spirit and attitude	+4	2.033
19	Improve the awareness of respecting and protecting the environment	+4	1.781
14	Increase interest in geography	+3	1.456
4	4. Improve my ability to collect information and data	+3	1.324
32	The progress and development of a region should not be shelved under the pretext of protecting a few birds/animals.	+3	1.205
37	By comparison, classroom teaching is more important	−4	−2.033
28	Become aware of a few prejudices	−4	−1.781
39	I will recommend this learning method to others.	−3	−1.708
9	Provide opportunities for using knowledge in class	−3	−1.662
10	Deepen the understanding of classroom knowledge	−3	−1.496

"The knowledge learned before fieldwork is beneficial to deepen the impression and understanding during the fieldwork. The fieldwork may take up time, affect or disrupt the plan for a period of time, or delay or reduce the study time of other subjects. Do what you can, and do not blindly recommend to others."

(Student 8).

"Different pupils adapt to different learning methods... should let them choose by themselves." (Students 9).

They most agreed with the promotion of scientific spirit (Statement 8), environmental awareness (Statement 19), and interest in the subject of geography (Statement 14). This result was consistent with those of previous studies [40–42,73]. However, similar to Viewpoint 2, the understanding of the students about the social and economic dimensions of SD is insufficient (Statement 32).

"Through fieldwork, I realized some different ways of economic recycling, thus changing my view on science and understanding the truth, attitude, and spirit of science." (Student 8).

"I met some difficulties after I got into this interdisciplinary study. I will try my best to solve them... Before this fieldwork, I was more perfunctory to geography; I felt the joy of achievement when I could pose detailed questions or complete mind maps, and I gradually became interested in geography." (Student 9).

"Through a series of studies, interactions, and activities in interdisciplinary study, I consolidated geographical knowledge and increased my interest in geography." (Student 10).

6.4. I obtained an awareness of local needs and sustainability issues and raised my positive feelings toward nature and learning

Similar to Viewpoint 1, this Viewpoint (**Table 6**) affirms that the activities can deepen awareness and positive feelings about nature (Statements 2 and 3). Students experienced the needs of the local communities and sustainability issues through the activities (Statements 20 and 22) and provided examples of sustainability issues. Students gained the opportunity to understand the community and to interact directly with community members through fieldwork. In this manner, the students became concerned with other interesting issues, which enhanced their sense of place within

Table 6. Top ranked statements for Viewpoint 4.

No.	Statement	Normalized Factor Scores	*Z*-Score
2	Increase my curiosity about nature	+4	1.891
22	Better understand the needs of local communities	+4	1.891
3	Better appreciate and value the beauty, delicacy of nature	+3	1.418
20	Explain sustainable development using examples	+3	1.418
1	Improve my interest in learning	+3	1.418
10	Deepen my understanding of classroom knowledge	−4	−1.891
9	Provide opportunities for using knowledge in class	−4	−1.891
8	Comprehend the scientific spirit and attitude	−3	−1.418
6	Improve the ability to use a graphic expression	−3	−1.418
7	Learn the methods of scientific inquiry	−3	−1.418

the site or their place of citizenship, including social responsibility [36–39]. Meanwhile, this mode can effectively enhance the interest of students in learning

(Statement 1), which is consistent with the findings that the effects of PBL include significantly increasing interest in learning and motivation [72].

> "I can learn about local needs through practical methods... It gave me an example to explain local sustainable energy." (Student 10).

This view is consistent with Viewpoint 3, which argues that fieldwork lacks the use of classroom knowledge (Statements 9 and 10) but improves scientific spirit (Statement 8) and the scientific method of inquiry (Statement 7).

6.5. Consistent viewpoints

Although the benefits differed across students, they agreed on both statements at basically the same level (**Table 7**).

Table 7. Consensus statements among four viewpoints.

No.	Statement	Viewpoint 1		Viewpoint 2		Viewpoint 3		Viewpoint 4	
		Normalized Factor Scores	*Z*-Score	Normalized Factor Scores	*Z*-Score	NormalizedFactor Scores	*Z*-Score	Normalized Factor Scores	*Z*-Score
4	Improve the ability to collect information and data	+3	1.45	+1	0.42	+3	1.32	+2	0.95
5	Improve the ability to observe, record, and analyze data	0	0.08	−1	−0.53	+1	0.5	+1	0.47
11	Understand the usefulness of book knowledge in daily life	0	0.15	0	−0.32	−2	−0.78	−2	−0.95
21 *	Shape thinking and ability in circular development	+1	0.53	+1	0.63	0	0.05	2	0.95
30	Cultivate the quality to bear hardship and hard work	0	0.02	0	−0.32	2	0.61	0	−0.00

(All listed statements are non-significant at $P > 0.01$, and those with an * are also non-significant at $P > 0.05$).

1) To a certain extent, interdisciplinary project-based fieldwork develops the ability of students to collect information and data (Statement 4).

Table 6 demonstrates that although the students possess varying degrees of recognition of this ability, an improvement is recognized. This ability is mainly obtained from preliminary visits, interviews, and online searches before fieldwork and hands-on during the fieldwork (**Figure 7**). It reflects the activities related to hands-on more easily accepted by students.

2) Interdisciplinary project-based fieldwork enhances thinking skills for circular development (Statement 21) and deepens the understanding of the students about the socio-economic dimension of SD. This result is closely related to the theme of the fieldwork. We can also note it through the circular economy mind maps which students draw from different perspectives (see attachments).

Figure 7. Collect soil and water samples.

6.6. Suggestions for improvement

To increase hands-on and experiments, "I think we can do more experiments to let more students feel the charm of geography."

7. Discussion

In teaching geography in junior high schools in China, only a few schools conduct fieldwork outside of the school setting, and even fewer attempt interdisciplinary PBL fieldwork. This is due to various barriers, including safety concerns, financial costs, teachers' heavy workloads [46], time constraints [4,96], limited parental support [97,98], and the emphasis on examinations [44].

This study made an initial attempt, and although the results were not perfect, it provided a different kind of experience and reward for the students and inspired the researchers to reflect on it.

First, although the students exhibited differences, they can all gain SD competencies. This finding indicates that students frequently gain from fieldwork. For example, a few students clearly understand the relationship among ecology, society, and economy; others are willing to participate in environmental protection activities; several agree to increase their environmental awareness; and a handful of them can explain SD using examples. However, not all students achieved a holistic understanding of SD. Although Viewpoint 1 provides a full consideration of the human dimensions of society and the economics of SD, Viewpoints 2 and 3 suggest that regional development should not be overlooked under the pretext of protecting birds and animals. Evidently, there is a natural progression to help all students achieve a holistic understanding of SD. The incremental steps in the short term will lead schools in the right direction in the long term.

Second, achieving the desired goal for all students may be challenging, especially for fieldwork, and requires sufficient time to ensure its effectiveness. The teacher organizer mentioned that students come from diverse classes, making it difficult for teachers to assess their ability to participate in PBL during the fieldwork design phase. However, achieving the teaching goal depends not only on the design but also on student participation in the teaching process. According to feedback from the teacher organizers, some students believe that "the ability to solve problems and the awareness of their own biases have not been improved." This may be due to limited time for activities, preventing students from engaging in deeper analysis and developing higher-order thinking skills. Recognizing that these abilities may not be

fully internalized after a single fieldwork experience, long-term implementation is necessary. Junior high school students should be given ample time to complete one or two tasks during fieldwork, with 20% of the time dedicated to reflection and discussion.

Third, arriving at a consensus across all viewpoints can be challenging, and reaching agreement on strongly supported and opposed statements is particularly difficult. Only two statements were largely agreed upon by the four viewpoints. For example, the students generally agreed that they had improved their ability to obtain information through activities such as surveys, interviews, and sampling (**Table 2**). Further analysis revealed that certain statements could be strongly agreed upon from two to three viewpoints. For example, Viewpoints 1, 2, and 3 all strongly agreed on the value of the field practice activity and did not consider classroom instruction as more important than field practice. Viewpoints 1 and 4 agree with the interest of students and knowledge of nature. Viewpoints 1 and 3 denied that the activity could enhance the critical thinking skills and a few of the biases of the students.

Fourth, the current finding aligns with existing research in that students' performance during practical, interdisciplinary PBL varies significantly among individuals. During the practical process, the division of labor within the group is often unclear, with one or two students taking the lead in group activities while other members participate passively or even merely observe, due to individual differences and varying degrees of project involvement. Consequently, students' sense of achievement can be polarized. For instance, a notable discrepancy was observed in the identification of improved problem-solving skills between Viewpoints 1 and 2. This difference is evident in the mind maps created by two students from the same group but representing different viewpoints. The student who made the most significant contribution to Viewpoint 2 created a mind map focused on strategies for a low-carbon agricultural park in Dongtan, Shanghai. In contrast, the student who contributed the most to Viewpoint 1 presented fragmented knowledge points. This suggests that the roles and levels of participation of the two students in the group work differed.

Fifth, the objectives of the interdisciplinary design were not sufficiently reached. This result may be related to the teaching experience of the geography teachers and the study habits of the students. Influenced by long-term sub-disciplinary teaching, the awareness of geography teachers about disciplinary integration is lacking; thus, they use traditional teaching methods. Interdisciplinarity and PBL are new methods of teaching and learning for teachers and students in junior high schools in China. Moreover, the complexity of this method influences the achievement of the desired goals to a certain extent.

Sixth, it is important to acknowledge the inherent limitations that may impact the interpretation and generalizability of the findings. Foremost among these limitations is the brief duration of the experimental period. The relatively short time frame within which the study was conducted may not have allowed for the full emergence of the long-term effects of the intervention, thus potentially underestimating the sustained impact of interdisciplinary PBL fieldwork on student outcomes. Additionally, the sample size employed in the Q-methodological analysis is notably small, consisting of only 13 students. This limited sample size may not be

representative of the broader student population, which could compromise the external validity of the study. The small sample size also means that the findings may be more susceptible to the influence of outliers or unique individual characteristics, which could affect the reliability of the conclusions drawn. Furthermore, the restricted scope of the study, both in terms of duration and sample size, may have constrained the detection of more nuanced or subtle effects of the interdisciplinary PBL fieldwork on students' learning experiences and outcomes. The complex interplay between various factors in a real-world educational setting may not have been fully captured due to these limitations. To address these limitations, future research should aim to conduct larger-scale and longer-term empirical studies. A more extensive and prolonged investigation would not only enhance the reliability of the findings but also provide a more comprehensive understanding of the multifaceted effects of interdisciplinary PBL fieldwork. Such research could explore the long-term academic, cognitive, and affective outcomes of students engaged in interdisciplinary PBL fieldwork, thereby offering more robust insights into the educational value and potential of this pedagogical approach.

As stated by one of the organizing teachers, "teachers give students more intellectual support but less support in methods and skills. Now, students attach great importance to the learning of classroom knowledge. So, I have to teach them what interdisciplinary learning is and what a mind map is."

This statement also indicates that interdisciplinary learning is mainly related to the study habits of students. A possibility exists that a few of the students, who were experiencing cognitive dissonance, were reluctant to step out of the comfort zone of the traditional single discipline of geography. Certain students familiar with uni-disciplinary teaching and learning may find that learning in an interdisciplinary manner is difficult [99]. Meanwhile, students may be unable to cope with the transition from the classic lecture format to student-centered learning techniques.

In addition, the geography teachers stated that geography is the major content on the basis of the definition of interdisciplinary curriculum standards, such that the relevant knowledge and methods of other subjects are not particularly highlighted. As the tutor said:

> "The students in the second year of junior high school have just begun to learn physics and have not yet learned chemistry; therefore, in the activity process of junior high school, teachers do not overemphasize the application of interdisciplinary knowledge, but through geographical investigation, let students subtly know some physical and chemical processes in fieldwork."

It is believed that meaningful interdisciplinary PBL is not a platter of disciplinary knowledge; instead, it is an engagement in the learning process through the authentic and meaningful exploration of problems in a manner similar to the problem-solving of adult experts. Therefore, support for students in analyzing their conceptions of disciplinary boundaries should be considered to support them in solving issues in SD. It may need more time to make students adapt to the new teaching method.

The evaluation of fieldwork is complex, which is reflected not only in the difficulty of comprehensively evaluating the operations of students comprehensively but also in the differences among students, who benefit differently from the same

activity. Moreover, the study was unable to use a uniform standard for measuring and evaluating the students. The purpose of evaluation should be to promote the better development of students, and the Q method holds a unique advantage in being able to respond well to individual differences and provide targeted measures in geography fieldwork that is organized for a small number of people.

8. Conclusion

Based on the background of global SD and China's curriculum standards for compulsory education, which emphasize interdisciplinarity, this study surveys students from a junior high school in Chongming, Shanghai, to investigate the achievements and shortcomings of fieldwork over the years. It involves designing specific activity steps with teachers, conducting these activities in the field, and innovating the teaching mode for fieldwork. The study engages students in learning knowledge and skills through an extended inquiry process structured around real-life questions and carefully designs products and tasks. Finally, the study uses Q-methodology to investigate the students' perceptions of fieldwork, explore their acceptance of this new pedagogy, evaluate the benefits gained, and verify the feasibility and effectiveness of the modified field practice approach.

The results suggest the importance of interdisciplinary learning on real-life issues. The study positively perceived the activity in terms of developing their ability to collect information and data, enhancing their thinking skills on circular development, and deepening their understanding of the socio-economic dimensions of SD. Despite the experience of these geography teachers in the field, the new field practice approach did not achieve the expected benefits, and the effectiveness of the activity varied across the students. Moreover, reaching a consensus was more difficult for the students, especially in terms of their biggest gains. The areas that some students felt they gained the most were deepening their understanding of nature and classroom knowledge, whereas others assumed that they reaped many benefits from problem-solving skills and environmental actions. Several students assumed that they gained the most from the scientific spirit, environmental awareness, and interest in geography, and others gained a deep understanding of local needs and SD issues and increased their interest in learning. Nevertheless, the study perceived a few statements as diametrically opposed to one another. The influencing factors are also multifaceted: the duration of the activity and the level of difficulty of the content, the cognitive level and existing knowledge base of the students, the participation and roles of students in the activity, the challenges and complexity of the teaching methods, the learning habits of students familiar with uni-disciplinary teaching, and the experience of the subject teachers who led the team. Thus, learning about the subject could take a long time for the students. Moreover, a longitudinal approach should be used to investigate the learning outcomes of this method.

Furthermore, the study was unable to evaluate the students using a uniform standard, but it should pay attention to the differences in the responses of individuals. The Q-method has unique advantages for practice activities in geography. The method can effectively highlight the effectiveness of practice activities from the perspective of the development and benefits of students, identify

problems in implementation, and improve field practice methods that exhibit important reference values.

As a pilot effort, this study sought to address the educational needs of problem-solving in interdisciplinary real-life scenarios. Although the students were randomly selected for fieldwork, we did not conduct a control group study. Thus, the effectiveness of the activities may vary across teachers, but continuous practice and innovation can be very helpful for the improvement of interdisciplinary learning.

Against this background, the study proposes better means for improving the organization of field practice activities, such as implementing projects with fewer tasks and time, providing opportunities for questions, reflections, and discussions as much as possible, and making use of the 20% overtime amount when designing the fieldwork. Furthermore, the study recommends the creation of a self-management culture in which the responsibility for project design and decision-making is transferred from the teacher to the students. In other words, students make decisions for themselves and are encouraged to learn how to learn.

The development and enrichment of the interdisciplinary field practice teaching model requires the ongoing efforts of educational researchers. Meanwhile, we further suggest that the curriculum content for teacher trainees in geography in university programs should not only raise their awareness of the value of interdisciplinary field activities but also provide opportunities for them to develop interdisciplinary teaching skills. This will enable new teachers to immediately apply interdisciplinary field activity instruction in secondary education. Additionally, the successful implementation of the program is inseparable from the support of school principals and other administrative personnel. They are required to formulate corresponding school regulations to ensure the safety and stability of the program and to endeavor to incorporate the achievements of interdisciplinary field activities into the evaluation systems for both teachers and students.

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Appendix A

Questionnaire

Survey on the Development of Field Practice Activities for Middle School Students

Dear students:

Hello! This study mainly investigates the successes and shortcomings encountered on fieldwork activities in secondary schools to improve the organization of field practice activities and enhance the quality of such activities. This questionnaire is anonymous and is for research purposes only. There is no right or wrong answer, so please feel free to fill it out according to the actual situation. Thank you!

1. What is your gender?
   A. Male B. Female
2. What grade are you in?
   A. 6th grade B. 7th grade C. 8th grade D. 9th grade
3. How many times have you participated in fieldwork?
   A. 1 time B. 2 times C. 3 times D. More than 3 times
4. Fieldwork makes me like geography class.
   A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
5. Fieldwork activities are closely related to classroom teaching and exam content.
   A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
6. In the fieldwork activities, the knowledge of many subjects in junior high school is used.
   A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
7. What is the extent of the difficulty of completing fieldwork activities?
   A. Very difficult B. Difficult C. Uncertain D. Easy E. Very easy
8. Fieldwork activities have improved my ability to solve real world problems.
   A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
9. Fieldwork activities have trained me to work despite difficulties and hardships.
   A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
10. Fieldwork activities have helped me to communicate with different people.
    A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
11. Fieldwork activities enable me to better understand the relationship between man and the natural environment.
    A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
12. Fieldwork activities enable me to learn more knowledge that is unavailable in books.
    A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
13. Fieldwork activities can inspire my awareness and ability to innovate.
    A. Strongly disagree B. Disagree C. Uncertain D. Agree E. Strongly Agree
14. What impressed me most about the fieldwork activities was ().
    A. Methods and abilities to solve practical problems
    B. Promoting the understanding of knowledge or the acquisition of new knowledge
    C. Comprehending the spirit and attitude of science
    D. Developing interest in the field of environment and sustainable development
    E. The joy of teamwork
    F. The chance for the comprehensive application of multidisciplinary knowledge
    G. Innovation ability
    H. Deepening my understanding of the local area
    I. Others: _____
15. What form of geography fieldwork activities would you prefer to participate in?

A.A lecture given entirely by a teacher
B. A lecture given mainly by a teacher
C. Working together to settle the assignment by the teacher and the students.
D. Mainly operated by students
E. Completely operated by students

16. What is my preferred way of evaluating fieldwork activities?
A. Teacher evaluation
B. Combination of teacher and student evaluation
C. Group members evaluating each other
D. Self-evaluation
E. No evaluation
17. In the fieldwork, I encountered the issue of sustainable development ().
A. Ecological and environmental problems
B. Biodiversity
C. Resource utilization
D. Population problems and poverty alleviation
E. Circular economy
F. Others_____
18. What are my main sources of knowledge about environmental and sustainable development?
A. Media (i.e., Internet, television, and newspapers)
B. Classroom teaching
C. Extracurricular activities
D. Parents and family
E. Others ____
19. How do I think fieldwork activities influence exam scores?
A. Significantly improve B. Improve C. Uncertain
D. Reduce E. Significantly reduce
20. Would I like to continue to participate in geography fieldwork activities as a method of learning and recommend it to others?
A. Yes B. No
21. What do you think are the shortcomings and problems in the current fieldwork activities? Please write your proposals.

Thank you again for your cooperation and support!

Appendix B

Table B1. Q statement.

	Statements
1.	Improve my interest in learning
2.	Increase my curiosity about nature
3.	Better appreciate and value the beauty, delicacy of nature
4.	Improve the ability to collect information and data
5.	Improve the ability to observe, record, and analyze data
6.	Improve the ability to use a graphic expression
7.	Learn the methods of scientific inquiry
8.	Comprehend the scientific spirit and attitude
9.	Provide opportunities for using knowledge in class
10.	Deepen the understanding of classroom knowledge
11.	Understand the usefulness of book knowledge in daily life
12.	Acquire new knowledge not taught in class
13.	Increase my knowledge and understanding of the local area
14.	Increase my interest in geography
15.	Improve my geographical skills
16.	Improve knowledge and ability in chemistry, biology, information, and other disciplines
17.	Conscious of their interests and abilities in the fields of environment and SD
18.	Better understanding of the relationship between ecology, society, and economy
19.	Improve the awareness of respecting and protecting the environment
20.	Explain sustainable development using examples
21.	Shape thinking and ability in circular development
22.	Better understand the needs of local communities
23.	Improve the integrated ability to solve local practical problems
24.	Improve the ability to cooperate and communicate with others
25.	Improve the ability for independent learning
26.	Improve system thinking
27.	Inspire innovation awareness and ability
28.	Become aware of a few prejudices
29.	Promote your independence, self-reliance and self-management
30.	Cultivate the quality to bear hardship and hard work
31.	The so-called ecological crisis facing mankind has been greatly exaggerated, and nature will be balanced over time
32.	The progress and development of a region should not be shelved under the pretext of protecting a few birds/animals.
33.	Laws and government regulation and control reduce pollution.
34.	Inspire reflection on the impact of personal behavior on the environment (normal competence)
35.	If it helps to protect the environment, I am willing to reduce consumption and not enjoy a comfortable life.
36.	I will actively participate in environmental protection activities.
37.	By comparison, classroom teaching is more important.
38.	I am willing to continue to participate in such field activities.
39.	I will recommend this learning method to others.