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Examining the role of transformational leadership in promoting sustainable practices among university teachers in Guangdong

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ABSTRACT

Sustainability is an important issue for universities worldwide, especially in fast-growing regions such as Guangdong Province, China. Although higher education institutions increasingly focus on sustainability, a gap remains between the promotion of sustainability by academic leaders and its actual implementation by educators. This study examines how transformational leadership influences sustainable practices in universities in Guangdong Province. Specifically, it explores the impact of transformational leadership on university teachers' attitudes, subjective norms, and behaviors related to sustainability. The research is based on a sample of 421 university teachers, selected using a stratified random sampling method. Structural equation modeling was conducted using SmartPLS 4 to analyze the data and measure these relationships. The findings show that transformational leadership significantly improves teachers' positive attitudes toward sustainability but does not directly increase their engagement in sustainable practices. This result reveals a gap between leaders' intentions and teachers' actions. The study provides useful insights for academic leaders and policymakers aiming to promote sustainability in higher education institutions.

1. Introduction

Sustainability is a global concern and has attracted the attention of many scholars in the field of education. Universities serve as centers of knowledge and innovation, placing them at the forefront of establishing and promoting sustainable practices (Zaidi et al., 2023; Warwick, 2016). Leadership is crucial in organizing and coordinating these efforts, particularly in Guangdong, where rapid urbanization and socioeconomic growth demand adaptive leadership strategies that integrate sustainability goals (Chung et al., 2023; Lin and Chiu, 2018). Academic leadership sets policies and practices towards sustainability while ensuring that culture values it. However, we do not know much about how this leadership affects policy and practice in these institutions (particularly universities in Guangdong) or about the culture behind them. This study combines transformational leadership theory with the theory of planned behavior (TPB) to examine how leadership shapes policies and a culture that prioritizes sustainability. In Guangdong's context, the integration of these theories is particularly relevant because of the interplay between traditional hierarchical structures and the province's progressive stance on sustainability. Transformational leadership's focus on inspiration and vision is well suited to align with Guangdong's collectivist ethos, where leaders are often seen as moral exemplars who guide institutional values (Chung et al., 2023). This alignment enables leaders to not only influence individual attitudes and behaviors but also institutionalize sustainability within the unique sociocultural framework of Guangdong. The researchers in this study define 'sustainable practices' as a range of behaviors designed to promote environmental stability, social well-being, and economic resilience in university environments. This covers things such as becoming involved with sustainability initiatives on campus, using sustainable resources for academic work, or simply advocating for others to make more eco-friendly choices in their day-to-day life. These actions also take shape at an institutional level by committing to saving energy and reducing waste while individuals have personal commitments embedded in their

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values (D'Amato and Korhonen, 2021; Aikens et al., 2018). In addition, educators have a significant effect on the 'leadership' component of this study, as they have the potential to form student views by influencing their behaviors towards sustainability. They can achieve this by captivating and motivating those in their vicinity with a distinct and vivid depiction of what sustainability entails while fostering ingenuity and accountability for environmental initiatives (Chitpin, 2020).

In this study, we aimed to investigate the relationship between 'leadership' and 'sustainable practices' within universities in Guangdong Province, with a specific focus on how leadership influences the active involvement of university teachers in these practices. We also examined different leadership styles and behaviors that foster, institutionalize, and promote sustainable practices within the academic environment. By analyzing the role of leadership in promoting sustainability among university educators in this region, we sought to understand how effective leadership can enhance the implementation of sustainable practices at higher education institutions.

2. Literature review

2.1. Sustainability and leadership in universities

Leadership in universities is key to sustainable practices. In higher education, the responsibility of leaders, policymakers, and academics is to turn potential into reality. Recent research underscores the importance of inclusive and systemic thinking in addressing sustainability challenges, as highlighted by Filho et al. (2020). This approach is particularly relevant for Guangdong universities, where sociocultural dynamics require tailored strategies to foster sustainability (Yu, 2023; Chung et al., 2023). However, these efforts are often hindered by resource limitations and varying levels of institutional commitment (Gallos and Bolman, 2021).

Faculty and staff also play significant roles within the context of leadership. Brinkhurst et al. (2011) characterized them as 'intrapreneurs' and established their crucial role in attaining campus sustainability. They operate internally, connecting the divide between hierarchical instructions and grassroots methods. According to Lee and Schaltegger (2014), leadership has a significant effect on our total learning process. The promotion of sustainability in curricula is strongly influenced by this approach. A combination of top-down and bottom-up initiatives is necessary to maintain a well-rounded approach to sustainability in all areas of education.

It is crucial to acknowledge the presence of students in this context as well. Warwick (2016) emphasized the importance of assigning leadership positions to achieve successful reform in higher education efforts. Students serve as internal catalysts for change, with their involvement being a crucial factor, if not the primary driving force, behind successful initiatives.

Universities and other organizations are always worth studying from a cross-cultural perspective. According to Yu (2023), cultural context helps define what should be done to ensure sustainability in colleges. Nevertheless, the leadership styles used across these colleges vary depending on the culture involved. This difference shows why it is necessary to apply strategies that are relevant only within particular settings so that we can appreciate alternate values prioritized by different societies as they strive towards their goals.

Finally, the tiers of leaders involved in making universities sustainable were discussed by Azizi (2023). These distributed nature theories and those advocating for environmental preservation also serve us with the knowledge complexity of the roles played during change sustainability at higher education levels.

2.2. Sustainability practices in Chinese universities

A comparative study by Wang et al. (2023) revealed that students in private universities demonstrated greater commitment to sustainability initiatives than did those in public institutions. This disparity is attributed to higher levels of engagement in sustainable campus activities and stronger stakeholder collaboration at the institutional level, a pattern observable in Guangdong's higher education landscape as well (Chung et al., 2023). The research revealed that, depending on what category they fall under, colleges may differ in terms of effectiveness in regard to pushing for sustainable actions as well as involving students in such moves.

Chinese universities have integrated sustainability into their programs of entrepreneurship education. Sustainability is infused into educational curricula by modularizing courses, employing interactive teaching modes, and adopting a strong three-dimensional teaching support system that embeds sustainability in every part.

Jiang et al. (2020) researched how design-based learning can be implemented in engineering education, especially in joint undergraduate programs between China and Australia. This has been proven to be an effective way to integrate various knowledge systems and promote sustainable development, particularly at regional colleges and universities in China. These types of educational innovations represent approaches to teaching that are consistent with sustainable development goals.

Niu et al. (2010) described the difficulties and possibilities of promoting sustainable development education in Chinese higher education. They identified challenges such as addressing regional imbalances and spreading educational approaches among other disciplines—indicating that there is still no consistent implementation of sustainability-focused education across regions and areas of study. Pang et al. (2017) noted several foundational

principles for sustainable higher education, which involve implementing regulatory systems that prioritize academic excellence, promoting new teaching methods, merging disciplines together, cultivating competency-based schooling, providing incentives to teachers, and adopting a global perspective. These principles reflect an all-encompassing view of what should be done towards achieving sustainability within universities, both intellectually and administratively speaking.

Students' behavior in terms of environmental sustainability is another important aspect. Wang et al. (2023) used the theory of value-belief norms and environmental consciousness as indicators to evaluate the environmentally sustainable behavior of college students in China. Researchers have found that personal values and beliefs play an important role in shaping sustainable actions according to broader theories based on extended values and belief norms.

Shuqin et al. (2019) developed a system for assessing sustainable campuses that measure different aspects of sustainability within higher education institutions, such as management, energy-saving methods, and eco-friendliness. Through this tool, many dimensions, from operational to cultural, can be examined when discussing what it means for universities to be sustainable.

From the above literature review, it is clear that the sustainability practices of Chinese universities are varied and dynamic. This approach is characterized not only by innovative teaching methods and active student participation but also by a comprehensive approach that considers both the academic content and the operational sustainability of the university environment.

2.3. Sustainability and leadership in the context of Guangdong

Guangdong Province, as a rapidly urbanizing region within China, presents a distinctive sociocultural and economic context that shapes the sustainability and leadership of universities. The province's integration into the Greater Bay Area has increased global influence, necessitating leadership approaches that balance traditional Chinese cultural norms with progressive sustainability goals (Chung et al., 2023; Lin and Chiu, 2018). For example, the collectivist culture prevalent in Guangdong emphasizes group harmony and consensus, which aligns with transformational leadership's focus on fostering collaboration and shared goals. However, fast-paced economic development and diverse demographic landscapes also demand adaptive leadership that can navigate the competing priorities of economic growth and environmental stewardship. This duality highlights the need for transformational leaders who can integrate sociocultural values with innovative strategies to promote sustainability within academic institutions. According to Wenxiang (2024), the president's responsibility system, supervised by the university party committee, is highly important. Furthermore, emphasis should be placed on talent development with investment in education and internationalization; all these elements indicate a comprehensive strategy aimed at transforming the region's educational landscape. Furthermore, Liu et al. (2019) identified the Guangdong University of Finance and Economics Library as a leading example of sustainable infrastructure. This library is an illustration of sustainable practices in university buildings, as it uses land resources intensively and optimizes indoor environment greening three-dimensionally. These actions demonstrate how sustainability has been incorporated into educational programs at higher learning institutions in addition to physically developing such schools.

A shift toward sustainable energy education is also evident in the Guangdong–Hong Kong–Macao Greater Bay Area. Institutions such as Sun Yat-sen University Chinese University Hong Kong University Macao are enhancing their renewable energy curricula, as observed by Chung et al. (2023). This transition indicates a broader commitment of sustainability regions' academic institutions to aligning global trends with regional sustainability goals.

In this study, Cao et al. (2015) looked at the Guangdong Sustainable Experimental Community, which seeks to embed sustainability principles into the wider community and affects university projects. This initiative underscores the imperative of collaborative innovation in propelling sustainable development and highlights how higher education institutions can trigger regional sustainability endeavors among participants. According to Lin and Chiu (2018), investments made in low-carbon energy infrastructures such as those found within the educational sector play a critical role in achieving sustainable economic growth at the local level while also mitigating climate change through reduced GHG emissions. Such commitment aligns with broader environmental targets set by both city authorities and central government agencies alike."

Guangdong sustainability leadership universities are closely connected to the region's wider objectives of scientific advancement, sustainable infrastructure, renewable energy, education, and community involvement. Universities in Guangdong play a crucial role in achieving sustainability goals, as evidenced by their leadership in curricular offerings, infrastructure development, and community projects.

2.4. Theoretical framework and research model

The integration of the theories of transformational leadership and planned behavior is at the heart of this theoretical framework. In doing so, it examines how leadership affects sustainable practices in institutions of higher learning. According to Bass et al.'s (1996), transformational leadership theory, leaders are portrayed as those who inspire followers to change for the better through them. The

theory also recognizes four key features of such leaders: Idealized influence (charisma), inspirational motivation, intellectual stimulation, and individualized consideration or empathy toward others' needs. This study seeks to understand how these qualities can be utilized by university managers, as they aim to foster ecological initiatives among their students and staff alike.

Ajzen (1991) introduced the theory of planned behavior (TPB), which proposes that an individual's behavior is determined by his or her intention to perform the behavior. Attitudes toward behavior, subjective norms, and perceived behavioral control also influence self-efficacy (Ajzen, 1991). With respect to this study, the TPB provides a framework for understanding how attitudes, norms, and beliefs about sustainability shape university settings.

Fig. 1 illustrates the integration of these two ideas within the study model. According to the model, the integration of transformational leadership concepts has a beneficial effect on the three components of the TPB, which in turn influences sustainability practices. This encompasses the influence of leaders on shaping attitudes toward sustainability, the subjective standards surrounding sustainable behaviors, and the perceived ability to regulate and implement these practices.

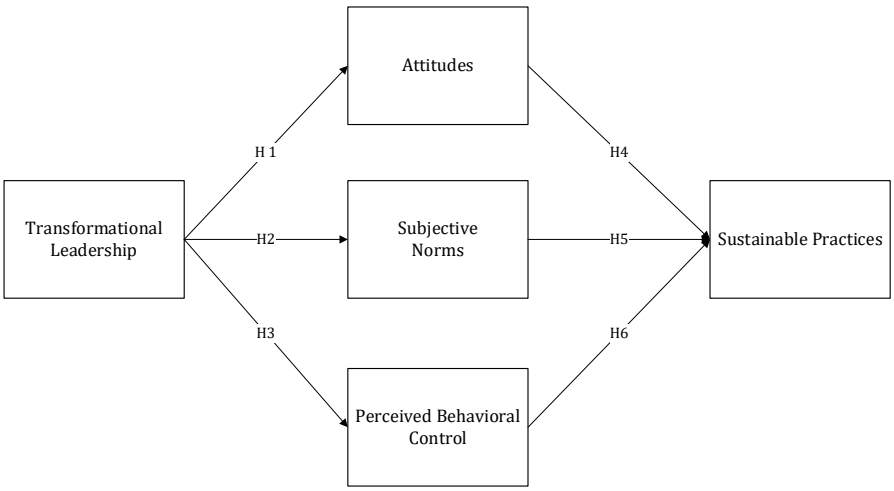

Fig. 1: Research model

In this proposed study, the variable framework looks at how leadership affects overall sustainable practices within universities. The independent variable under consideration is transformational leadership. It is perceived as a holistic phenomenon that encompasses more than a single notion. Instead, it represents the influence that specific types of leaders can have on sustainability activities. The mediating variables are derived from the TPB and include attitudes toward sustainability, subjective norms regarding sustainability, and perceived behavioral control over sustainability actions. These variables mediate how transformational leadership impacts a university community's overall engagement with environmentalism. The dependent variable is Engagement in Sustainable Practices, which measures all sorts of actions taken by individuals within the university to help attain sustainability goals. With this model, we should be able to clearly determine exactly what effects different leadership styles have on sustainable practices. On the basis of the above research model, we propose the following research hypotheses:

H1: Transformational leadership is positively associated with more favorable attitudes toward sustainability within universities.
H2: Transformational leadership is positively associated with stronger subjective norms supporting sustainability within universities.
H3: Transformational leadership is positively associated with greater perceived behavioral control over sustainability actions within universities.
H4: More favorable attitudes toward sustainability are associated with greater engagement in sustainable practices.
H5: Stronger subjective norms supporting sustainability are associated with greater engagement in sustainable practices.
H6: Greater perceived behavioral control over sustainability actions is associated with greater engagement in sustainable practices.

This research model and the corresponding hypotheses allow for a nuanced exploration of how leadership influences sustainability in higher education. By analyzing these relationships within the context of Guangdong University, this study aims to provide valuable insights into the dynamics of leadership and sustainability in the academic sector.

3. Methodology

3.1. Research design

The quantitative approach adhered to the research design of this study. The data were collected from various sources, including university lecturers and institutional documents on policies related to sustainability, among others. This choice

of approach is based on its ability to measure with accuracy and objectivity the relationships that take place between different variables. We measured transformational leadership against sustainable practices in higher education institutions; attitudes, subjective norms, and perceived behavioral control were also measured on the basis of the theory of planned behavior.

We aimed to investigate the direct and indirect impacts of transformational leadership on involvement in sustainable practices among universities via statistical hypothesis testing through theoretical framework-based quantitative design methods. We specifically sought to determine how individuals' attitudes, norms, and perceived control over sustainability actions are influenced by transformational leadership, which in turn leads to sustainable behavior.

3.2. Sample and setting

The sample size was determined via Cochran's formula (Cochran, 1977), a statistical approach tailored for finite population surveys. Other scholars have used this formula to determine research samples (Tang et al., 2023).

This formula incorporates critical parameters such as a 95% confidence level with a corresponding Z score of 1.96 and a margin of error set at 5%. In the absence of precise preexisting data, the proportion (p) of the attribute of interest in the population was conservatively estimated at 50%.

Cochran's formula is expressed as:

$$N_0 = \frac{Z^2 \times p \times (1 - p)}{E^2}$$

where, N_0 is the sample size; Z is the z value (in this case, 1.96 for a 95% confidence level); p is the estimated proportion of the population that has the attribute in question (set at 0.5 for maximum variance); E is the desired precision (in this case, 0.05 represents a 5% margin of error).

Connecting these values into the formula results in $N_0 = 384.16$

Thus, the initial sample size confirmed by this formula should be 384. Hence, the final calculated sample size for this study was determined to be 384.

3.3. Data collection methods

Wenjuanxing (www.wjx.cn), a commonly used and reliable online survey platform in China, conducted the survey, stratifying the sample to ensure representativeness across academic ranks and institutions. We adapted measurement tools from established scales and tailored them to the specific context of Guangdong universities, ensuring alignment with the study's objectives and providing a nuanced assessment of transformational leadership and sustainability practices.

We designed survey questions on the basis of our research purpose. After consulting many sources, we devised a series of well-organized inquiries that effectively assessed the following variables: transformational leadership, attitudes toward sustainability, subjective norms, perceived behavioral control, and engagement in sustainable practices. These scales have been tailored to meet the needs of higher education institutions in Guangdong. The questionnaire also included demographic inquiries that we utilized to collect contextual information about the participants, such as their position within the university and the type of institution with which they were affiliated.

3.4. Data analysis

This study carried out data analysis via SmartPLS 4, a powerful tool for partial least squares structural equation modeling (PLS-SEM). SmartPLS-4 is widely utilized by academics for handling complex data and modeling intricate relationships between variables. We began with initial descriptive statistics to determine the characteristics of the sample. Next, we employed PLS-SEM to analyze the data, which allowed us to assess the structural relationships among the constructs. Specifically, we aimed to determine whether transformational leadership had any direct or indirect effects on sustainable practices. The evaluation of the model fit was conducted via key indices such as the standardized root mean square residual (SRMR), the normed fit index (NFI), and the R-squared (R^2) values.

3.5. Variable measurement

The variables were measured via items adapted from established scales in the literature (e.g., "I found it easy to use" for perceived ease of use). These items were selected and modified for the context of higher education in Guangdong, China. The 5-point Likert scale was chosen to allow a nuanced capture of participants' responses, where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, and 5=Strongly Agree. An overview of how source items from the literature and adapted items used in this study compare is provided below, including references, as shown in Table 1.

4. Results

4.1. Demographic

The demographic profiles of the respondents provide a well-rounded understanding of the participants in the study. The survey, conducted in January 2024 among 421 university teachers in Guangdong Province, achieved a strong response rate, demonstrating the relevance of the research. As shown in Table 2, the sex distribution was relatively balanced, with 219 female and 202 male participants. In terms of position, most respondents

were teachers (322), followed by teaching assistants (99). With respect to academic rank, the majority were assistant teachers (128), associate professors (130), and lecturers (121), with professors making up a smaller portion (42). The respondents also varied in employment type, with 335 being full-time and 86 being part-time. The age distribution ranged from 25 to over 65 years, with the highest representation in the 35–44 (140) and 45–54 (121) age groups, reflecting a mix of early-career, middle-career, and senior educators.

Table 1: Measurement items

Variable	Source items(literature)	Adapted items (this study)	References
Transformational leadership (TL)	Demonstrates confidence in followers' abilities Encourages thinking about problems in new ways Has a clear sense of where the organization is going? Is optimistic about the future Encourages followers to think for themselves	TL-1. I feel inspired by my leader's vision for sustainability TL-2. My leader encourages innovative approaches to sustainability TL3. My leader communicates a clear sustainability agenda TL4. My leader is positive about our sustainability prospects TL5. My leader supports autonomy in sustainability initiatives	Carless et al. (2000)
Attitudes toward sustainability (ATS)	Belief in the importance of environmental reporting for sustainable development Perceived social expectation to engage in environmental reporting Self-assessment of the ability to produce accurate environmental reports	ATS-1. I believe that sustainability is crucial for our university's future ATS-2. I value the role of sustainability in academic settings ATS-3. Sustainability is an important factor in my university decisions	Alam et al. (2020)
Subjective norms regarding sustainability (SNRS)	Attitude towards the environmental impact of personal consumption Influence of family and friends on sustainable consumption choices	SNRS-1. There is a strong social expectation to engage in sustainability at my university. SNRS-2. My peers and colleagues value sustainability practices	Matharu et al. (2020)
Perceived Behavioral control over sustainability actions (PBCSA)	Confidence in one's ability to make sustainable consumption choices	PBCSA-1. I feel capable of contributing to sustainability initiatives at my university	Matharu et al. (2020)
Engagement in sustainable practices (ESP)	Intention to buy sustainably sourced food products Preference for environmentally friendly packaging Willingness to pay a premium for sustainable food products	ESP-1. I actively participate in sustainability initiatives at my university ESP-2. I prefer using sustainable resources in my academic work ESP-3. I advocate for sustainable practices among my peers	Dowd and Burke (2013)

Table 2: Demographic information

Category	Options	Gender		Total
		Female	Male	
Position	Teacher	171(53.1%)	151(46.9%)	322
	Teaching assistant	48(48.5%)	51(51.5%)	99
Designation	Assistant teacher	68(53.1%)	60(46.9%)	128
	Associate professor	67(51.5%)	63(48.5%)	130
	Lecturer	63(52.1%)	58(47.9%)	121
	Professor	21(50.0%)	21(50.0%)	42
Type of employment	Full-time	178(53.1%)	157(46.9%)	335
	Part-time	41(47.7%)	45(52.3%)	86
Age group	25-34	54(57.4%)	40(42.6%)	94
	35-44	71(50.7%)	69(49.3%)	140
	45-54	64(52.9%)	57(47.1%)	121
	55-64	20(40.8%)	29(59.2%)	49
	65 or older	10(58.8%)	7(41.2%)	17

4.2. Validation of reliability and validity

The reliability of the survey instrument was assessed via Cronbach's alpha, a commonly used measure of internal consistency.

As shown in Table 3, the reliability and validity assessment of the constructs in this study reveal varying levels of internal consistency and construct reliability. Attitudes toward sustainability (ATS) and engagement in sustainable practices (ESP) exhibit moderate internal consistency, with Cronbach's alpha values of 0.584 and 0.529, respectively, both falling below the ideal threshold of 0.7. However, the composite reliability (rho_c) values for ATS (0.782) and ESP (0.761) suggest that these constructs are reliably measured, with AVE values of 0.547 and 0.514, respectively, indicating acceptable convergent validity. The SNRS has the lowest internal consistency, with a Cronbach's alpha of 0.405. While this value indicates a limitation in internal consistency, additional evaluations using composite reliability (rho_c=0.768) and average variance extracted (AVE=0.625) suggest that the construct retains adequate validity. To address this issue further, future studies could enhance reliability by employing a larger and more diverse sample to reduce variability and better capture the construct's dimensions. Moreover, refinements in the data collection processes and validation protocols are recommended to improve the overall robustness of the measurements. TL demonstrates the strongest internal consistency, with a Cronbach's alpha of 0.725 and high composite reliability (rho_a=0.851, rho_c=0.819), although its AVE of 0.483 is slightly

below the preferred threshold, suggesting that further refinement may enhance its convergent validity. Overall, while some constructs exhibit lower-than-ideal internal consistency, the composite reliability and AVE values indicate that the constructs are generally reliable and valid.

Table 3: Reliability and validity assessment of the constructs

Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ATS	0.584	0.595	0.782	0.547
ESP	0.529	0.528	0.761	0.514
SNRS	0.405	0.418	0.768	0.625
TL	0.725	0.851	0.819	0.483

4.3. SEM test

Table 4 presents the path coefficients from the structural equation modeling analysis, highlighting the relationships between variables. The strongest direct effect observed is between TL and ATS, with a path coefficient of 0.686, indicating that transformational leadership significantly influences positive attitudes toward sustainability. This is followed by the effect of TL on SNRS (0.590) and PBCSA1 (0.444), suggesting that leadership also has a substantial effect on social norms and perceived behavioral control. With respect to the impact on sustainable practices, ATS has the strongest direct effect on ESP (0.345), followed by SNRS (0.234) and PBCSA (0.186). These results imply that while all three mediators—ATS, SNRS, and PBCSA—are important in driving engagement in sustainable practices, attitudes toward sustainability have the most significant influence. Overall, the path coefficients underscore the critical role of transformational leadership in shaping attitudes, norms, and perceptions that collectively foster sustainable behaviors within academic institutions.

Table 4: Path coefficients of relationships among the variables

Path relationships	Path coefficients
ATS -> ESP	0.345
PBCSA -> ESP	0.186
SNRS -> ESP	0.234
TL -> ATS	0.686
TL -> PBCSA	0.444
TL -> SNRS	0.590

Table 5 shows the statistical results for the relationships between the study variables. The original path coefficients (O) and the sample means (M) are very similar, suggesting that the data is consistent. All t-values are higher than the threshold of 1.96, and the p-values are all below 0.001. This means the relationships found are statistically significant. The strongest link is between transformational leadership (TL) and attitudes toward sustainability (ATS), with a coefficient of 0.686 ($T = 28.537$, $p < 0.01$). This indicates that transformational leadership has a strong effect on shaping positive attitudes toward sustainability. TL also has a strong effect on subjective norms regarding sustainability (SNRS) with a coefficient of 0.590 ($T = 18.620$, $p < 0.01$), and a moderate effect on perceived behavioral control over sustainability actions (PBCSA), with a coefficient of 0.444 ($T = 10.041$, $p < 0.01$).

Among the three mediators that affect engagement in sustainable practices (ESP), attitudes toward sustainability (ATS) has the strongest effect ($O = 0.345$, $T = 7.741$, $p < 0.01$), followed by SNRS ($O = 0.234$, $T = 4.930$, $p < 0.01$), and PBCSA ($O = 0.186$, $T = 4.118$, $p < 0.01$). These findings highlight that attitudes play the most important role in encouraging sustainable behavior, and that transformational leadership helps shape both these attitudes and related social norms in university settings.

Table 6 presents the specific indirect effects of TL on ESP through three mediators: SNRS, PBCSA, and ATS. The analysis reveals that TL has the strongest indirect effect on ESP through ATSs, with a value of 0.237, indicating that attitudes toward sustainability significantly mediate the relationship between leadership and sustainable practices. This suggests that leadership's influence on sustainability is most effectively channeled through enhancing positive attitudes among university teachers. The indirect effect through SNRS is also notable, with a value of 0.138, demonstrating that social norms play a crucial role in linking leadership with sustainable behavior. However, the indirect effect of TL on ESP through PBCSA is the weakest at 0.083, suggesting that while perceived control over sustainability actions contributes to the mediation, its impact is comparatively less significant. Thus, the results underscore the importance of fostering positive attitudes and social norms to effectively translate transformational leadership into sustainable practices within academic institutions.

Table 5: Path coefficients, t statistics, and p values for key relationships

Path relationships	Original sample (O)	Sample mean (M)	Standard deviation (SD)	T-statistics (|O/SD|)	P-values
ATS -> ESP	0.345	0.347	0.045	7.741	0.00*
PBCSA> ESP	0.186	0.187	0.045	4.118	0.00*
SNRS> ESP	0.234	0.236	0.048	4.93	0.00*
TL-> ATS	0.686	0.689	0.024	28.537	0.00*
TL > PBCSA	0.444	0.446	0.044	10.041	0.00*
TL > SNRS	0.59	0.592	0.032	18.62	0.00*

*: $p < 0.01$

Table 6: Specific indirect effects of variables

Variables	Specific indirect effects
TL -> SNRS -> ESP	0.138
TL -> PBCSA -> ESP	0.083
TL -> ATS -> ESP	0.237

The model fit indices presented in Table 7 indicate that the structural equation model has a generally acceptable fit with the data, although there are areas for improvement. The SRMR values for both the saturated (0.087) and estimated (0.096) models are below the threshold of 0.10, suggesting that the model's residuals are small and that the fit is good. The d_ULS and d_G values are also low, further indicating that the model covariance structure closely aligns with the observed data. However, the chi-square values (607.141 for the saturated model and 653.414 for the estimated model) suggest that while the model fits reasonably well, it may benefit from refinement. The normed fit index (NFI) values of 0.649 and 0.623 for the saturated and estimated models, respectively, are below the ideal threshold of 0.90, indicating that the model does not fit as well as desired and could be improved to enhance its explanatory power in the future.

Table 7: Model fit indicators

Indicators	Saturated model	Estimated model
SRMR	0.087	0.096
d_ULS	0.797	0.960
d_G	0.274	0.308
Chi-square	607.141	653.414
NFI	0.649	0.623

As shown in Table 8, the results of the Fornell–Larcker criterion analysis indicate that most constructs exhibit good discriminant validity, with the square root of the average variance extracted (AVE) values generally exceeding their correlations with other constructs. Specifically, the constructs of ESP, PBCSA, and SNRS all show that their square roots of the AVE values (0.717, 1.000, and 0.791, respectively) exceed the corresponding inter-construct correlations. While some values, particularly those between ATS and TL, are less than ideal, they are still close to the acceptable threshold. The correlation between ATS and TL (0.686) is slightly below the square root of the AVE for TL (0.695), suggesting that while these constructs are distinct, there is a minor overlap. This overlap is not significant enough to undermine the overall discriminant validity of the constructs but may warrant further refinement in future studies.

Table 8: Fornell–Larcker criterion

	ATS	ESP	PBCSA1	SNRS	TL
ATS	0.739				
ESP	0.533	0.717			
PBCSA	0.371	0.402	1.000		
SNRS	0.508	0.479	0.374	0.791	
TL	0.686	0.661	0.444	0.590	0.695

4.4. Hypothesis testing

The SEM results provide strong support for the hypothesized relationships between transformational leadership and various aspects of sustainability within universities. The analysis confirms Hypothesis 1 (H1), indicating that transformational leadership is positively associated with more favorable attitudes toward sustainability. This is evident from the path coefficient of 0.686 between transformational leadership (TL) and attitudes toward sustainability (ATS), which is statistically significant (T=28.537, p<0.01) and indicates a substantial impact of leadership on shaping positive sustainability attitudes among university teachers. Similarly, Hypothesis 2 (H2) is supported, demonstrating that transformational leadership is positively associated with stronger subjective norms supporting sustainability within universities. The path coefficient of 0.590 between TL and subjective norms regarding sustainability (SNRS) is significant (T=18.620, p<0.01), highlighting the important role of leadership in influencing social norms that promote sustainable practices within the academic community.

Hypothesis 3 (H3) is also confirmed by the data, showing that transformational leadership positively influences greater perceived behavioral control over sustainability actions within universities. The path coefficient of 0.444 between TL and perceived behavioral control (PBCSA) is significant (T=10.041, p<0.01), suggesting that effective leadership enhances the confidence and perceived ability of university members to engage in sustainable actions.

Hypotheses related to the direct impact of these mediating factors on engagement in sustainable practices (ESP) are also supported. Hypothesis 4 (H4) is confirmed, with a path coefficient of 0.345 between ATS and ESP, which is statistically significant (T=7.741, p<0.01). This finding indicates that more favorable attitudes toward sustainability strongly drive engagement in sustainable practices, underscoring the importance of fostering positive attitudes among educators.

Hypothesis 5 (H5) is supported, with a path coefficient of 0.234 between SNRS and ESP (T=4.930, p<0.01), affirming that stronger subjective norms regarding sustainability are indeed associated with greater engagement in sustainable practices. This relationship highlights the critical role of social

expectations and peer influence in motivating sustainable behaviors within universities.

Finally, Hypothesis 6 (H6) is validated by the positive association between greater perceived behavioral control and engagement in sustainable practices, as indicated by the path coefficient of 0.186 between PBCSA and ESP ($T=4.118$, $p<0.01$). Although this effect is weaker than that of ATS and SNRS, it still emphasizes the importance of perceived control in enabling individuals to take sustainable action. In summary, the hypothesis testing results strongly support the proposed model, demonstrating the significant influence of transformational leadership on attitudes, norms, and perceived control related to sustainability and, subsequently, on engagement in sustainable practices within university settings.

5. Discussion

The findings of this study align with the literature, reinforcing the significant role of transformational leadership in promoting sustainability within higher education institutions. Previous studies, such as those by King and Bouchard (2011) and Zaidi et al. (2023), have emphasized the influence of transformational leadership on encouraging sustainability in academic settings. Our study extends these insights by using structural equation modeling to quantify the effects of transformational leadership on attitudes, norms, and perceived behavioral control regarding sustainability among university teachers in Guangdong Province.

The results confirm that transformational leadership fosters positive attitudes toward sustainability (ATS), strengthens subjective norms regarding sustainability (SNRS), and enhances perceived behavioral control over sustainability actions (PBCSA). These findings suggest that transformational leaders in universities play a crucial role in shaping the psychological and social factors that drive sustainable behaviors. These findings are consistent with the theory of planned behavior (TPB), which posits that attitudes, subjective norms, and perceived behavioral control are key predictors of behavioral intentions and actions. Despite the significant influence of transformational leadership on mediating factors such as attitudes, norms, and perceived behavioral control, the direct translation of these factors into ESPs remains less pronounced. This aligns with prior studies by D'Amato and Korhonen (2021) and Aikens et al. (2018), which highlighted the complexities individuals face in translating sustainability intentions into consistent actions. Additionally, the low internal consistency observed in SNRS underscores the need for methodological improvements in future research. Expanding sample sizes and refining data collection methods could enhance the reliability of constructs such as SNRS, thereby providing a more robust basis for evaluating the link between mediators and sustainable practices. Similarly, Rahlin et al. (2021a) highlighted the importance of safety knowledge and leadership in shaping the safety climate and performance, which parallels the role of transformational leadership in influencing sustainability behaviors. Furthermore, the importance of safety leadership and its role in creating a supportive climate for sustainability was also discussed by Rahlin et al. (2021b), who demonstrated the need for strong leadership in driving sustainable practices. This gap highlights the complexity of behavior change and suggests that while leadership can inspire and motivate employees, additional mechanisms may be needed to facilitate the actual adoption of sustainable practices.

Path analysis further revealed that attitudes toward sustainability have the most substantial impact on engagement in sustainable practices, followed by subjective norms and perceived behavioral control. This finding indicates that while all three factors are important, fostering a strong belief in the value of sustainability within the university context is the most critical driver of sustainable actions. Transformational leaders who effectively communicate the importance of sustainability and create a culture that values these practices are more likely to see their efforts translate into real-world actions by university members. This conclusion is supported by the findings of Graves et al. (2013), who highlighted how transformational leadership and organizational climate significantly influence employee pro-environmental behaviors, reinforcing the crucial role of leadership in promoting sustainable practices within organizations.

Additionally, the study is subject to certain methodological limitations. The reliance on an online survey platform, while efficient, may have led to the underrepresentation of individuals with limited access to digital tools or preferences for alternative data collection methods. Furthermore, although stratified sampling ensured diversity across academic ranks and institutions, some subgroups, such as part-time faculty or administrators, may have been less represented. The measurement tools, while adapted from established scales, were tailored to the specific context of Guangdong universities, potentially limiting their generalizability to other regions or settings. Future research should address these constraints by incorporating mixed-method approaches, such as interviews or focus groups, to provide a more comprehensive understanding of the studied constructs.

6. Conclusion

This study offers important insights into how transformational leadership supports sustainable practices in universities across Guangdong Province. Using structural equation modeling (SEM), we examined how transformational leadership relates to key factors such as attitudes toward sustainability, social norms, and perceived control over

sustainability actions—and how these, in turn, influence engagement in sustainable practices.

The results strongly support the proposed model. They show that transformational leadership plays a major role in shaping positive attitudes, reinforcing social expectations, and increasing individuals' sense of control—each of which helps encourage sustainable behavior among university teachers.

The strongest connection was found between transformational leadership and attitudes toward sustainability. This emphasizes the key role of leadership in shaping how sustainability is viewed and valued in academic settings. The study also highlights that social norms and perceived control help explain how leadership can lead to real, practical actions that support sustainability. Although there is some minor overlap between variables, the model as a whole maintains good validity, confirming that each factor represents a distinct concept.

These findings are meaningful for university leaders and policymakers. They suggest that promoting sustainability in higher education requires developing transformational leaders who can inspire positive attitudes, foster a culture that supports sustainability, and give individuals the confidence and ability to act. Future studies should continue refining these concepts and explore other factors that may influence how leadership affects sustainability, so that universities can continue to lead progress toward sustainability goals.

List of abbreviations

TL	Transformational leadership
ATS	Attitudes toward sustainability
SNRS	Subjective norms regarding sustainability
PBCSA	Perceived behavioral control over sustainability actions
ESP	Engagement in sustainable practices
TPB	Theory of planned behavior
SEM	Structural equation modeling
PLS-SEM	Partial least squares structural equation modeling
SRMR	Standardized root mean square residual
NFI	Normed fit index
AVE	Average variance extracted
rho_a	Composite reliability
rho_c	Composite reliability
Z	Z-value in Cochran's formula
E	Desired precision in Cochran's formula
O	Original sample
M	Sample mean
SD	Standard deviation
d_ULS	Unweighted least squares discrepancy
d_G	Geodesic distance

Compliance with ethical standards

Ethical considerations

Informed consent was obtained from all participants, and data confidentiality was maintained throughout.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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