

Article

Place-Based Case Teaching in Economic Geography: Fostering Sustainability Competencies Through Hometown Industry Observation

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Abstract

Traditional economic geography teaching has failed to effectively help students identify the sustainable development intentions contained in industrial transformation. Sustainable Development Education (ESD) has become a key path to address this challenge, but there remains a lack of empirical exploration of how to effectively integrate ESD into economic geography courses. Therefore, this study embeds place-based teaching into the course and creates a ten-week intervention module called “Observation of Hometown Industries” at a comprehensive university in Hubei Province, China, requiring 105 second-year undergraduate geography majors to conduct field research on the sustainable transformation of local industries. Based on a mixed research design, the results indicated that the most pronounced gains occurred in students’ self-efficacy for sustainability (relative increase 20.0%), closely followed by sustainability-related knowledge and sense of place belonging (19.8%), and systems-thinking capacity (18.2%), with effect sizes ranging from 0.76 to 0.89, indicating moderate-to-strong educational relevance. Qualitative analysis further revealed that this place-based teaching approach helps students recognize the complex trade-off between economic growth, environmental conservation, and social equity in the sustainable transformation of industries. This study provides empirical evidence for cultivating key sustainable literacy in higher education and offers an operational teaching model for integrating ESD into economic geography courses.

Keywords: place-based case teaching; economic geography; education for sustainable development; higher education; industrial transformation



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1. Introduction

The United Nations’ 2030 Agenda for Sustainable Development establishes the Sustainable Development Goals (SDGs) as a guiding framework for global development. Among them, SDG 4 (Quality Education) calls for inclusive, equitable, quality education and the promotion of sustainable development [1]. In the field of higher education, a core task of universities is to equip future decision-makers and professionals with the ability to solve complex sustainable problems [2]. Education for Sustainable Development (ESD), as a systematic approach that integrates sustainable principles and practices into education at all levels, aims to cultivate key competencies such as systems thinking, anticipatory thinking, normative thinking, strategic thinking, and collaboration among learners [3–5]. However, despite the widespread recognition of ESD at the policy level, its systematic integration in higher education curricula still faces significant challenges [6].

It is important to clarify the conceptual relationship between ESD and Environmental Education (EE). While these two fields share significant overlap and are often used interchangeably in the literature, they are not identical constructs. EE is a 'hegemonic narrative' that tends to incorporate any new methods, including sustainable development education, into its theoretical framework [7]. The multidimensional nature of ESD implementation often leads to conceptual blurring between sustainability education and environmental education in policy and practice [8]. Further research suggests that environmental education is an overarching framework that incorporates the concept of sustainable development while maintaining its unique identity as a field primarily focused on the relationship between humans and the environment [9]. The fluidity of this concept has significant implications for higher education as it indicates that sustainable teaching must be professionalized rather than offered as a one-size-fits-all curriculum.

For geography majors preparing for careers in regional planning, economic development, or environmental management in higher education, they require different sustainability competencies than those studying law, engineering, or teacher education. A versatile and one-size-fits-all approach to sustainable development training, which assumes that all college graduates should receive the same sustainable development content, is neither efficient in teaching nor suitable in their profession. Sustainability challenges require the application of specialized knowledge from specific disciplines within an interdisciplinary framework. In contrast, in primary and secondary education that establishes a basic environment and civic values, universal sustainability literacy should be cultivated [10]. This viewpoint is consistent with the UNESCO roadmap [11], which emphasizes that higher education institutions should focus on cultivating advanced sustainable development skills related to students' future professional fields, rather than just replicating general sustainability awareness content.

However, existing research indicates that the implementation of ESD in higher education is generally fragmented, often limited to elective courses or isolated teaching modules, rather than systematically embedded in the core curriculum system of various disciplines [12,13]. Bibliometric analysis shows that although research on ESD in higher education is growing rapidly, empirical research at the curriculum level is still insufficient [14]. The reasons for this dilemma are multifaceted: on the one hand, subject teachers lack pedagogical content knowledge to integrate sustainable issues into professional teaching [15]. On the other hand, many teachers and students have a significant "psychological distance" towards sustainable challenges, viewing climate change as something happening in distant regions or future generations, and industrial transformation as an abstract policy issue unrelated to their own careers and life [16,17]. This psychological distance seriously weakens the potential of ESD to cultivate genuine attitudes and behavioral changes.

Place-based Education is a teaching method that embeds learning in the physical, cultural, and economic contexts where students actually live. Using it to bridge the aforementioned gap is a very effective path [18,19]. When abstract concepts are integrated into familiar hometown industry cases, it can narrow psychological distance, make learning content more relevant, increase student participation, and achieve better results [20,21]. In the field of ESD, a local approach has been shown to enhance students' participation in local sustainability issues, deepen their understanding of complex socio-ecological systems, and strengthen their sense of place and willingness to take action [22–25]. Additionally, in higher education, local ESD practices are often carried out through field visits, community cooperation, and project-based learning. Domestic research has also found that combining place-based teaching with industrial heritage and cultural background can effectively enhance learners' sustainable literacy [26,27].

Although place-based ESD research has made some progress, existing research mostly focuses on environmental science or ecology, and there are few studies that approach social sciences such as economic geography [28]. Economic geography mainly focuses on the spatial organization of economic activities, industrial transformation, and regional development, which can help us gain a deeper understanding of the economic dimensions of sustainability. Especially industrial transformation, which is closely related to SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure), and SDG 13 (climate action), economic geography can be said to have a natural disciplinary advantage in this regard [15]. In addition, place-based ESD mainly relies on on-site inspections or service learning, and the exploration of case teaching is still insufficient. Case teaching has long been proven to be an effective teaching method in the fields of business and public policy [29]. Few studies have systematically evaluated the impact of local case teaching on different aspects of students' sustainable literacy, such as knowledge, systems thinking and self-efficacy.

Based on the above analysis, it is found that the current research results lack empirical research on incorporating ESD into economic geography courses. In addition, there is insufficient exploration of case-based teaching as a teaching method in ESD that focuses on field visits or service learning, and a lack of systematic evaluation of the multidimensional impact of place-based teaching on sustainability literacy. In China, the policy framework of "ecological civilization" provides a unique policy background for the promotion of ESD. At the same time, the majority of students in universities in most parts of China come from their own provinces, which provides a natural foundation for implementing place-based teaching. In this context, this study proposes a place-based case teaching model of "home-town industry observation", aiming to answer the following two research questions: how to design place-based teaching interventions in economic geography courses to effectively integrate ESD goals? What impact does local case teaching have on students' sustainable knowledge, systems thinking, local participation, and sustainable self-efficacy?

By designing and implementing this teaching model, and using a mixed methods approach to evaluate its effectiveness, an empirical evaluation was conducted on the place-based case teaching of ESD in economic geography, providing an operational and replicable teaching model to incorporate sustainable development education into core social science courses. Based on the theoretical framework and literature review, we propose the following research hypothesis: Place-based case teaching will be associated with a significant improvement in students' sustainability knowledge, systems thinking abilities, place-based sense of agency and attitudes and sustainability self-efficacy.

2. Data and Methods

2.1. Research Participants

This mixed-methods study was designed following established methodological guidelines [30]. The study was conducted in the second semester of the 2025~2026 academic year at a comprehensive university in central China. The implementation lasted for ten weeks (a total of 70 days) and was divided into four consecutive stages. Participants were second-year geography major students from two parallel classes, with 52 and 53 students, respectively. Figure 1 summarises the demographic characteristics of the participants.

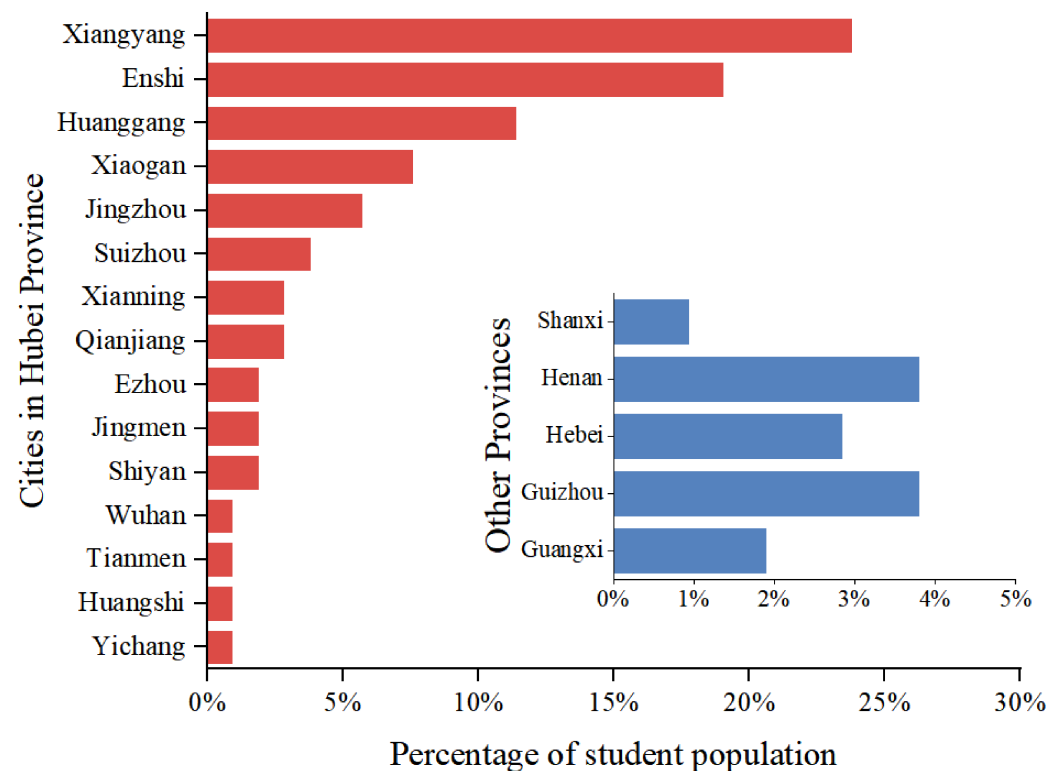


Figure 1. Demographic characteristics of participants ($N = 105$).

The institutional context is typical of many local universities in China. Most students come from the province where the university is located. This demographic structure creates both opportunities, as local knowledge brought by students can be activated as a learning resource, and challenges for students without a local background, who may feel a weaker connection to the primary case context. For students from outside Hubei Province, two options are provided: (1) choose a city in their hometown and conduct the same sustainability analysis on a local industry, or (2) compare the industry in their hometown with comparable industries in Hubei. This dual option design aims to ensure that all students can meaningfully participate in place-based learning, regardless of where they come from. In order to support non-local students, the teacher provided additional guidance in the first stage, helping them obtain statistical yearbooks and environmental reports from their hometown provinces, and provided one-on-one consultation to help them identify suitable case industries. The analytical framework for all groups (environmental, economic, social, and transformational dimensions) should be consistent to ensure comparability of learning outcomes.

2.2. Design of the Place-Based Case Teaching Model for ESD

The intervention was designed as a ten-week project organised into four sequential stages, following an action research cycle of “Plan-Act-Observe-Reflect”. The full teaching timeline is presented in Table 1.

Table 1. Intervention timeline and activities by stages.

Stages	Weeks	Teacher Activities	Student Activities	ESD Learning Objectives
Stage 1: Case preparation	1–4	Introduce ESD framework, distribute project guidelines, establish analytical framework with sustainability dimensions; administer pre-survey	Form groups by hometown (5~6 members), select local industries for investigation	Understand sustainability as an integrated economic–environmental–social framework
Stage 2: Independent inquiry	5–8	Provide guidance on accessing sustainability data (statistical yearbooks, environmental reports), conduct mid-term checks, give case-specific feedback	Collect industrial data including environmental indicators, analyse sustainability challenges and opportunities, prepare progress reports	Analyse sustainability trade-offs; develop systems thinking about industrial transformation
Stage 3: Presentation and discussion	9	Moderate presentations, facilitate peer Q&A (emphasising sustainability connections), synthesise cross-case patterns	Deliver a 5-min presentation and a 5-min Q&A; respond to peers' questions on sustainability aspects	Articulate how local industrial transformation relates to broader sustainability goals
Stage 4: Assessment	10	Administer post-survey, analyse performance on ESD-specific questions, collect qualitative feedback	Complete surveys; participate in reflective writing; submit final case analysis reports	Self-assess learning gains in sustainability knowledge and competencies

2.2.1. Stage 1: Case Preparation

This stage focused on introducing students to the ESD framework and building a resource bank of place-based cases. The teacher introduced the SDGs and key sustainability concepts: systems thinking, sustainability trade-offs, and the three dimensions of sustainable development (economic viability, environmental integrity, and social equity). Students in each class were divided into nine groups of 5~6 members, with priority given to grouping students from the same hometown or the same province to leverage shared local knowledge. The teacher constructed a case resource bank based on the distinctive industrial structure of Hubei Province, making explicit connections to ESD outcomes (Table 2). Students could choose a city in their home province for their case, and students from outside Hubei could either select a city in their home province or conduct a comparative analysis with industries in Hubei. The representative cities and their characteristic industries in Hubei Province are detailed in Tables 2 and A1.

Table 2. Six representative cases in Hubei province industries and sustainability dimensions.

Industry	Location	Sustainability Focus	Relevant SDGs ¹	ESD Competency Focus
New energy vehicle transition	Xiangyang	Transition from conventional to NEV manufacturing; emissions reduction; industrial restructuring	SDG 9, SDG 7, SDG 13	Systems thinking; strategic competence

Table 2. *Cont.*

Industry	Location	Sustainability Focus	Relevant SDGs ¹	ESD Competency Focus
Eco-industrial development (Qi'ai)	Huanggang	Transition from traditional agriculture to sustainable industry; ecological certification; rural livelihoods	SDG 8, SDG 12, SDG 15	Systems thinking; normative competence (value trade-offs)
Low-carbon tourism	Yichang	Balancing tourism growth with Yangtze ecological protection; climate adaptation	SDG 11, SDG 13	Anticipatory competence; strategic competence
Optoelectronics cluster transformation	Wuhan	Green technology innovation; energy efficiency; sustainable high-tech development	SDG 7, SDG 9, SDG 12	Systems thinking; interpersonal competence (multi-stakeholder analysis)
Hydrogen heavy-duty truck industry	Shiyan	Clean energy transport; technology diffusion and industrial location	SDG 9, SDG 13	Systems thinking; strategic competence
Selenium-rich eco-agriculture	Enshi	Eco-agriculture; biodiversity conservation; poverty alleviation in mountainous areas	SDG 1, SDG 2, SDG 15	Systems thinking; normative competence

¹ SDG 1: No Poverty; SDG 2: Zero Hunger; SDG 7: Affordable and Clean Energy; SDG 8: Decent Work and Economic Growth; SDG 9: Industry, Innovation and Infrastructure; SDG 11: Sustainable Cities and Communities; SDG 12: Responsible Consumption and Production; SDG 13: Climate Action; SDG 15: Life on Land.

The teacher developed an analytical framework requiring students to address four sustainability-related questions for each case: (1) Environmental dimension: What are the environmental impacts of this industry (past, present, and projected future)? How does the industry address climate change mitigation and adaptation? (2) Economic dimension: How does the industry contribute to regional economic development? What economic trade-offs are involved in pursuing more sustainable practices? (3) Social dimension: How does industrial transformation affect local communities, workers, and vulnerable groups? What issues emerge? (4) Sustainable transformation: What pathways exist for the industry to shift towards more sustainable practices? What obstacles and opportunities exist?

2.2.2. Stage 2: Independent Inquiry

In this stage, students independently collected and analysed data outside class. They were guided to use multiple data sources, including statistical yearbooks, government environmental reports, corporate sustainability disclosures, news reports, and, where possible, primary data from local interviews. Two dedicated guidance sessions were arranged: one on accessing and interpreting environmental data, and one on applying sustainability frameworks to industrial case analysis. The mid-term check required each group to submit a 500-word progress report summarising preliminary findings on the sustainability dimensions of their chosen case.

2.2.3. Stage 3: Presentation and Discussion

This stage was conducted in the classroom. Each group delivered a 5-min presentation structured around the four sustainability dimensions, followed by a 5-min peer Q&A. The teacher moderated the discussion, emphasising cross-case connections, such as comparing how different industries faced similar sustainability trade-offs between economic growth and environmental protection. Peer evaluation was also introduced. Each group rated the other groups' presentations based on three criteria: depth of sustainability analysis, use of evidence, and clarity of argument.

2.2.4. Stage 4: Assessment

The assessment stage used a multi-component evaluation approach (Table 3). The final case analysis report required students to synthesise their findings on the sustainability dimensions of their chosen industry and propose pathways towards more sustainable transformation. The mid-term examination included dedicated sustainability knowledge questions (10% of total score), systems thinking questions (10%), and ESD-related case analysis questions (25%).

Table 3. Course assessment components with ESD elements.

Assessment Component	Weight	ESD-Specific Elements
Mid-term progress report	10%	Identification of sustainability dimensions
Group presentation	20%	Depth of sustainability analysis; integration of economic-environmental-social dimensions
Peer evaluation	10%	Assessment of peers' ESD analysis
Data collection completeness	10%	Quality of evidence for sustainability claims
Final case analysis report	25%	Sustainability pathway analysis; stakeholder trade-offs
Mid-term exam: ESD questions	25%	Case analysis (25%), sustainability knowledge (10%), systems thinking (10%)

2.3. Instruments and Data Analysis

2.3.1. Pre- and Post-Intervention Surveys

A self-administered survey questionnaire was developed to assess changes in students' sustainability knowledge, systems thinking, place-based engagement attitudes, and sustainability self-efficacy (Appendix A). The questionnaire comprised four subscales with a total of 24 items, adapted from validated instruments in the ESD literature [12,31]. All items used a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The subscales were:

- (1) Sustainability knowledge (6 items). Assessed students' understanding of sustainability concepts, including the relationship between industrial development and environmental outcomes, climate change adaptation, and sustainable development principles. Sample item: "I understand how industrial transformation in my hometown relates to climate change mitigation."
- (2) Systems thinking (6 items). Evaluated the ability to analyse complex interconnections among economic, environmental, and social dimensions. Sample item: "I

can analyse the environmental, economic, and social implications of local industrial development trajectories.”

- (3) Place-based sense of agency and attitudes (6 items). Reflected students’ sense of connection to local sustainability issues and motivation for engagement. Sample item: “I feel a personal responsibility to contribute to the sustainable development of my hometown region.”
- (4) Sustainability self-efficacy (6 items). Showed students’ confidence in analysing and responding to sustainability challenges. Sample item: “I am confident in applying sustainability frameworks to analyse real-world industrial cases.”

The pre- and post-intervention surveys underwent validation procedures. Internal consistency was assessed using Cronbach’s α : for the pre-survey, full-scale $\alpha = 0.84$ (95% CI [0.79, 0.88]), subscale α ranged from 0.80 to 0.88; for the post-survey, $\alpha = 0.89$ (95% CI [0.85, 0.92]). These values indicated good internal consistency. Content validity was established through a review process by three experts, with two sustainability education experts and one education measurement expert. They evaluated the representativeness and appropriateness of the project, resulting in a Content Validity Index (CVI) of over 0.85 for each subscale. The structural validity was extracted using principal axis factorization method and subjected to Promax oblique rotation to obtain four factor solutions corresponding to the four hypothesized subscales, explaining 68.4% of the total variance. The loadings of each item on the attribution factor are all greater than 0.50, and the cross loadings are all less than 0.30. Combined with the extremely high Kaiser-Meyer-Olkin (KMO) value of 0.87, it fully confirms the solid construct validity of this questionnaire. The surveys were administered in the first week (pre-test) and the tenth week (post-test) of the semester. All 105 students completed both surveys (100% response rate).

2.3.2. Examination Score

Three types of examination questions were used, assessing different dimensions of learning:

- (1) ESD-related case analysis questions (25 points). Students analysed a scenario based on the transformation of the automotive industry in Xiangyang and answered questions about (a) environmental rationale for shifting to new energy vehicles, (b) economic trade-offs and opportunities, (c) social impacts on workers and local communities, and (d) policy recommendations to promote more sustainable transformation.
- (2) Sustainability knowledge questions (10 points). Short-answer questions assessing factual knowledge of sustainability concepts (SDGs, climate change mitigation, sustainable industrial development).
- (3) Systems thinking questions (10 points). Short-answer questions requiring students to map the interconnections among economic, environmental, and social factors influencing their case industry’s sustainability trajectory.

The remaining 55 points covered conventional economic geography content, with conventional theoretical questions of equal value used as a comparison.

Paired-sample *t*-tests were chosen as the primary analytical method because they are appropriate for within-subject pre-post designs, allowing each student to serve as their own control. The normality assumption for the paired-samples *t*-test was verified by examining the distribution of within-participant difference scores using the Shapiro–Wilk test ($p > 0.05$), confirming that the differences were approximately normally distributed. Cohen’s *d* was calculated as a measure of effect size using the formula for paired samples ($d = M_{diff} / SD_{diff}$) [32]. Paired-sample *t*-tests were also used to compare performance on ESD-specific questions versus conventional theoretical questions. Statistical significance was set at $p < 0.05$.

2.3.3. Qualitative Data Collection

Three types of qualitative data were collected:

- (1) Open-ended survey responses. Students answered two open-ended questions: “What have you learned about sustainable development from this project?” and “What challenges did you encounter when analysing the sustainability dimensions of your case industry?”
- (2) Focus group interviews. Twenty-four students (22.9% of the sample) participated in four focus groups (six students each), selected for diversity in hometown, gender, and prior academic performance. Each focus group interview lasted about 45 min, was audio-recorded, and transcribed.
- (3) Teaching log. The teacher kept a weekly teaching log, recording observations of student engagement, challenges encountered, and adjustments made during implementation.

The qualitative data were analysed using the six-phase thematic analysis method: familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and writing the report [33]. Coding was conducted by the first author, and 20% of the transcripts were double-coded by another trained teacher to establish inter-coder reliability, with a κ value of 0.80. All data were anonymized prior to analysis, participants were assigned codes rather than identified by name, data were stored on password-protected institutional servers accessible only to the research team, and participants were informed of their right to withdraw at any time without consequences.

3. Results

3.1. Quantitative Data Analysis

3.1.1. Pre- and Post-Survey Comparisons

Figure 2 presents descriptive statistics and paired sample *t*-test results for four survey dimensions, with error bars representing standard deviations and significance markers ($p < 0.01$) indicating statistically significant improvements. All dimensions showed statistically significant improvement from pre-test to post-test ($p < 0.01$). The greatest improvement was in sustainable knowledge (mean difference 0.61, Cohen’s $d = 0.86$), followed by local efficacy and attitude (+0.60, $d = 0.89$), sustainable self-efficacy (+0.59, $d = 0.82$), and systems thinking (+0.53, $d = 0.76$). The relative increase in the mean values of each dimension ranges from 18.2% to 20.0%, with a moderate to large effect size.

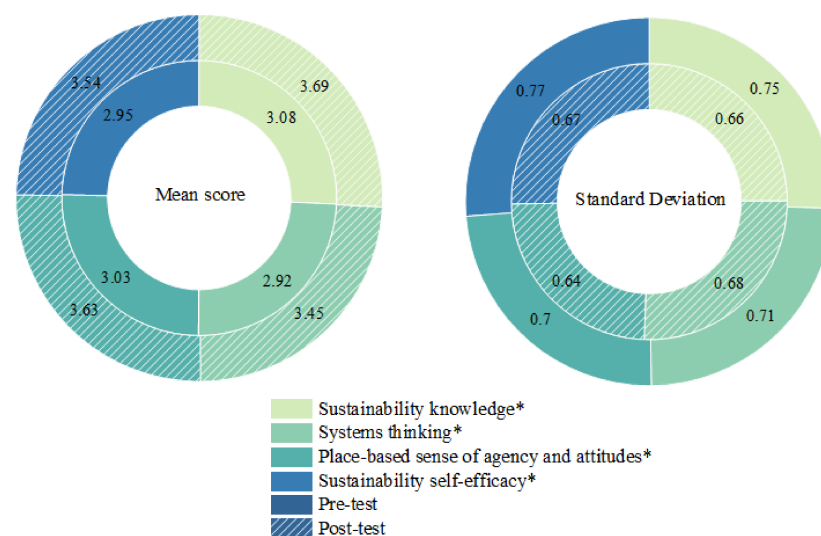


Figure 2. Pre- and post-intervention survey scores ($N = 105$). * means that the significance marker p -value is less than 0.01.

The pre-test mean of each dimension is between 2.92 and 3.08, indicating that students have limited understanding of sustainable frameworks at the beginning of the course and lack confidence in applying relevant concepts to analyze industry cases. The post-test mean increased to the range of 3.45 to 3.69, indicating substantial progress after the ten-week intervention. The effect size of the system thinking dimension ($d = 0.76$) is significant, but slightly lower than other dimensions. The relative increase in the mean values of each dimension is consistent with moderate-to-large educational relevance.

3.1.2. Examination Score Analysis

The examination scores differed significantly across question types (Figure 3). On the case analysis issues related to ESD with a maximum score of 25 points, the mean score was 21.6 ($SD = 2.2$, scoring rate = 86.4%), significantly higher than the mean of 18.0 ($SD = 2.7$, scoring rate = 74.0%) on the conventional theoretical questions (25 points maximum). These results indicate that the place-based case teaching method was particularly effective in developing students' ability to apply sustainability frameworks to real-world industrial scenarios, whereas their ability to reproduce theoretical knowledge in a decontextualised format, while still adequate, was relatively weaker.

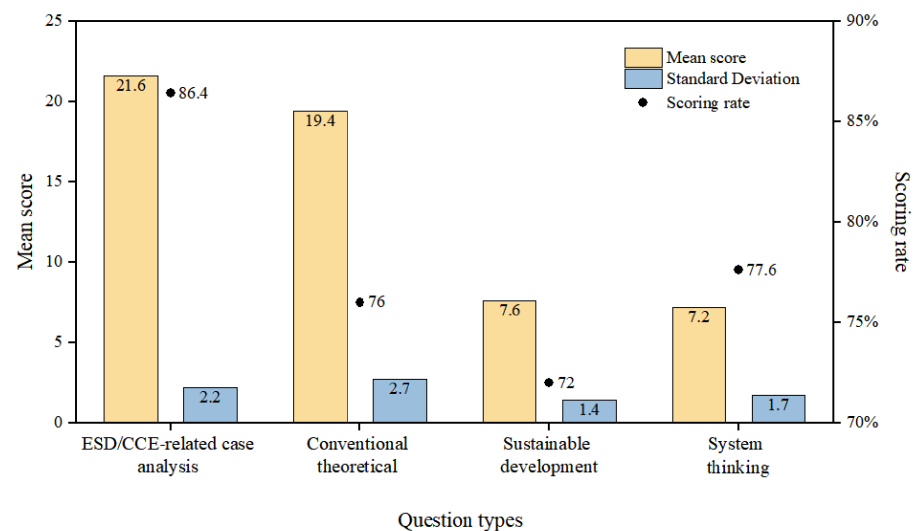


Figure 3. Comparison of examination scores by question type ($N = 105$).

Further analysis of sub-dimensions within the case analysis questions revealed that students performed strongest on the environmental dimension (mean sub-score 6.3/7, 88.6%), followed by policy recommendations (5.2/6, 86.7%), economic trade-offs (5.9/7, 84.3%), and social equity (4.2/5, 84.0%). Although the social equity dimension had a relatively high success rate, students in focus groups commonly reported that “analysing social impacts is more difficult than analysing environmental impacts”.

3.1.3. Subgroup Analysis

Subgroup analysis compared students from Hubei Province ($n = 91$) with those from other provinces ($n = 14$). On the post-test survey, Hubei students scored significantly higher than non-Hubei students on the place-based sense of agency and attitudes subscale. Hubei students have an average score of 3.71 with an SD of 0.69, while non-Hubei students have an average score of 3.21 with an SD of 0.74. However, no significant differences were found on sustainability knowledge, systems thinking, or sustainability self-efficacy (all $p > 0.05$). This pattern suggests that while the place-based teaching method strengthened local students' emotional connection and motivation to engage with sustainability issues in

their home province, the cognitive sustainability competencies developed were comparable between the two groups.

To sum up, the quantitative results indicate that the “Hometown Industry Observation” place-based case teaching intervention was associated with measurable improvements in sustainability knowledge, systems thinking, place-based sense of agency, and self-efficacy. The effect sizes, $d = 0.76\sim 0.89$, suggest that the intervention was associated with reliable educational gains. However, because the study did not include a pure control group receiving traditional lecture instruction, not all learning gains can be attributed solely to the place-based teaching components. This limitation is partially compensated by the qualitative analysis that follows.

3.2. Qualitative Data Analysis

Through thematic analysis of responses to open-ended questionnaires, focus group interviews, and teaching logs, four core themes were distilled to mirror students’ learning experiences and the challenges they encounter.

3.2.1. Theme 1: Making Sustainability Concrete and Personal

The students unanimously reported that the process of analyzing local industries in their hometowns translated abstract sustainable development concepts into tangible and personally relevant issues. A student from Xiangyang, researching the transformation of the new energy vehicle industry, stated in a focus group: “Previously, when I heard terms like ‘industrial transformation’ and ‘sustainable development,’ I thought they were abstract policy documents. This is something the government does, far from me. However, upon investigating how my father’s Dongfeng factory transitioned to producing electric vehicles, I realized that sustainable development was intricately linked to my family’s livelihood. The term ‘transformation’ is no longer a simple concept. I truly understood it through my father’s concerns about retraining and employment security.” (Xiangyang Student, Focus Group 2).

A student from Qichun, focusing on the Qi’ai industry, shared: “*Artemisia argyi* cultivation was initially just a traditional means for villagers to earn some extra income. When I applied a sustainable development framework to analyze the environmental impact of cultivation, economic benefits for farmers, and the social issue of profit distribution, I suddenly recognized that this local specialty was connected to several Sustainable Development Goals (SDGs).” (Qichun Student, Focus Group 3).

In the open-ended questionnaire, most students explicitly wrote, “I used to think sustainability was unrelated to me, but now I see its close connection to my life.” The Teacher’s Diary (Week 4) noted: “After class, numerous students voluntarily shared stories about industrial transformations in their hometowns. This change filled me with joy, as it indicated the students’ willingness to engage in dialogue with their instructor.”

3.2.2. Theme 2: Developing Systems Thinking Through Trade-Off Analysis

Student reports necessitate the simultaneous analysis of environmental, economic, and social dimensions, compelling students to confront intricate trade-offs. This constitutes a fundamental aspect of systems thinking capability. A student from Yichang (conducting research on low-carbon tourism) remarked, “The most challenging aspect is recognizing that there is no flawless solution. While a thriving tourism industry yields substantial economic benefits, it concurrently leads to increased carbon emissions from transportation and heightened hotel waste. Protecting the Yangtze River is crucial for climate preservation, yet restricting development adversely impacts local businesses. I must deliberate on trade-offs rather than merely enumerating facts.” (Yichang student, Focus Group 1).

One student wrote in the post-test open-ended questionnaire, “Sustainable analysis has imparted to me that every economic decision entail environmental and social repercussions; one cannot solely focus on one dimension while disregarding the others.” Another student highlighted, “I am beginning to perceive connections that previously eluded my notice. Energy policies influence factory siting, which in turn affects rural employment, subsequently impacting population migration, and ultimately influencing urban carbon emissions.”

However, some students also conveyed in the open-ended questionnaire that “trade-off analysis is excessively challenging, and at times, we are uncertain about which dimension holds greater significance.” Teacher’s Diary, Week 7 Entry: “It is imperative to furnish students with additional decision matrix tools and stakeholder analysis frameworks to bolster their support.”

3.2.3. Theme 3: Enhanced Place-Based Sense of Agency and Motivation

Several students indicated that the project has bolstered their sense of connection and responsibility towards pursuing sustainable development in their hometowns. A student from Wuhan, who researched the Optics Valley Optoelectronic Industry Cluster, noted in a reflection record: “Previously, I believed I would eventually depart from Wuhan for a larger city. However, this semester, after examining how the Optics Valley has become more sustainable, I now feel a stronger sense of belonging towards Wuhan’s future. I aspire to be involved in its transformation, rather than merely passing through.” (Wuhan student, reflection record).

The sense of local-oriented efficacy is notably pronounced among students from rural regions. A student from Enshi remarked, “I am very happy that this course project has chosen my hometown mountainous area as the theme of development and sustainable development. It instills in me the perception that my hometown holds significance within this academic framework.” (Enshi student, Focus Group 4).

Quantitative data corroborates this qualitative observation: the average score for the statement “I am willing to contribute to the sustainable development of my hometown” rose from 3.11 in the pre-test to 3.85 in the post-test (+0.74, $d = 0.89$). The enhancement in place-oriented efficacy among rural students (+0.81, $d = 0.94$) slightly surpassed that among urban students (+0.55, $d = 0.72$), although this disparity did not attain statistical significance.

3.2.4. Theme 4: Uneven Data Access and Analytical Challenges

Despite the positive learning outcomes achieved, students face considerable challenges in acquiring high-quality, sustainable data pertinent to their selected industries. In an open-ended questionnaire, a student focusing on small and medium-sized manufacturing enterprises remarked: “Securing environmental data for this industry is arduous. Companies refrain from issuing sustainability reports. Government statistics are typically aggregated at the municipal level without industry-specific differentiation. My sole reliance is on news reports, which, however, provide qualitative information rather than hard data.” (Open-ended questionnaire, Student No. 37).

The teacher’s log corroborates this challenge, noting in Week 5: “Numerous students require assistance with data acquisition, particularly those in groups focusing on non-large enterprises.” In response, the teacher incorporated alternative data sources during Phase 2, for example, industry association reports, academic case studies, and environmental impact assessment summaries. However, the accessibility of data across different industries remains uneven. Some students choose large standardized industries such as automotive and optoelectronics. They stated that ‘the data is relatively accessible’. And some students

choose small and medium-sized industries such as agricultural product processing and traditional manufacturing, which often encounter data scarcity.

4. Discussion

This study aims to design and implement a locally centered case teaching intervention within the economic geography curriculum and evaluate its observed associations across four dimensions: students' sustainable knowledge, systems thinking, locally centered efficacy, and sustainable self-efficacy. Both quantitative and qualitative findings collectively demonstrate that the "Hometown Industry Observation" project was associated with significant improvements across all four dimensions, with a moderate to large effect size ($d = 0.76\sim 0.89$). The three most salient findings were compared and discussed with those from existing research, and pointed out the limitations in the implementation process.

4.1. Place-Based Case Teaching Shortens Psychological Distance and Enhances Relevance

The most salient finding from both quantitative and qualitative data is that grounding abstract sustainability concepts in the industries of students' hometowns appears to narrow their psychological distance to sustainability issues. This conclusion is corroborated by the substantial effect size ($d = 0.89$) observed in the dimensions of place-based efficacy and attitude. Qualitative data further substantiate this by illustrating a clear shift in students' perceptions, from viewing sustainability as a "distant policy" to recognizing its direct relevance to their own livelihoods. This finding aligns closely with the psychological distance theory framework [17]. These scholars have noted that individuals often perceive climate change and sustainability challenges as geographically and temporally remote, thereby diminishing their engagement and motivation. This study extends this theoretical framework to the field of educational intervention. The situational teaching method, which is crucial for transformative environmental education, can serve as an effective strategy to narrow psychological distance [9]. As these authors have stated, learning based on students' life experiences and local environments generates stronger emotional and cognitive engagement compared to teaching without context.

The observed change in place-based efficacy in this study ($d = 0.89$) indicates a substantial educational improvement. This magnitude aligns with the theoretical framework proposed by a previous study, which synthesized evidence suggesting that environmental education can effectively influence sense of place through direct experiences and instruction [20]. The stronger improvement observed in our study may stem from the greater intensity and duration of our intervention with a ten-week sustained inquiry, which offers a more comprehensive approach than the short-term interventions typically examined in prior studies. In addition, analyzing the issue of industrial transformation, which is directly related to the livelihood and career prospects of students' families, may generate stronger emotional and cognitive resonance than the more common environmental themes in previous studies.

4.2. Significant Improvement of Systems Thinking Requires Sufficient Teaching Support

Although students demonstrated a statistically significant improvement in the dimension of systems thinking ability ($d = 0.76$), this increase was slightly smaller than the other three dimensions. Qualitative data reveal that students believe that trade-off analysis, especially balancing the three dimensions of economy, environment, and society, has great cognitive difficulty. Some students have difficulty determining which dimension should be prioritized. This finding is consistent with the broader observation that sustainability competencies, including systems thinking, require targeted and sustained pedagogical efforts to develop fully, rather than being acquired incidentally through standard instruc-

tion [5]. The ten-week intervention in this study was associated with the initiation of significant development of systems thinking abilities, but it has not yet fully consolidated them. The relatively small gain of systems thinking ($d = 0.76$) may also reflect the limited scope of sustainability dimensions involved in intervention measures. As indicated in the literature on Socio-scientific Issues (SSI), effective systems thinking requires involvement in a wide range of interrelated issues, including dimensions of health, social justice, and equity [34–36]. Our teaching interventions do not include SDG 3 (health) and SDG 10 (reducing inequality), which may limit students' ability to form a fully integrated systemic perspective on industrial transformation.

In addition, SSI literature emphasizes the importance of argumentation techniques, evidence use, and inquiry-based methods in addressing complex sustainability challenges [34,36]. The trade-off analysis required in our intervention requires students to weigh competing environmental, economic, and social factors, representing a form of SSI reasoning that may support the development of students' evidence-based reasoning and critical thinking abilities. As demonstrated by Guevara-Herrero [34], involving students in real social science controversies, such as the sustainability of consumption patterns, can cultivate the necessary argumentative and analytical skills to address real-world sustainability challenges.

It is worth noting that qualitative feedback shows that students have begun to demonstrate more complex causal reasoning, such as tracing how energy policies affect factory location, how factory location affects rural employment, how rural employment affects population migration, and how population migration affects urban carbon emissions, although they still have difficulties in balancing priorities. This finding suggests that interventions appear to have supported the development of the foundational skills of systems thinking, while higher-level skills such as multi-criteria decision-making remain challenging. In the context of sustainability case analysis, students face a high internal cognitive load due to the inherent complexity of multidimensional trade-off analysis. Without appropriate scaffolding such as decision matrices, stakeholder mapping tools, and structured analysis frameworks, this cognitive burden may overwhelm students and hinder learning. Future research can draw on cognitive load theory [37] and introduce scaffolding tools such as decision matrix tools and stakeholder analysis frameworks in the second lesson to help students manage the cognitive complexity of multi-criteria trade-off analysis. These scaffolding tools are available throughout the entire independent investigation phase to support students in navigating the competitive environment, economic, and social dimensions of case analysis.

4.3. Unequal Acquisition of Survey Data

The results from qualitative analysis showed unequal opportunities for sustainable data acquisition among different industries. Students who choose large-scale standardized industries such as automobiles and optoelectronics have relatively easy access to report data, while students who choose small and medium-sized enterprises such as agricultural product processing and traditional manufacturing generally face data scarcity. This finding is consistent with previous research results on the conceptualization of collective environmental literacy [25]. This concept emphasizes that effective collective action requires not only individual knowledge and skills, but also shared resources, including accessible information and data, which are fairly distributed among community members. Uneven access to such shared resources can undermine the capacity of groups to identify, deliberate, and act upon sustainability challenges. Our study extends this collective literacy perspective to the higher education classroom context, revealing that unequal data acquisition not only hinders group inquiry but also measurably affects academic performance, thereby potentially creating an equity issue within place-based teaching approaches.

However, from the perspective of competency-based education, unequal data access may not necessarily be a problem; in fact, it can serve as a valuable teaching opportunity. Sustainable development education is essentially multidimensional, and its solutions require flexible and transferable tools, including argumentation, evidence assessment, modeling, querying, and information retrieval, rather than detailed content knowledge [8,9]. Handling incomplete or contradictory information is a decisive feature in solving real-world sustainable development problems [34,36]. Therefore, the scarcity of data requires students to develop key information literacy skills, evaluate the quality and reliability of existing evidence, and make reasonable judgments under uncertain conditions, which are crucial for addressing complex sustainability challenges. Education must prepare learners, not by teaching them all the problems, but by equipping them with tools to solve any problems they may encounter [10]. Therefore, future iterations of this intervention should intentionally utilize data scarcity as a learning opportunity, providing students with scaffolding to cultivate the reasoning and inquiry skills needed to navigate information-limited environments.

The seemingly student-centered teaching method of “researching your hometown’s industries” may actually inadvertently lean towards students who happen to come from areas with higher levels of industrial documentation. To alleviate this issue, future implementation should consider establishing a hierarchical data support system, for example, providing government data packages or enterprise sustainability report summaries in advance for data-scarce industries. AI-assisted data capture tools, such as automatically extracting information from corporate ESG reports, may also provide scalable solutions to address data inequality issues.

4.4. Scope of Sustainable Development Goals in Teaching Interventions

Although the industrial cases in Table 2 are analyzed through environmental, economic, and social dimensions, several SDGs that are meaningfully linked to industrial sustainability, including SDG 3 (Health), SDG 6 (Clean Water), SDG 10 (Reduce Inequality), SDG 16 (Peace and Justice), and SDG 17 (Partnership), have not been explicitly included in teaching or evaluation. As demonstrated by Pérez-Martín and Esquivel-Martín [9], the “One Health” framework links environmental quality, water pollution, and human health in a way directly related to industrial transformation. Similarly, Banos-González et al. [38] and García-Fortes et al. [39] demonstrated how socio-scientific issues related to consumption and waste generation elucidate the dimensions of social justice and equity in sustainable development. The absence of these SDGs from our intervention means that students’ systems thinking development, which has the smallest benefit among the four measurement dimensions, may have been constrained by the limited scope of the interconnection of SDGs. These missing SDGs will be incorporated into the subsequent teaching process.

5. Conclusions

The ten-week “Hometown Industry Observation” place-based case teaching intervention was implemented in an Economic Geography course with 105 second-year geography majors at a comprehensive university in Hubei Province, China. By guiding students to investigate the sustainable transformation of industries in their hometowns, the intervention measures combine abstract concepts of sustainable development education with familiar environments for students. Using a mixed-methods approach that combined pre- and post-intervention surveys, examination score comparisons, and qualitative data, the study systematically examined the observed changes on students’ sustainability knowledge, systems thinking, place-based engagement attitudes, and self-efficacy. Quantitative results

indicated statistically significant improvements across all four dimensions, with moderate to large effect sizes ($d = 0.76\text{--}0.89$). Students performed significantly better on ESD case analysis questions than on conventional theoretical questions, with particularly strong performance on environmental and economic dimensions, indicating that place-based case teaching may offer particular benefits in cultivating knowledge application abilities, while the social equity dimension still left room for improvement. Qualitative analysis further revealed the core mechanisms of place-based teaching: making sustainability knowledge embodied by reducing psychological distance, developing systems thinking through trade-off analysis, and enhancing engagement motivation by strengthening place-based sense of agency. At the same time, uneven data access across industries was identified as a major implementation barrier, and it measurably affected the academic performance of data-disadvantaged groups. However, from a competency-based educational perspective, data scarcity can serve as a valuable pedagogical opportunity, requiring students to develop critical information literacy skills, evaluate evidence quality, and make reasoned judgments under uncertainty, and future iterations should deliberately leverage this as a learning opportunity with appropriate scaffolding. The four-stage progressive design of this model, including case preparation, independent exploration, presentation and discussion, and assessment and reflection, provides a feasible implementation path for integrating sustainable development education into economic geography and related social science courses. Future research should employ randomized controlled trial designs to establish causal relationships, examine the replicability of this model across a broader range of disciplines and institutional contexts, and develop tiered data support tools for data-scarce industries, for example, building open-source local sustainability databases or exploring AI-assisted information extraction techniques to lower data access barriers.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki. According to Article 32 of the Measures for Ethical Review of Life Science and Medical Research Involving Human Subjects (National Health Commission Document No. 4 [2023]), ethical review and approval were exempted for this study because it involved anonymous survey and interview data that did not cause harm to human subjects, did not involve sensitive personal information, and had no commercial interests. This determination was confirmed by the Scientific Ethics Special Committee of Hubei University of Arts and Science through consultation. However, due to the institutional policy of not issuing formal exemption letters for this category of research, a formal exemption document is not available. The study's protocol and application materials were reviewed and acknowledged by the committee.

Informed Consent Statement: Informed consent was obtained from all research participants. All data were anonymised to protect participant privacy.

Data Availability Statement: Data are not publicly available due to privacy restrictions.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Education for Sustainable Development (ESD) Learning Outcomes Survey

Instructions: Please select the option that best reflects your current feelings for each statement below: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

Part 1: Sustainability Knowledge (6 items)

1. I can explain the concept of “sustainable development” and its three core dimensions (economic, environmental, social).
2. I understand the relationship between industrial transformation in my hometown and climate change mitigation.
3. I am familiar with at least five of the United Nations Sustainable Development Goals (SDGs) and their main content.
4. I can give an example of how an industry can transition from unsustainable to more sustainable practices.
5. I understand the mechanism by which industrial carbon emissions contribute to global warming.
6. I can name at least two policies that China has implemented to promote green industrial development.

Part 2: Systems Thinking Competence (6 items)

1. I can analyse the interconnections and trade-offs among the environmental, economic, and social dimensions of an industry.
2. When studying an industry, I consider the environmental impacts of its upstream supply chain and downstream consumption chain.
3. I can identify how an economic decision (e.g., factory location) indirectly affects social equity in local communities.
4. I can draw a concept map illustrating the interactions among factors (policy, technology, market, resources) in industrial transformation.
5. I understand the links between local industries and global sustainability challenges (e.g., carbon emissions from supply chains).
6. When analysing sustainable development issues, I can consider both short-term benefits and long-term consequences.

Part 3: Place-Based Engagement Attitudes and Sense of Agency (6 items)

1. I feel that industrial development in my hometown is closely related to my personal life.
2. I care about the environmental quality and sustainable development status of my hometown.
3. I believe I have the ability to contribute to the sustainable development of my hometown (e.g., through research, advocacy, or career choices).
4. I am willing to participate in environmental or social welfare activities in my hometown in the future.
5. This course has made me more aware of applying the knowledge I have learned to solve local practical problems.
6. I feel that local governments and enterprises should listen more to the opinions of the younger generation on sustainable development.

Part 4: Sustainability Self-Efficacy (6 items)

1. I am confident in applying sustainability frameworks (e.g., life-cycle analysis) to analyse a real-world industrial case.
2. Even when complete data are lacking, I can make reasonable inferences about the sustainability of an industry.

3. I can propose at least two concrete recommendations for improving the sustainability of a small or medium-sized enterprise.
4. I am able to explain to non-specialists the connection between climate action (SDG 13) and local industrial transformation.
5. Faced with a complex sustainability controversy (e.g., the environmental impact assessment of a new factory), I can form and justify my own position.
6. I believe that through my professional knowledge and actions, I can have a positive impact on the sustainable development of my hometown.

Part 5: Open-Ended Questions

What is the most important thing you have learned about sustainable development from this project? (Please answer in a few sentences.)

What were the main challenges you encountered when analysing the sustainability dimensions of the industry you selected? (Please answer in a few sentences.)

Background Information (anonymous, for statistical analysis only)

Gender: Male/Female

Hometown: Within Hubei Province (please specify city: ____)/Outside Hubei Province (please specify province: ____)

Have you previously taken any courses related to sustainable development or the environment? Yes/No

Thank you for your participation!

Table A1. Other representative cases in Hubei province industries and sustainability dimensions.

Industry	Location	Sustainability Focus	Relevant SDGs ¹	ESD Competency Focus
Non-ferrous metal smelting to electronics	Huangshi	Transition from traditional copper smelting to electronics; circular economy; green transformation of resource-based industry	SDG 9, 12, 13	Systems thinking; strategic competence
Textile and garment industry	Jingzhou	Green upgrading; employment equity in traditional manufacturing	SDG 8, 9, 12	Normative competence; interpersonal competence
New energy battery materials (GEM recycling industrial park)	Jingmen	Resource recycling; closed-loop supply chains; circular economy	SDG 7, 9, 12	Systems thinking; strategic competence
Airport economy zone (SF Express cargo hub)	Ezhou	Green logistics; low-carbon transport	SDG 9, 11, 13	Systems thinking; anticipatory competence
Paper products industry	Xiaogan	Water conservation; emission reduction; sustainable raw materials	SDG 6, 12, 13	Systems thinking; normative competence
Bamboo industry	Xianning	Carbon sinks; sustainable forestry; biomass energy	SDG 7, 13, 15	Systems thinking; anticipatory competence

Table A1. Cont.

Industry	Location	Sustainability Focus	Relevant SDGs ¹	ESD Competency Focus
Special-purpose vehicles and emergency equipment industry	Suizhou	Green design of emergency equipment; carbon-neutral transformation of heavy manufacturing	SDG 9, 13	Strategic competence; systems thinking
Non-woven fabrics industry	Xiantao	Biodegradable materials; plastic pollution substitution; circular economy	SDG 12, 13, 14	Strategic competence; normative competence
Crayfish processing industry	Qianjiang	Aquaculture wastewater treatment; recirculating water systems; circular food economy	SDG 6, 12, 14	Systems thinking; strategic competence
Cotton cultivation and primary processing	Tianmen	Sustainable agriculture; water-fertiliser management; green textile chain	SDG 2, 6, 12	Normative competence; systems thinking
Forest ecotourism and biodiversity conservation	Shennongjia	Carbon sinks; ecological compensation; conservation-based development	SDG 8, 13, 15	Anticipatory competence; normative competence

¹ SDG 2: Zero Hunger; SDG 6: Clean Water and Sanitation; SDG 7: Affordable and Clean Energy; SDG 8: Decent Work and Economic Growth; SDG 9: Industry, Innovation and Infrastructure; SDG 11: Sustainable Cities and Communities; SDG 12: Responsible Consumption and Production; SDG 13: Climate Action; SDG 14: Life Below Water; SDG 15: Life on Land.

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