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Exploratory Research on AI Empowerment in the Management of Higher Education Institutions in Zhejiang from an ESG Perspective

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ABSTRACT

Against the global sustainable development backdrop, Chinese universities have shortcomings in advancing sustainable development, including ambiguous Environmental, Social, and Governance (ESG) awareness in the academic community, lack of quantitative campus sustainable development assessment mechanisms, and no collaboration mechanism among university administrators, teachers, and students. With Artificial Intelligence (AI)'s rapid development, there is a new way to solve this predicament, and Zhejiang has the foundation to integrate sustainable development with AI. This paper adopts descriptive analysis to explore the differences in students' ESG awareness levels. Then, using K-means clustering analysis, it conducts unsupervised segmentation of student groups based on core variables such as ESG awareness and AI acceptance, identifies typical behavioral patterns, and portrays group profiles. Meanwhile, it identifies key weak links based on the current status of ESG management, constructs a model of influencing factors on campus ESG management effectiveness by combining multiple linear regression, and reveals the mechanism of action of these influencing factors. Finally, it uses the forward LR method to construct a binary Logistic regression model, revealing how demographic characteristics and cognitive levels affect individuals' willingness to support ESG practices. The research yields the following outcomes, (1) University ESG promotion has initial achievements but faces superficial student cognition and general wait-and-see attitudes toward AI-empowered ESG; (2) Students' environmental participation and ESG environmental goals significantly impact university management effectiveness; (3) AI empowerment is largely influenced by students' environmental values. This study has the following significance, (1) It contributes to the achievement of SDG.11 (Sustainable Development Goal 11) of the global sustainable development goals; (2) It constructs an "ESG + AI" management framework, enabling universities to become "micro-units" in global sustainable development practices; (3) Taking advantage of the popularity of AI technology, it leverages AI's capabilities in intelligent monitoring and in-depth analysis

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of massive and complex ESG data to reshape a data-driven ESG practice model.

1. Introduction
1.1 Research Background

In the global sustainable development process, the United Nations Global Compact's 2004 report "Who Cares Wins" first introduced the Environmental, Social, and Governance (ESG) framework. Its core objective was to promote the integration of environmental, social, and governance factors into investment decisions within the financial industry. After nearly two decades of development, this framework has evolved into a globally recognized standard for measuring the sustainable development capabilities of organizations. It has expanded from the financial sector to the corporate domain and further extended into the field of higher education. As key entities in talent cultivation and social services, higher education institutions face multiple practical challenges in implementing ESG principles. To address the disconnection between talent training and industry demands, universities need to establish interdisciplinary programs (such as the "Carbon Neutrality Science and Engineering" major introduced by the Ministry of Education in 2022) and promote dual-degree initiatives similar to Tongji University’s "Environmental Science-Accounting" dual-degree program. To bridge the gap between academia and practice, universities should collaborate with enterprises to build practical training bases (exemplified by the joint establishment of a practice base between Tongji University and the Shanghai Energy Exchange) and undertake research projects proposed by companies (as illustrated by Duke University’s master’s program in "Business, Climate, and Sustainability"). To overcome relatively rigid organizational mechanisms, higher education institutions should adopt ESG governance structures that integrate resources (represented by the Center for Sustainable Education at the University of Colorado Boulder) and align with professional qualification certifications (with the "SPARK model" for ESG talent being one potential option).

Currently, ESG practices in Chinese universities still face multi-dimensional bottlenecks. Energy consumption monitoring is fragmented, and the efficiency of express packaging disposal is low. There is insufficient participation from both faculty and students, and the cultivation of sustainability literacy lacks systematic approaches. Cross-departmental collaboration remains inadequate, and data sharing is hindered by barriers. Traditional manual solutions struggle to address these challenges due to issues such as data inaccuracy, limited coverage, and inefficient data-sharing channels. Therefore, artificial intelligence (AI) technology has become a crucial support in resolving these problems, as it can collect and analyze data in real time, build efficient interactive platforms, and break down data barriers.

As the capital of Zhejiang Province, Hangzhou is the "core area of China's New Generation AI Innovation and Development Pilot Zone," hosting nearly 700 core AI enterprises. It has formed a complete industrial ecosystem spanning from algorithm development to hardware manufacturing. The technological achievements and practical experience accumulated in areas such as smart energy management and intelligent waste classification not only serve the local region but also possess the potential to benefit the entire country. As the core of the province's development, Hangzhou’s AI industry advantages provide comprehensive industrial support across the entire chain for ESG practices in Zhejiang’s universities through technological outreach and resource integration. This makes it a typical example of regional industries empowering university sustainability in China. Zhejiang Province, as a pioneer in China's digital economy, has consistently promoted the deep integration of technological innovation and sustainable development. It has set a clear goal of "empowering green campuses with digital technology" in university governance. The alignment between Hangzhou's AI strengths and the ESG needs of Zhejiang's universities not only offers mature technological pathways for local institutions but also leverages the province's digital ecosystem to facilitate the scalable implementation of AI-enabled models. The outcomes of these explorations can provide other Chinese provinces with replicable "Zhejiang Experiences," directly contributing to the enhancement of ESG governance in Chinese universities and advancing China's sustainable development goals.

1.2 Literature Review

1.2.1 Research on the current situation and optimization path of ESG practice in colleges and universities

（1）A Study on the Practical Value and Impact of ESG in International Universities

As the global sustainable development process continues to advance, higher education institutions are increasingly emphasizing the ESG (Environmental, Social, and Governance) concept, and related research has exhibited a progressively deepening developmental trajectory. In the theoretical foundation stage, Kasia Lundy, Seth Reynolds, and Stephen Auton-Smith (2022) pioneered the construction of a core theoretical framework, proposing that universities can effectively attract top talent and deepen engagement with surrounding communities by developing well-considered ESG strategies supported by comprehensive action plans and transparent communication mechanisms[Error! Reference source not found.]. This research clarified the core logic of implementing ESG principles in higher education, laying a theoretical groundwork for subsequent practical exploration. Moving into the practical validation stage, Irina M. Akopyants [2] built upon the aforementioned theoretical framework by integrating ESG concepts into specific practical contexts within Russian higher education institutions. Through empirical research, it was found that the systematic implementation of ESG principles can significantly enhance the quality of higher education [2], successfully achieving a transition from theoretical conception to practical application and further validating the tangible value of ESG in the university setting. In the impact mechanism refinement stage, Shih-Tse Lin and Kao-Shan Chen [3] delved deeper into the pathways through which ESG practices exert their influence, exploring their specific effects on student behavioral intentions from multiple theoretical perspectives. They concluded that university ESG practices can positively guide student behavior and strengthen students' emotional attachment to their institutions [3]. Compared to prior research focusing on overall institutional quality improvement, this study shifts the perspective down to the individual student level, enriching the international research dimensions on the impacts of ESG practices in higher education.

(2) Exploration and Localization Research on ESG Practices in Chinese Universities

ESG practices and their localization in Chinese universities have been extensively researched with fruitful outcomes. In the construction of ESG information disclosure systems, Dong Jiangchun (2023) and Chen Zhishu (2023) reviewed international standards and proposed a framework designed around objectives, principles, content, and disclosure methods to enhance information transparency through institutional mechanisms [4]. Mo Fei [5] introduced an indicator system comprising 40 metrics across four dimensions—environmental, social, governance, and education—discussed common issues in disclosure models, and noted that while digital tools can optimize website-based disclosure, balancing comprehensiveness and cost remains challenging [5]. The application of ESG principles focuses on energy conservation, emission reduction, and collaborative governance. Guo Li

[6] developed a multi-level coupling model integrating spatial, stakeholder, technological, and informational dimensions, proposing a dynamic mechanism to support emission reduction strategies, though the model's adaptability across diverse universities requires further validation [6]. In the integration of green campus initiatives and internal controls, Xue Han [7] highlighted the alignment between ESG and green internal control objectives while pointing out practical challenges such as cognitive conflicts and transition difficulties, noting that existing strategies lack specificity for local universities [7]. Research in sustainable development extends across multiple dimensions. Liu Yue [8] proposed three key objectives and related principles for green renovation of university teaching buildings but lacked quantitative analysis of costs and environmental benefits [8]. Zhai Xuesong *et al.*, [9] employed a super-efficiency SBM-DEA model to evaluate efficiency, revealing a global average efficiency of 0.57 for universities, with China at 0.78 but significant regional disparities. They recommended resource reallocation and international collaboration to enhance efficiency, though the universality of indicators needs refinement [9]. The dual-carbon theme has become a recent research hotspot. Li Wenda *et al.*, [10] explored talent cultivation models for carbon neutrality goals but faced challenges such as interdisciplinary integration and resource constraints [10]. Li Jiping [11] proposed low-carbon campus pathways based on case studies but identified insufficient research on synergistic mechanisms between energy transition and stakeholder behavior [11]. Additionally, Luo Juxiang [12] found that under the New Engineering Discipline framework, experimental teaching demonstration centers can achieve sustainable development through systemic restructuring, with Sanming University serving as a reference for local institutions, though model replication is constrained by resource endowments [12].

1.2.2 Exploring AI-enabled applications in university management

（1）Theoretical Exploration and Cutting-Edge Challenges in the Integration of AI and ESG

ESG and AI represent two highly prominent development trends today. The ESG framework focuses on environmental, social, and governance dimensions to achieve sustainable development goals, while AI technology, with its powerful capabilities in data analysis, prediction, and automation, has become a key force driving economic development and social progress. The team led by Evgeny Burnaev [13] observed a scarcity of research simultaneously addressing practical cases across all three core ESG areas, with even less attention paid to the potential challenges AI poses to ESG. Furthermore, as the public release of the groundbreaking ChatGPT-3.0 coincided with their manuscript submission date, a comprehensive analysis of its impact on the ESG domain was not feasible [13]. Sunan Liu [14] addressed this research gap by using ChatGPT as a case study to propose a comprehensive, multi-dimensional educational strategy framework (e.g., developing curricula that integrate AI with ESG) to foster students' deep understanding of ESG principles. The findings indicate that within the "AI + Education" context, AI is actively driving high-quality educational development, demonstrating significant potential, particularly in cultivating ESG-related competencies [14]. Mario Marlito R. Domingo [15] introduced the conceptual framework of an "AI-ESG Integration Model," concluding that AI is increasingly influencing ESG initiatives, presenting both opportunities and challenges [15].

(2) Research on Practical Pathways for AI-Driven Transformation in University Management

Scholars have conducted multi-dimensional research on the practical pathways for AI-driven transformation in university management, primarily focusing on three core dimensions: the digital transformation of management tools, the expansion and deepening of management objects, and the innovation of management concepts. Attention has also been paid to adaptation issues in practice and the reform priorities for specific types of universities. Regarding the digital transformation of management tools, Zhu Peipei [16] and Chen Lu [18] pointed out that digital technologies can reconstruct the financial management models of universities. By constructing smart finance platforms, financial data can be transformed into valuable assets to achieve precise decision-making support [16]. Lü Shuyang [17] argued that technologies such as artificial intelligence and big data can promote the upgrade of educational management models. Forming a three-dimensional enabling framework encompassing technology, mechanisms, and ecology can enhance management efficiency and response speed [17]. In terms of the expansion and deepening of management objects, Tian Shengwen *et al*., [18] mentioned that new quality productive forces not only optimize traditional management areas such as teaching and research but also drive the transformation of student management towards digitalization and personalization. Utilizing information tools can meet the diverse needs of students and enhance the precision and flexibility of management [18]. Concerning the innovation of management concepts, Zhang Zhao [19] indicated that the concept of new quality productive forces, centered on innovation, synergy, and efficiency, can prompt universities to break down disciplinary barriers in the teaching domain by constructing interdisciplinary research platforms and to overcome departmental fragmentation in administrative management by establishing industry-education integration mechanisms. This promotes a shift in the overall management philosophy from administrative dominance to collaborative innovation [19]. However, existing research also points out practical adaptation issues such as conflicts between technology application and traditional management systems and balancing data security with privacy protection. Furthermore, Sun Gongqi [20] emphasized that application-oriented undergraduate universities need to strengthen industry-education integration and university-enterprise cooperation through management system reforms to serve local economic and social development [20].

1.3 Research Gaps, Significance, and Objectives

Driven by the dual forces of deepening global digital transformation and the emergence of the ESG framework as a core paradigm for sustainable development, the transformative impact of digital technologies on the education sector is becoming increasingly pronounced. Employing AI to empower university ESG management has emerged as a critical direction for promoting high-quality development in higher education. However, existing research reveals significant gaps in exploring the practical pathways for integrating ESG and AI within the specific context of higher education institutions. First, there is a lack of targeted analysis concerning the characteristics of group differences in ESG cognition among university students and their underlying influencing mechanisms, particularly when considering the cognitive logic and information acquisition habits across different genders, majors, and educational levels. As students are core participants in campus ESG practices, their cognitive differences directly impact the effectiveness of these initiatives. Second, there is an absence of systematic empirical investigation into both the current application status of AI technologies in campus sustainability management and students' awareness of its specific value in ESG dimensions such as environmental protection. This contrasts sharply with the mature application cases of AI in ESG fields like carbon footprint tracking and energy optimization. Third, practical issues such as the correlation between the effectiveness of campus environmental practices and the level of ESG management, and the alignment between publicity efforts and the participation rates of teachers and students, remain to be further clarified.

The significance of this research is substantial, as it can provide support for the theoretical development of ESG in higher education while also offering practical solutions for universities. In terms of theoretical value, this study deepens the theoretical integration of ESG and university management from the perspective of new quality productive forces. By incorporating AI technology into university ESG practices, it can overcome the limitations of outdated technology and insufficient resource integration inherent in traditional management approaches. It aims to reveal the coupling logic between technological innovation and sustainable development concepts, enrich the application connotation of new quality productive forces in non-corporate organizational contexts, and provide a new theoretical perspective for the systematic implementation of ESG in higher education. From a practical application standpoint, addressing pain points in Zhejiang province's university ESG practices—such as management efficiency, data monitoring, and stakeholder engagement—this research proposes to develop an adaptive "ESG+AI" management framework as an enabling solution. This framework leverages intelligent collaborative systems to optimize cross-departmental processes, establishes real-time monitoring platforms to resolve data lag issues, designs personalized interactive tools to enhance participation, and creates a unified data center to achieve deep integration of digitalization and ESG. It aims not only to provide a systematic solution for universities in Zhejiang to overcome practical challenges but also to offer a replicable practice model for similar higher education institutions across the country.

Based on the identified research gaps and significance, the core objective of this study is to explore effective pathways for empowering ESG management in Chinese universities with artificial intelligence. Centering on this objective, three key research components are proposed: 1. To uncover the current state of ESG management cognition among university students and identify the main bottlenecks. 2. To systematically delineate the primary problems and challenges currently faced by universities in ESG management practice. 3. To explore the effective pathways and application mechanisms for utilizing artificial intelligence technology to empower university ESG management.

2. Research Methodology

2.1 Theoretical Foundation

This study is theoretically underpinned by the KAP model proposed by Vandamme in 2009. This model originated in the field of family planning and population studies in the 1950s.This model elucidates the intrinsic relationships among "Knowledge-Attitude-Practice," all of which are influenced by the social environment. Within this framework, knowledge is the prerequisite for behavioral change, attitude serves as the impetus for action, and practice is the external manifestation of knowledge and attitude. In this research, the KAP model provides a "cognition-affection-behavior" closed-loop framework for analyzing university students' ESG and environmental awareness. It facilitates the assessment of students' knowledge related to ESG and AI to identify the starting point and weaknesses in university ESG education, analyzes students' attitudes towards ESG practices to pinpoint drivers and barriers to behavioral change, and tracks students' actual ESG practices to verify the translation effect of knowledge and attitude into action. The ultimate goal is to promote the shift among students from merely "understanding ESG" to "actively practicing ESG," thereby consolidating the foundational role of students in advancing university sustainability.

2.2 Questionnaire Survey Method

This study selected university students from various types of institutions in Zhejiang Province as the sample population, considering that students are direct participants in university governance and core subjects of campus sustainable development, and their ESG cognition and AI application experiences hold significant reference value for investigating AI-enabled pathways. A three-stage Probability Proportional to Size (PPS) sampling method was employed, stratified by "administrative region - academic level - major." This involved first selecting six regions based on the weight of the number of universities per region, then determining the sample size stratification by academic level (undergraduate, postgraduate, etc.), and finally categorizing majors based on their relevance to ESG/AI before randomly selecting specific majors and survey participants. Supplementary sampling was conducted in cases of non-response.

The initial sample size was calculated using the infinite population sampling formula, targeting a 95% confidence level, a 5% margin of error, and a conservative population proportion estimate of 0.5, resulting in 385 respondents. This initial size was subsequently adjusted using the finite population correction formula, considering the total population of approximately 1.5 million university students in Zhejiang Province; the final required sample size remained 385. To ensure the scientific rigor of the questionnaire design and the clarity of question phrasing, a pre-test was conducted by distributing and collecting 100 preliminary questionnaires. Based on the feedback, ambiguous wording, response options, and logical sequence were optimized. A total of 530 questionnaires were distributed both online and offline. After excluding invalid responses, 516 valid samples were obtained, which adequately meets the requirements for subsequent statistical analysis.

3. Results

3.1 Research on group differences in students' ESG cognition

3.1.1 Distribution of ESG awareness

This study distributes ESG perceptions and gets the following results.

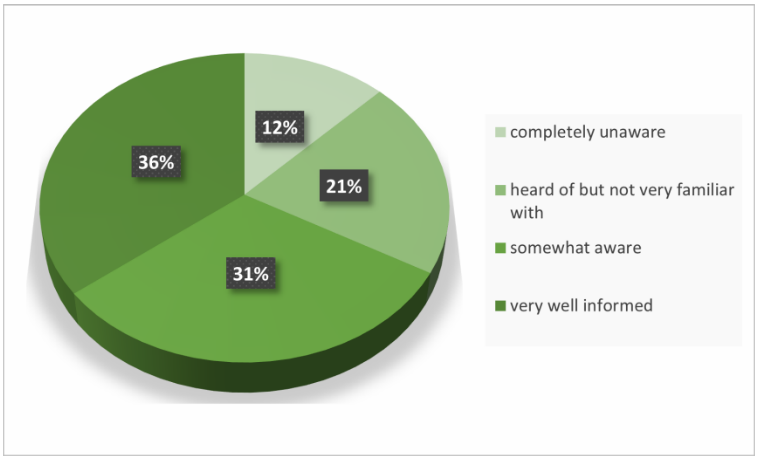

Fig. 1. ESG cognitive distribution

This part concludes that only 12% of students do not understand ESG at all, but as many as 64% of students are in the shallow cognitive stage of "heard of but not very well" or "know some" in Figure 1, indicating that college students' overall cognition of ESG It is still mainly preliminary, and the in-depth understanding needs to be improved.

3.1.2 Group structure of cognitive differences: A cross-analysis based on gender, education and major

This part understands the group structure of cognitive differences through cross-analysis. The chi-square test results show that students' gender, academic level, and professional background are all significantly associated with their ESG cognition ($p < 0.05$).

In this questionnaire, the male and female samples are 1: 1, the distribution is balanced, and the data are representative and objective. In terms of gender, the proportion of men who self-rated as "very well aware" of ESG was higher, while the proportion of women who "did not understand at all" and "knew some" was higher, with a very significant difference (p < 0.01); Educational background: the proportion of junior college and undergraduate "very well understood" exceeds that of master's degree, and the proportion of doctor's degrees rises to 37.2%, but the overall correlation is not positive (p = 0.027); majors, agriculture and medicine, humanities and social sciences have lower ESG awareness than natural sciences, and engineering (p = 0.01). The questionnaire results are shown in Figure 2.

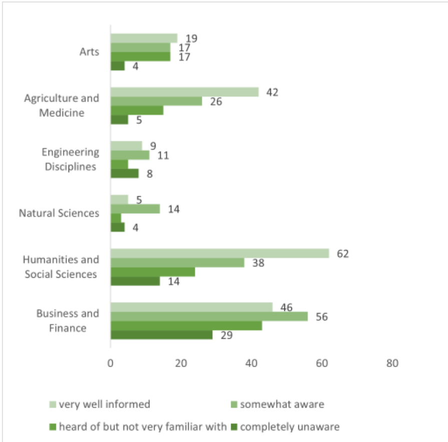

Fig. 2. ESG awareness of different majors

3.1.3 Identification of ESG cognitive heterogeneity based on K-means clustering

This section aims to reveal the cognitive differences of different ESG groups. Combined with the previous analysis, it is determined that education level, professional background, and AI trust are the key variables that affect students' ESG cognition, and this is used as the basis for cluster analysis.

One-way ANOVA shows that, in terms of academic qualifications, there are significant differences in ESG cognition among students with different academic qualifications (F = 3.60, p = 0.014); junior college students and undergraduates have significantly higher cognition than master's students, and doctoral students have no significant difference with other groups; In terms of majors, there are significant differences in cognition among students of different majors (F = 4.44, p = 0.001). The cognition of agricultural medicine, humanities, and social sciences is significantly higher than that of business and engineering, and the cognition of engineering is the lowest.

In k-means clustering analysis, this chapter determines the optimal number of clusters to be 5 through the elbow method (when k = 5, there is an inflection point, and the square sum in the cluster decreases slowly) and the contour coefficient method (when k = 5, the coefficient reaches a peak value of 0.572, and the clustering effect is the best) , as shown in Figure 3.

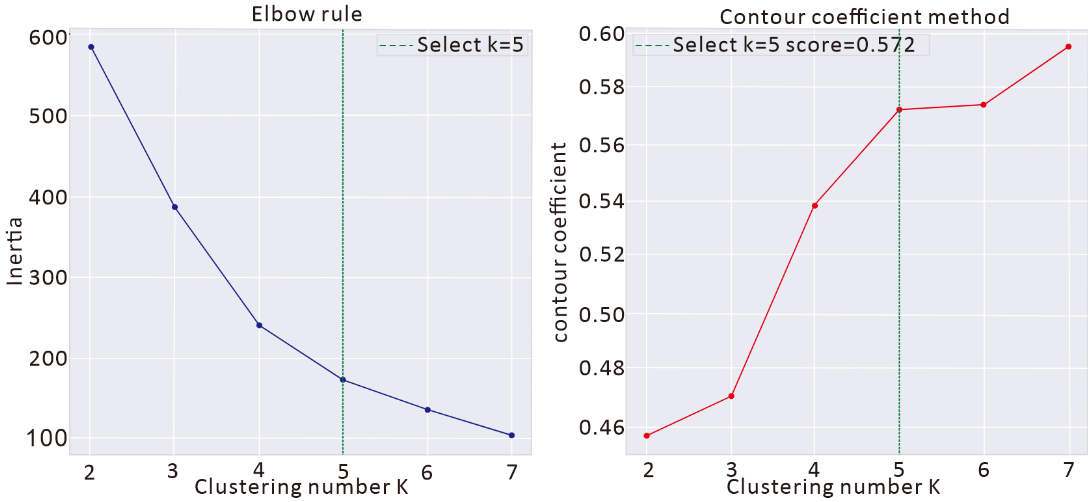

Fig. 3. ESG cognitive clustering elbow rule and contour coefficient method

In order to more intuitively show the differences in ESG cognition among different groups, this chapter uses principal component analysis (PCA) to reduce the dimension of the raw data and draws a cluster scatter plot based on PCA. The figure shows the distribution of the five clusters in two-dimensional space with the first and second principal components as the coordinate axes, as shown in Figure 4.

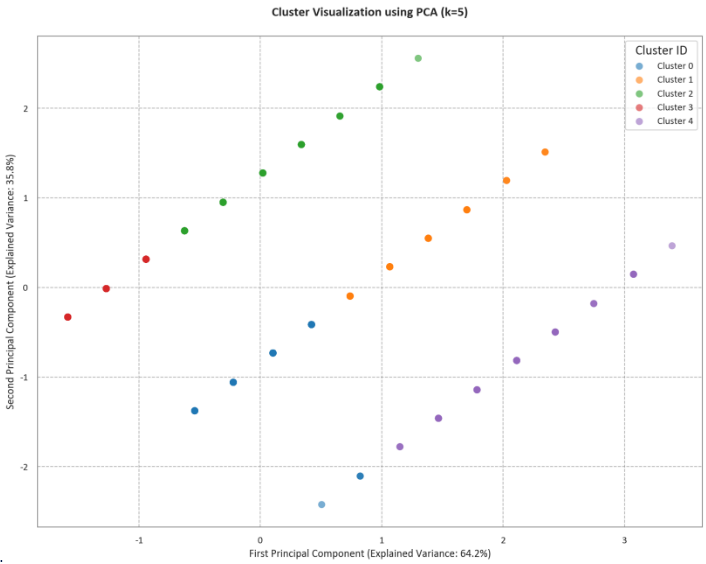

Fig. 4. Clustering visualization based on PCA

Based on the results of the cluster analysis, five types of student groups with distinctive characteristics were identified, as follows:

Practitioners: 143 people (27.7%), with high awareness of ESG (3.72) and high trust of AI (3.00), mainly undergraduates, focusing on humanities, social sciences and arts, are active supporters of smart campus construction, with demonstration potential.

High cognitive skeptics (cluster 0): 126 people (24.4%), high ESG cognition (3.39) and low AI trust (1.97), mainly undergraduates, focusing on humanities and social sciences, agree but doubt AI, It is necessary to rely on technical transparency and ethical education to enhance trust.

Low cognition and high trust: 119 people (23.1%), low ESG cognition (2.50) and high AI trust (3.00), mainly undergraduate and junior college students, across multiple majors, "emphasizing technology over science," need to strengthen interdisciplinary integration education.

General skeptics: 76 people (14.7%), low awareness of ESG (2.22), and low trust in AI (2.00), mainly undergraduates, focusing on humanities and social sciences, double low recognition, general education courses,and publicity are needed to improve awareness.

Technology exclusion group: 52 people (10.1%), low ESG awareness (2.38 points), extremely low AI trust (1.00 points), including some masters and Ph.D.s, cross-humanities, social sciences and natural sciences, and AI empowerment Campus ESG acceptance is low.

3.2 Diagnosis and attribution research on ESG management shortcomings in colleges and universities
3.2.1 Gap in school publicity and perception

In this chapter, the number of publicity awareness is used as the input proxy variable, and the subjective judgment of students on "whether the school is acceptable" is used as the perception index. Cross tabs are constructed, and chi-square tests are carried out. The specific distribution of data supporting this association and the visualization of the correlation trend are presented in Figure 5,the results showed that there was a very significant association between the two ($\chi^2 = 32.073$, $p < 0.001$), and the more publicity the students knew, the higher the proportion of perceived school: 44.8%-51.7% of the students who knew 1-2 publicity items perceived the school; among the students who knew 4 or more publicity items, more than 85.7% felt the school; and 100% of the students who knew the six propaganda items perceived the school. However, it should be noted that 40.7% of the students who are aware of the three promotions still do not perceive the school; and some high publicity investment groups (such as those who know 4 publicity items) have a small sample size, suggesting that there is an imbalance in the school's publicity coverage.

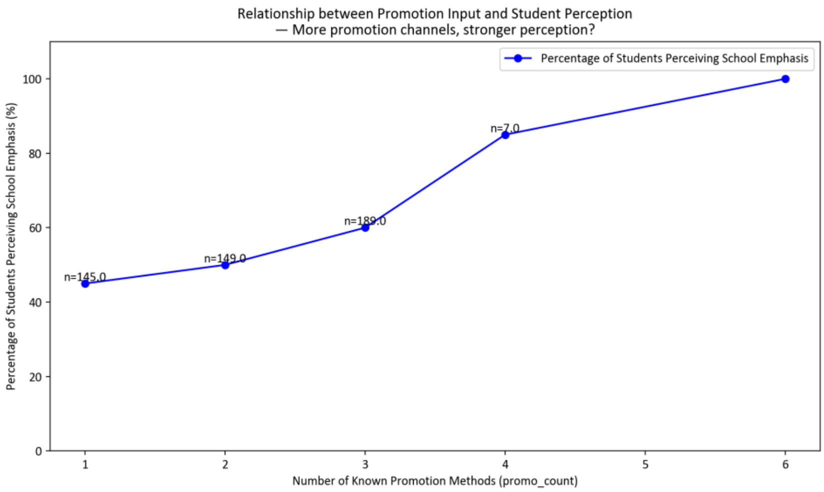

Fig. 5. The relationship between the amount of publicity investment and students' perception

In the analysis of the school's publicity effect, it is also necessary to pay attention to potential problems: even with high publicity investment, there are still situations that students do not perceive-among the students who know the three publicity items, 40.7% said that they do not perceive the school's approval; At the same time, some high-publicity investment groups (such as those who know 4 publicity items) have a small sample size, which suggests that there is an imbalance in the coverage of school publicity work.

In order to judge whether it is suitable for principal component analysis, this part first tests the applicability of five dimensions, including low-carbon infrastructure of campus ESG management: KMO = 0.72 (> 0.6, variable correlation is above medium, factor analysis is required), Bartlett The spherical test is significant ($\chi^2 = 487.32$, $p < 0.001$, rejects the variable independence hypothesis), confirming that the data is suitable for principal component analysis, as shown in Table 1.

Table 1
KMO and Bartlett test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.878
Bartlett's sphericity test	Approximate chi-square	1309.935
	degree of freedom	10
	salience	0.000

In this chapter, principal component analysis is used to extract factors,as shown in Table 2. Only one component has an eigenvalue > 1 (3.433), explaining 68.669% of the variance, and the other components have weak explanatory power. Therefore, extracting the first principal component has a good dimensionality reduction effect and retains most of the original variables. information. Analysis of common factor variance showed that the common factor variance of each variable was 0.660-0.709, and the first principal component could explain 66%-71% of the variance of each variable. The information extraction is sufficient and representative. The component matrix shows that the load coefficients of the five management dimensions on the first principal component are all over 0.80, and they are all positive and highly concentrated. They are strongly positively correlated with the principal component and have the same direction, reflecting the potential comprehensive structure together.

Table 2
Component matrix

	compositions
	1
Low Carbon Infrastructure Management	.828
Resource Recycling Process	.821
ESG Policy Implementation	.840
Monitoring and Disclosure of Environmental Protection Data	.842
Systematic Publicity and Education of Environmental Protection	.813

Based on the above analysis, this section names the first principal component extracted as "Comprehensive Weakness of Campus ESG Management," which is used to reflect students' overall perception of colleges' and universities' dimensional governance capabilities. The specific calculation formula is as follows (see Eq. (1)):

$$\mathrm{Re} = Comprehensive weakness of campus ESG management = 0.828Z1 + 0.821Z2 + 0.840Z3 + 0.842Z4 + 0.813Z5 \quad (1)$$

Among them, Z1 to Z5 represent the standardized values of five original variables, namely, the systematic standardized scores of low-carbon infrastructure management, resource recycling process, ESG policy implementation, environmental protection data monitoring and disclosure, and environmental protection publicity and education.

3.2.3 Construction of a model of influencing factors of campus ESG management effectiveness based on multiple linear regression

Before establishing the regression equation in this chapter, the correlation coefficient analysis shows that the weakness of ESG comprehensive management is significantly negatively correlated with the participation in environmental protection activities and the awareness rate of environmental protection goals and is significantly positively correlated with the degree, and the activity participation is significantly positively correlated with the awareness rate of goals.

Based on this, a multiple linear regression model is established with the influencing factors of ESG management efficiency as the dependent variables and the participation, accessibility, and awareness of environmental protection activities as independent variables (see Eq. (2)):

$$\mathrm{Re} = FactorsAffectingESGManagementEffectiveness = \beta_0 + \beta_1 \times ParticipationinEnvironmentalProtectionActivities + \beta_2 \times Availability + \beta_3 \times EnvironmentalProtectionAwarenessRate + \varepsilon_\mathrm{i} \quad (2)$$

(β_0 is the intercept, β_1- β_3 is the coefficient, ε_i is the random error, obeys the normal distribution of expectation 0 and variance σ^2),and was analyzed by SPSS (significance level 0.05).

Table 3
Results of logistic regression models predicting AI empowerment support

model		Unnormalized coefficient		normalization factor		
		B	Standard error	Beta	t	salience
1	(Constant)	14.701	1.151		12.771	.000
	Participation in Environmental Activities	-1.352	.363	-.162	-3.729	.000
	Sustainable importance	1.031	.385	.115	2.681	.008
	Environmental awareness rate	-.462	.201	-.100	-2.295	.022

The preliminary multiple linear regression model available from the above Table 3 is(see Eq. (3)):

$$\mathrm{Re} = FactorsAffectingESGManagementEffectiveness = 14.701 - 1.352 \times ParticipationinEnvironmentalProtectionActivities + 1.031 \times Availability - 0.462 \times EnvironmentalProtectionAwarenessRate \quad (3)$$

Table 4
Goodness of Fit Summary

model	R	R square
1	.238[a]	.057

Taking the weakness of ESG comprehensive management as the dependent variable, whether to participate in environmental protection activities, whether to be able to, and whether to know environmental protection goals as the independent variables for regression analysis, the ANOVA results show that the regression model is overall significant (F = 10.274, p <. 001); The three independent variables collectively explain the 5.1% variation in ESG integrated management weaknesses (post-R ² = 0.051), and the residual analysis indicates that the data are based on the regression model assumptions.

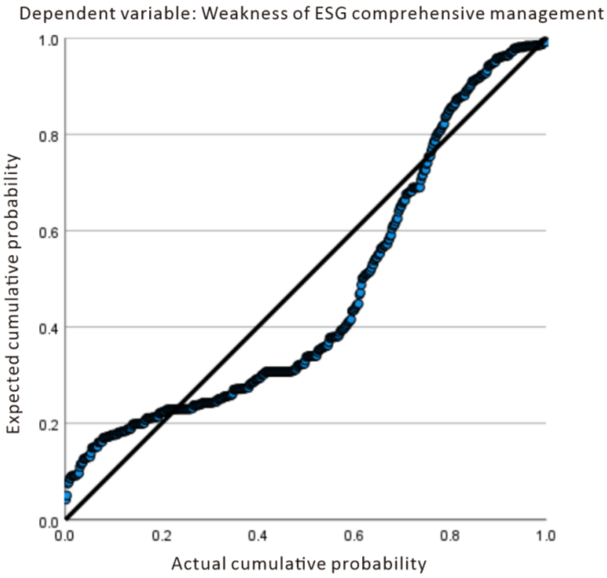

Fig. 6. Normal P-P plot of regression normalized residuals

The Figure 6 above compares the cumulative probability of the standardized residual error of the regression model with the theoretical normal distribution. The horizontal axis is the measured value, and the vertical axis is the expected value. Most of the blue dots are close to the diagonal, indicating that the residual distribution is close to the normal distribution and conforms to the regression premise; only the two ends deviate slightly, and the overall impact is small. To sum up, the standardized residual basically conforms to the normal distribution, which supports the good statistical properties and applicability of the model.

3.3 Precise policy implementation path of AI empowering campus ESG
3.3.1 Status assessment of campus AI empowerment level

Table 5
Distribution of students' evaluation of campus AI empowerment level

		frequency	Percentage
effective	low	56	10.9
	middle	198	38.4
	high	262	50.8
	total	516	100.0

Half of the students (50.8%) believe that the level of AI empowerment in the current campus environmental protection measures is relatively high, but nearly half (49.3%) still believe that it is at a medium or low level, indicating that although the application of AI in campus management has a certain foundation, it still needs to be further promoted and deepened, as shown in Table 5.

3.3.2 Analysis of influencing factors of AI support willingness based on logistic regression

This part is to explore the impact of demographic characteristics, ESG cognition, and AI understanding on students' willingness to support AI-enabled school management. Taking "whether to support AI empowerment" as the dependent variable, the forward LR method is used to do binary logistic regression screening. Significant predictors, and at the same time, campus accessibility, awareness rate of environmental protection goals, participation in environmental protection activities, educational background, and publicity degree are used as independent variables for analysis.

Building the logistics model (see Eq. (4)):

$$\mathrm{Re} = logit(P) = \beta_0 + \beta_1 \times degree + \beta_2 \times Awareness\ rate\ of environmental\ protection\ goals + \beta_3 \times Participation\ in\ Environmental\ Activities + \beta_4 \times Education + \beta_5 \times Degree\ of\ publicity \quad (4)$$

(P is the probability of taking 1 from the dependent variable, β_0 is the intercept, β_1- β_5 is the coefficient of the independent variable), it is preliminarily obtained (see Eq. (5)):

$$\mathrm{Re} = logit(P) = -1.530 + 2.773 \times degree + 0.238 \times Awareness\ rate\ of environmental\ protection\ goals + 0.272 \times Participation\ in\ Environmental\ Activities - 0.499 \times Education - 0.279 \times Degree\ of\ publicity \quad (5)$$

This part uses "whether AI empowerment is supported" as the dependent variable for binary logistic regression: although the model has a slight fitting deviation (Hosmer-Lemeshaw test p = 0.030), it is overall significant (χ^2 = 195.682, p < 0.001), Nagelkerke R ^{2} = 0.425, the classification accuracy rate is 78.9%, and the results are credible. Among the variables, degree has the strongest effect (B = 2.773, p < 0.001, OR = 16.002), and publicity breadth (OR = 1.269) and awareness of environmental protection goals (OR = 1.312) have positive effects; those who participated in environmental protection activities (OR = 0.607) and were highly educated (OR = 0.756) had lower support,as shown in Figure 7.

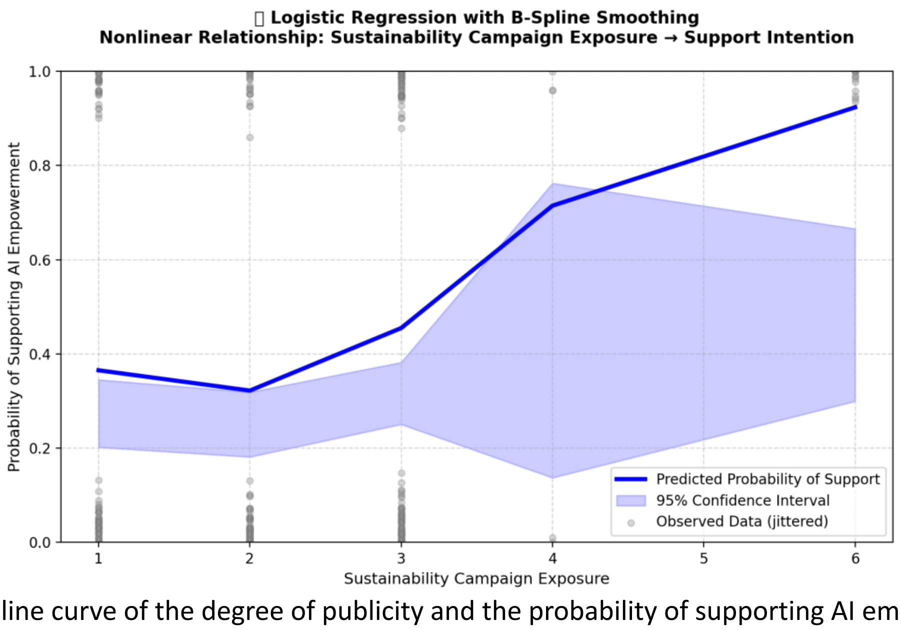

Fig. 7. B-spline curve of the degree of publicity and the probability of supporting AI empowerment

The model evaluation showed that the predicted curves were in good agreement with the real data points, and the 95% confidence interval was narrow, indicating that the model fitting effect and prediction ability were strong.

3.3.3 ESG-AI bidimensional population identification based on K-means clustering

Based on the clustering of ESG cognitive behavior, combined with the implementation of AI empowerment, this chapter re-performs ESG-AI two-dimensional clustering. This section combines ESG cognitive-behavioral clustering and AI empowerment implementation issues to carry out ESG-AI two-dimensional clustering. Before K-means clustering, according to the difference analysis, variables such as campus accessibility and awareness rate of environmental protection goals have a significant impact on AI empowerment support, and participation in environmental protection activities has a significant impact on the weakness of ESG comprehensive management, etc. Variables, as the main basis for clustering.

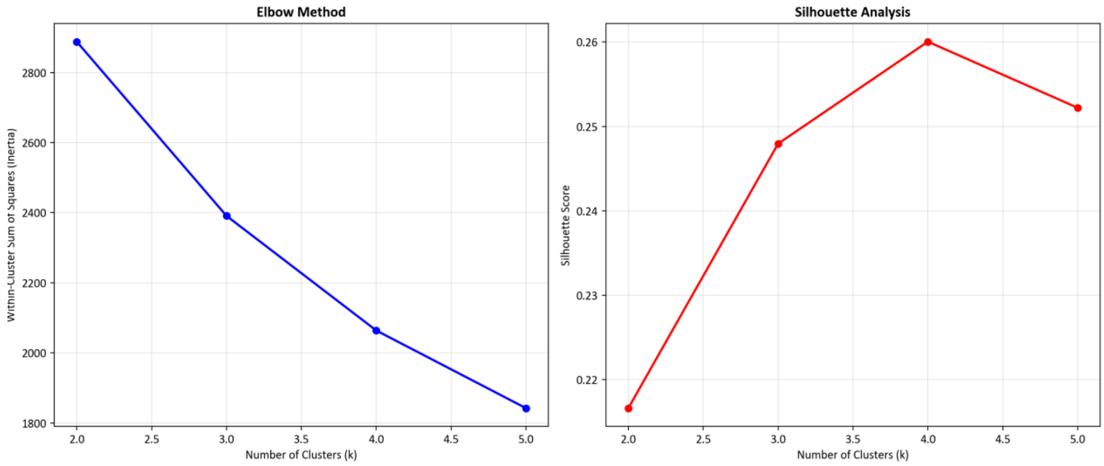

Fig. 8. ESG-AI two-dimensional clustering elbow method and contour coefficient method

The elbow rule and contour coefficient method are combined to determine the cluster number, as shown in Figure 8: the elbow rule shows that k = 3 or 4 is reasonable (the square sum within the cluster decreases significantly when k = 2-3 and slows down after k = 3-4), and the contour coefficient method shows that the coefficient reaches the maximum value of 0.26 when k = 4 (clustering is optimal), so k = 4 is determined. In order to visually display the differences in ESG cognition, K-means is used to cluster the original data, draw a scatter plot illustrating the relationship between ESG comprehensive attitude (horizontal axis) and AI acceptance (vertical axis), as shown in Figure 9, mark 4 clusters, and present their two-dimensional distribution and group characteristics.

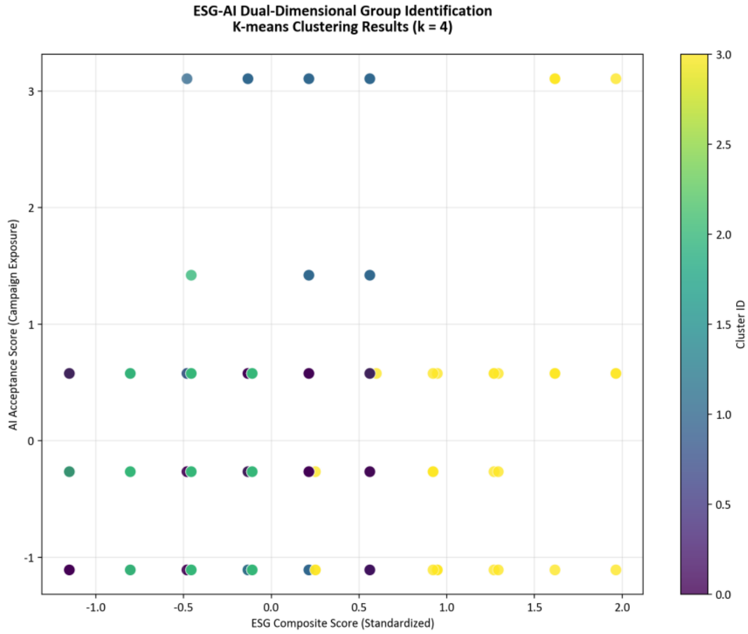

Fig. 9. ESG-AI two-dimensional population identification

Information alienation type (cluster 0): highly educated (1.19), slightly above average (0.13), but low awareness of environmental protection (-0.746), participation (-0.253), publicity (-0.192), rejection of AI (-0.559), and ESG management is weak (0.282). It belongs to the "capable, less active" group and needs to be accurately reached. Green technology advocates (cluster 1): high accessibility (0.811), environmental awareness (0.221), publicity (0.344), support for AI (1.092), relatively complete ESG management (0.096), education (-0.186), and participation (-0.253) to be improved; has the potential of opinion leaders.

Double disconnection type (cluster 2): Can (-0.886), participation (-0.253), publicity (-0.26), rejection of AI (-0.796), education (-0.511), and ESG management (-0.326) are the weakest; there is a need to supplement environmental education and digital literacy.

Practice pioneers (cluster 3): extremely high environmental protection participation (3.955), but low environmental protection awareness (0.183), low environmental protection awareness (-0.473), generally support AI (0.263), weak ESG management (0.498), and need to transform actions into concept recognition.

4. Conclusion

Based on the UN Sustainable Development Goal 4 (SDG 4) and China's "Education Power Building Outline (2024–2035)" issued by the Central Committee of the Communist Party of China and the State Council, which proposes to "open up new tracks for development and shape new advantages through the digitalization of education" and explicitly emphasizes "promoting artificial intelligence to facilitate educational transformation," the following conclusions are drawn:

As a fundamental component of sustainable development, the ESG framework reveals a discernible gender-based disparity in awareness and engagement. Specifically, male respondents demonstrate greater attentiveness to ESG issues than their female counterparts. This disparity stems primarily from the environmental dimension of ESG, which is intrinsically linked to technical fields such as environmental engineering, data management, and technology—domains historically characterized by male predominance. The gender-skewed occupational structure within these sectors inherently constrains female participation and interest in ESG-related discourse. At the disciplinary level, a counterintuitive pattern emerges. Students specializing in agriculture, medicine, humanities, and social sciences exhibit markedly higher self-assessed ESG awareness compared to those in STEM (Science, Technology, Engineering, and Mathematics) disciplines. This phenomenon can be attributed to the intrinsic congruence between the core concerns of the former fields—including ecological sustainability, social equity, and governance—and the foundational tenets of ESG. Conversely, STEM disciplines prioritize technical execution and operational efficiency, frequently entailing energy-intensive research processes that contravene ESG ideals such as carbon neutrality and zero-waste objectives. This misalignment engenders not only technological and economic challenges but also diminishes identification and engagement with ESG frameworks among STEM students.

Based on previous research findings, educational level, disciplinary background, and trust in AI have been identified as significant factors influencing students' ESG awareness. Therefore, this study employs K-means clustering analysis, using these three variables as the basis for clustering, and categorizes the results into five distinct groups. Among these, the category of "Ideal Practitioners" warrants particular attention. This group demonstrates a strong understanding and acceptance of both ESG and AI should be guided to transition from active supporters to innovative practitioners, promoting ESG principles on campus and serving as role models. Meanwhile, the category of "Low Awareness-High Trust" individuals also requires focus. These students tend to prioritize technical skills over conceptual understanding and could benefit from collaborative learning activities designed to enhance their ESG awareness through practice. This approach would help channel their trust in technology toward a deeper comprehension of the broader implications of sustainable development.

To tackle the challenges of "unidimensional assessment and difficulty in quantifying overall weakness" in university ESG management, this study initially identifies core variables influencing campus ESG management effectiveness and their interrelationships through correlation coefficient analysis. Building upon these key variables, principal component analysis is subsequently conducted to integrate multidimensional information, ultimately deriving a quantitative equation for the "Comprehensive Weakness Index of Campus ESG Management." The results demonstrate that the Comprehensive Weakness Index exhibits a significant negative correlation with participation in environmental activities and awareness rates of environmental goals, while exhibiting a significant positive correlation with the prioritization of sustainable development. Furthermore, a significant positive correlation exists between participation in environmental activities and awareness rates of environmental goals. Prospectively, universities should pursue synergistic advancements across five dimensions: developing comprehensive policy frameworks, enhancing resource integration and cross-departmental collaboration, establishing regular evaluation mechanisms, promoting technological innovation and application, and strengthening engagement mechanisms for faculty and students. Only through such multifaceted strategies can institutions effectively mitigate management deficiencies and holistically enhance the overall effectiveness of campus ESG management.

Finally, this study employs two-dimensional K-means clustering to categorize ESG-AI engagement into four distinct profiles. The "Green Tech Advocates" demonstrate robust cognitive internalization of sustainability principles and high receptivity to AI-enabled solutions, constituting a pivotal cohort for advancing AI-driven sustainability initiatives. Nevertheless, their practical influence remains constrained by educational attainment and participation barriers, underscoring the imperative to translate cognitive potential into actionable leadership through enhanced knowledge structures and innovative practice. Conversely, the "Dual-Disconnected" group exhibits significant deficits across cognitive, attitudinal, behavioral, and technological dimensions, primarily attributable to disciplinary isolation and informational insularity, which engender limited motivation and capability. Targeted interventions should establish connections between sustainability topics and personal interests, leverage AI development opportunities, and harness peer effects to transition this demographic from passive observers to active participants.

In summary, while AI provides a foundational tool for enhancing sustainability management in universities, its broader implementation encounters both opportunities and challenges. Opportunities include using big data analytics and machine learning for precise ESG assessment, dynamic monitoring, and optimized resource allocation—enabling improved energy efficiency and cost reduction. Key challenges consist of limited student awareness of AI applications in sustainability, hindering adoption; and operational bottlenecks such as fragmented data systems, insufficient sensing infrastructure, the energy paradox of AI models, and high costs with uncertain returns—collectively impeding scalable deployment.

Grounding the analysis in ESG awareness, this study systematically evaluates current ESG management practices in Zhejiang Province's higher education institutions. It introduces an integrated "ESG + Digital AI" management model, aligning with digital transformation trends to support the transition toward sustainable, smart higher education. However, the study has several limitations, including a sample that does not distinguish among university types (*e.g., "Double First-Class," ordinary undergraduate, vocational, public, or private institutions*) and a narrow focus on students, omitting views from administrators, faculty, and external partners. Future research should incorporate qualitative methods such as interviews, include multi-stakeholder perspectives, and employ longitudinal designs to better assess outcomes and causal mechanisms.

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