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Significance of Technological Innovations in Promoting Environmental Literacy and Sustainable Consumption Mediated by Digital Marketing

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ABSTRACT

As environmental concerns increase and consumption patterns change, paying attention to sustainable consumption behavior as one of the key goals of sustainable development has become important and examining the factors affecting it is essential. The present study aims to investigate the impact of technological innovation on sustainable consumption behavior and analyze the mediating and moderating roles of digital factors, providing a scientific and practical framework for understanding and managing consumer behavior. The present study is applied in terms of its purpose and quantitative in terms of the type of data collection and based on a correlational approach with an emphasis on structural equation modeling. The statistical population consisted of 12,000 students at Urmia University, and the sample size of the study was determined to be 200 on the basis of the number of items. In order to increase the reliability of the research, 500 electronic questionnaires were distributed through stratified sampling. In this study, SPSS 23, AMOS 24, and Excel 2024 software were used to test the hypotheses. The results showed that technological innovation has a direct and positive effect on sustainable consumption behavior ($\beta=0.438$). Also, technological innovation affects digital marketing capabilities ($\beta=0.531$) and digital marketing capabilities play an effective mediating role in relation to sustainable consumption ($\beta=0.213$). In addition, green digital learning as a moderating variable strengthens the effect of technological innovation on digital marketing capabilities ($\beta=0.064$) and the effect of digital marketing capabilities on sustainable consumption behavior ($\beta=0.076$). The findings show that the simultaneous use of technological innovations, the development of digital marketing capabilities, and the promotion of green digital learning can effectively strengthen sustainable consumption behavior. In general, this study emphasizes the importance of technological innovation and green digital learning in promoting sustainable consumption and improving the efficiency of digital marketing capabilities.

KEYWORDS

Sustainable Consumption Behavior, Digital Marketing Capabilities, Technological Innovation, Green Digital Learning.



Introduction

According to the World Commission on Environment and Development (1987), sustainable development entails the conscious utilization of natural resources, environmental protection, and the assurance of continued development for future generations. In this context, aligning consumption and production patterns with sustainability principles has emerged as a fundamental objective of sustainable development (Wang et al., 2019). In recent years, the concepts of "sustainability" and "sustainable consumption" have gained increasing prominence in academic and policy discussions regarding the environmental impacts of consumption (Ekrami et al., 2018). Consequently, achieving sustainable consumption is considered a prerequisite for realizing sustainable development (Fuchs & Boll, 2018). Beyond the role of governments, consumers also play a significant part in advancing sustainable development (Quoqab & Mohammad, 2020). In the current landscape, rapid global changes necessitate innovative approaches to organizational management, particularly within the realm of marketing (Al-Ababneh, 2020). Driven by heightened environmental awareness and consumer demands for transparency and social responsibility, many enterprises are leveraging digital marketing tools to promote ethical and sustainable consumption patterns (Qureshi, 2025). Formulating effective marketing strategies in the digital economy requires an understanding of the technological innovations that underpin digital marketing (Oklander et al., 2018). Furthermore, digital transformation has facilitated the integration of new technologies into organizational business and marketing processes, enabling firms to enhance efficiency while simultaneously addressing sustainability imperatives (Zarei & Mohammadkhani, 2024). This trend indicates that technological innovations can play a significant role in promoting sustainable consumption behavior. The adoption of technological innovations directly influences sustainable consumption behavior (Sharma et al., 2023). Digital technologies also enable the transparent communication of corporate sustainability efforts and facilitate more effective engagement

with environmentally conscious consumers (Kumar, 2024). In recent decades, digital marketing has evolved alongside the expansion of the internet and the emergence of sustainable business models (Yao, 2024). Overall, the synergy between technological innovation and digital marketing accelerates the transition toward sustainable consumption by raising awareness, improving access to sustainability-related information, and facilitating consumer engagement.

Despite the growing importance of sustainability, it remains unclear how the simultaneous interplay of technological innovation, digital marketing capabilities, and green digital learning shapes sustainable consumption behavior (Isaac et al., 2025; Kamboj & Rahman, 2017; Yu, 2025). Most prior studies have examined these variables in isolation; thus, a comprehensive study of their simultaneous effects represents a significant research gap. By modeling these relationships, the present study addresses this gap, establishes its scholarly position within the body of domestic and international research, and provides a foundation for educational and environmental policymaking. Therefore, the central research question is: "Does technological innovation influence sustainable consumption behavior, considering the moderating role of green digital learning and the mediating role of digital marketing capabilities?"

Methodology

In terms of purpose, this study is fundamental; regarding data collection, it is quantitative and employs a correlational approach emphasizing structural equation modeling. Data were collected using a standard questionnaire featuring a five-point Likert scale ranging from "strongly disagree" to "strongly agree." The statistical population comprised all students at Urmia University, totaling approximately 12,000 individuals. The sample size was determined based on the item-to-sample ratio. Given the 20 items across four main constructs and a recommended ratio of 10 to 20, a minimum of 200 participants was required; however, to enhance precision, 500 questionnaires were distributed online across

various faculties using stratified sampling, and analyzable data were collected.

The stratified sampling method was implemented by first determining each faculty's share of the total sample size based on its specific student population, accounting for the varying number of students across Urmia University's faculties. Subsequently, questionnaires were distributed among students within the quotas allocated to each faculty. The study's questionnaire consisted of 20 items: the standard questionnaire by Xiao and Li (2011) was used to measure sustainable consumption behavior; the questionnaire by Parasuraman (2000) was used to measure technological innovation; the questionnaire by Wang (2020) was used to measure marketing capabilities; and the questionnaire by Al-Habusi et al. (2023) was used to measure green digital learning. Data analysis was conducted using SPSS 23 for preliminary analyses and descriptive statistics, AMOS 24 for structural equation modeling and hypothesis testing, and James Gaskin's method (via Excel 2024) to assess construct validity and reliability. To evaluate construct reliability and validity, composite reliability (CR) and average variance extracted (AVE) were first calculated for each construct. The CR values for all constructs exceeded 0.7, indicating satisfactory reliability. Similarly, AVE values for all constructs were above 0.5, demonstrating adequate convergent validity. To assess discriminant validity, Maximum Shared Variance (MSV) and Average Shared Variance (ASV) indices were calculated. The results showed that the AVE of each construct exceeded both the MSV and ASV indices, indicating sufficient construct distinctiveness. Overall, all ASV, CR, AVE, and MSV values fell within acceptable ranges, confirming the validity of the constructs. Furthermore, Cronbach's alpha values for all variables exceeded 0.7, reflecting construct reliability and internal consistency. The Cronbach's alpha coefficient for the entire questionnaire was 0.938, indicating a satisfactory level of reliability.

Results

Demographic data from the respondents (N=500) indicated that the Faculty of Literature and Humanities accounted for the highest

percentage (20.8%) of participants, while the Faculty of Architecture, Art, and Urban Planning and the Faculty of Natural Resources accounted for the lowest (3.2%). Women comprised 66.6% of the respondents, and men comprised 33.4%. Finally, the majority of respondents (70.2%) fell within the 18–25 age range. Based on Kline (2011) and Byrne's (2023) rules of thumb, a value greater than 5 indicates a lack of multivariate normality. Consequently, the assumption of multivariate normality for the data was not met. To address this issue and ensure accurate estimation of path coefficients as well as mediating and moderating effects, a bootstrapping method with 2,000 resamples was employed. This method allows for the correction of effects resulting from the lack of multivariate normality, thereby ensuring the reliability of the model's results.

Model fit indices indicated that all metrics fell within acceptable ranges; thus, the condition for adequate model fit was satisfied. Hypothesis testing results revealed a positive and significant relationship between sustainable consumption behavior and technological innovation, with a standardized coefficient of 0.457. The second hypothesis also confirmed a positive and significant relationship between digital marketing capabilities and technological innovation, with a standardized coefficient of 0.627. Finally, the third hypothesis, addressing the relationship between sustainable consumption behavior and digital marketing capabilities, was confirmed with a standardized coefficient of 0.355.

Ultimately, green digital learning plays a positive, partial moderating role in the relationship between technological innovation and digital marketing capabilities, as well as between digital marketing capabilities and sustainable consumption behavior.

All relationships are statistically significant at the 95% confidence level (significance level = 0.000). The coefficient of determination (R^2) indicates the proportion of the dependent variable's variance explained by the predictors. In the research model, the R^2 values are 0.67 for digital marketing capabilities and 0.768 for sustainable consumption behavior, demonstrating the model's high explanatory power regarding the variations in these constructs.

Bootstrap test results indicate that digital marketing capabilities act as a mediating variable between innovation and sustainable consumption. Given the values of $\beta = 0.213$ and $p = 0.000$, the mediation effect is significant.

A summary of the hypothesis test results shows that all six research hypotheses were confirmed: (1) the effect of technological innovation on sustainable consumption behavior, (2) the effect of digital marketing capabilities on sustainable consumption behavior, (3) the effect of technological innovation on digital marketing capabilities, (4) the mediating effect of digital marketing capabilities on the relationship between technological innovation and sustainable consumption behavior, (5) the moderating effect of green digital learning on the relationship between technological innovation and digital marketing capabilities, and (6) the moderating effect of green digital learning on the relationship between digital marketing capabilities and sustainable consumption behavior.

This study was conducted to examine the roles of technological innovation, digital marketing capabilities, and green digital learning in promoting sustainable consumption behaviors. The findings indicate that technological innovation plays a pivotal role in driving consumer behavior.

The study's theoretical framework is grounded in the Diffusion of Innovation theory and Capabilities theory; the former explains how the adoption of new technologies can alter consumer attitudes and behaviors, while the latter demonstrates that by leveraging digital resources and skills, organizations can shape consumer behavior and amplify the impact of technological innovation on sustainable consumption. Green digital learning is conceptualized as a sustainable digital capability that facilitates the responsible use of new technologies and enhances the effects of technological innovation and digital marketing on sustainable consumption behavior.

Specifically, the results of the first hypothesis test revealed that technological innovation has a significant positive impact on consumer behavior, leading to the provision of products and services that both meet consumer

needs and reduce their environmental impact. This finding aligns with research by Isaac et al. (2025), which demonstrated that technological innovation and industrial adaptability can foster sustainable consumption patterns and lifestyles within small and medium-sized enterprises (SMEs). From a practical standpoint, organizations can drive consumer behavior toward sustainability by developing new technologies, designing green products, and launching environmentally focused educational campaigns.

The results of the second hypothesis test indicate that technological innovation has a significant positive impact on digital marketing capabilities. This finding aligns with research by Mousavifard and Hassani (1401) and Ebrahim et al. (2025), demonstrating that organizations adopting technological innovation possess a greater capacity to utilize digital tools and channels for marketing. By facilitating rapid customer communication, providing accurate and engaging information, and enabling consumer behavior analysis, digital marketing capabilities can amplify the impact of technological innovation on shaping sustainable consumption behaviors. These results also concur with findings by Yu (2025) and Qureshi (2025), which showed that targeted digital strategies, relevant content and messaging, and environmental awareness-raising can significantly influence sustainable consumer behavior.

Mediation analysis revealed that digital marketing capabilities serve as an effective mediator between technological innovation and sustainable consumption behavior. This implies that the direct impact of technological innovation on sustainable consumption is maximized when organizations effectively leverage their digital marketing capacities. Advanced digital capabilities enable broader consumer reach, the communication of sustainability-related messages, and enhanced engagement; consequently, technological innovation influences not only product production and delivery but also consumer attitudes and behaviors.

Therefore, it is recommended that organizations employ advanced digital and analytical tools to monitor and improve

consumer behavior, ensuring that sustainability messages are conveyed in a targeted manner.

Green digital learning plays a significant role as a moderator in these pathways. The findings indicate that higher levels of green digital learning amplify the impact of technological innovation on digital marketing capabilities and the influence of digital capabilities on sustainable consumption behavior. Organizations and consumers possessing greater green digital knowledge and skills are better able to comprehend digital innovations and messages, translating them into sustainable behaviors. These results align with research by Al-Halbusi et al. (2023) and Budz et al. (2023), demonstrating that green digital literacy and skills can steer consumer behavior toward responsible, eco-friendly choices. From a practical standpoint, providing green digital training and developing online educational content can enhance the effectiveness of digital marketing campaigns and technological innovations.

The combination of the three constructs—technological innovation, digital marketing capability, and green digital learning—offers effective pathways for promoting sustainable consumption, suggesting that influencing consumer behavior without simultaneously addressing these dimensions would yield limited results. By leveraging emerging technologies such as artificial intelligence and the Internet of Things (IoT), organizations can optimize resource management and supply chains, reduce energy and resource consumption, and communicate their

sustainability messages more effectively and precisely. Furthermore, implementing green digital educational campaigns and online learning tools enhances consumers' skills and understanding regarding sustainable behaviors, thereby reinforcing the impact of technological innovation and digital marketing on eco-friendly choices.

Conclusion

This study demonstrates that achieving sustainable consumption behavior requires simultaneous attention to technological innovation, digital marketing, and green digital learning; this tripartite combination provides a comprehensive and practical framework for promoting sustainable consumption. Without addressing these dimensions concurrently, the impact of organizations on consumer behavior will be limited, and environmental goals will not be fully realized.

The study's limitations include the use of a sample restricted to a single geographic region and data collection via self-report questionnaires. Furthermore, cultural and social variables that could influence sustainable consumption behavior were not examined. It is recommended that future research investigate the impact of these constructs in diverse settings using more varied samples, experimental methods, and behavioral data, and that the role of other social and cultural factors in shaping sustainable consumption behavior be analyzed.

«مقاله پژوهشی»

تبیین نقش نوآوری‌های فناورانه در ارتقای سواد محیط‌زیستی و مصرف پایدار: با میانجی‌گری بازاریابی دیجیتال

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چکیده

با افزایش دغدغه‌های محیط‌زیستی و تغییر الگوهای مصرف، توجه به رفتار مصرف پایدار به‌عنوان یکی از اهداف کلیدی توسعه پایدار اهمیت یافته و بررسی عوامل مؤثر بر آن امری ضروری است. پژوهش حاضر با هدف واکاوی تأثیر نوآوری فناورانه بر رفتار مصرف پایدار و تحلیل نقش میانجی و تعدیل‌گری عوامل دیجیتال، چارچوبی علمی و کاربردی برای درک و مدیریت رفتار مصرف‌کننده ارائه می‌دهد. پژوهش حاضر به لحاظ هدف، بنیادی و به لحاظ نوع گردآوری داده‌ها، کمی و مبتنی بر رویکرد همبستگی با تأکید بر مدل‌سازی معادلات ساختاری بود. جامعه آماری شامل ۱۲ هزار دانشجوی دانشگاه ارومیه بود و اندازه نمونه پژوهش بر اساس تعداد گویه‌ها ۲۰۰ نفر تعیین شد. رای افزایش اطمینان، ۵۰۰ پرسشنامه الکترونیکی از طریق روش نمونه‌گیری طبقه‌بندی شده توزیع گردید. در این پژوهش از نرم‌افزارهای SPSS 23، AMOS 24 و Excel 2024 برای آزمون فرضیه‌ها استفاده شد. نتایج نشان داد که نوآوری فناورانه تأثیر مستقیم و مثبت بر رفتار مصرف پایدار دارد ($\beta=0/438$). همچنین، نوآوری فناورانه بر قابلیت‌های بازاریابی دیجیتال اثرگذار است ($\beta=0/531$) و قابلیت‌های بازاریابی دیجیتال نقش میانجی مؤثری در رابطه با مصرف پایدار ایفا می‌کند ($\beta=0/213$). علاوه بر این، یادگیری دیجیتال سبب به‌عنوان متغیر تعدیل‌گر، اثر نوآوری فناورانه بر قابلیت‌های بازاریابی دیجیتال ($\beta=0/064$) و اثر قابلیت‌های بازاریابی دیجیتال بر رفتار مصرف پایدار ($\beta=0/076$) را تقویت می‌کند. یافته‌ها نشان می‌دهد که بهره‌گیری همزمان از نوآوری‌های فناورانه، توسعه قابلیت‌های بازاریابی دیجیتال و ترویج یادگیری دیجیتال سبب می‌تواند به شکل مؤثری رفتار مصرف پایدار را تقویت کند. این پژوهش بر اهمیت نوآوری فناورانه و یادگیری دیجیتال سبب در ترویج مصرف پایدار و ارتقای کارایی قابلیت‌های بازاریابی دیجیتال تأکید دارد.

واژه‌های کلیدی

رفتار مصرف پایدار، قابلیت بازاریابی دیجیتال، نوآوری فناورانه، یادگیری دیجیتال سبب.

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Introduction

According to the World Commission on Environment and Development (1987), sustainable development means the conscious use of natural resources, the protection of the environment, and the assurance of sustainable development for future generations. In this regard, the coordination of consumption and production patterns with the principles of sustainability is considered as one of the fundamental goals of sustainable development (C. Wang et al., 2019). In recent years, the concepts of sustainability and sustainable consumption have gained increasing importance as key elements in scientific and policy discussions related to the environmental consequences of consumption (Ekrami et al., 2020). Therefore, the realization of sustainable consumption is a prerequisite for achieving sustainable development (Fuchs & Boll, 2018). In addition to the pivotal role of governments, consumers play an important role in promoting sustainable development (Quoquab & Mohammad, 2020). Sustainable consumption behavior is a set of conscious actions to prevent the destruction of natural resources and protect the environment that take into account the well-being of present and future generations (Carrete et al., 2012).

In the current situation, rapid global changes require new approaches in the management of organizations, especially in the field of marketing (Al-Ababneh, 2020). With increasing environmental awareness and consumer pressure for transparency and social responsibility, many firms are using digital marketing tools to promote ethical and sustainable consumption patterns (Qureshi, 2025). Developing effective marketing strategies in the digital economy requires an understanding of technological innovations and forms the basis of digital marketing (Oklander et al., 2018). Digital transformation has also led to the integration of new technologies into the business and marketing processes of organizations to increase efficiency and respond to sustainability requirements (Zarei & Mohammadkhani, 2024). This trend suggests that technological innovations can play an effective role in promoting sustainable consumption behavior. The adoption of

technological innovations directly influences sustainable consumption behavior (Sharma et al., 2023). Digital technologies also enable transparent communication of companies' sustainability efforts and more effective engagement with environmentally conscious consumers (Kumar, 2024). In recent decades, digital marketing has developed on the basis of the spread of the Internet and the emergence of sustainable business models (Yao, 2024). Overall, the synergy between technological innovation and digital marketing accelerates the transition to sustainable consumption by increasing awareness, improving access to sustainability-related information, and facilitating consumer participation.

Moreover, rapid advances in digital technologies have transformed educational systems, making the integration of technology into curricula an inevitable necessity (Zou et al., 2025). The use of new technologies in interactive learning environments, especially in universities, has played an effective role in enhancing student learning (Sjahruddin et al., 2022). These technologies provide a high capacity for sustainability education and can strengthen environmental attitudes and behaviors. Research shows that participation in digital courses and interactive tools can increase environmental knowledge by more than 40% (Liu et al., 2025).

Given the key role of the younger generation in shaping future consumption patterns and their continuous interaction with digital technologies and tools, students are considered an influential group in the adoption of digital marketing innovations and the development of sustainable consumption behavior. Their continuous use of technology and extensive interaction with digital platforms provide a true reflection of consumers' reactions to digital strategies and organizational actions in the area of sustainability. On the other hand, students, as the younger generation, have the most interaction with emerging technologies and digital marketing. In other words, students are not only current consumers, but also future managers, decision-makers, and trendsetters of consumption patterns in the near future. Changing behavior in this layer of society will have sustainable effects on the entire body of

society in the long term. Therefore, studying sustainable consumption in this group has a preventive and prospective aspect. Consequently, considering these characteristics, students are considered an appropriate statistical population in this area of research.

In spite of the increasing importance of sustainability, it is still unclear how the simultaneous interaction of technological innovation, digital marketing capabilities, and green digital learning shapes sustainable consumption behavior (Isaac et al., 2025; Kamboj & Rahman, 2017; Yu, 2025). Most previous research has examined these variables separately, yet a comprehensive study of their simultaneous effect remains an important research gap. Filling this gap could provide valuable practical insights for organizations and policymakers to promote sustainable consumption, in addition to developing theoretical foundations.

Sustainable consumption behavior: In recent years, attention has been paid to the fact that consumption is a complex issue and has both positive and negative consequences for the consumer and society. Therefore, concepts such as sustainable consumption have been proposed in order to address the consequences of consumption. Sustainable consumption behavior is often used instead of specific terms such as pro-environmental consumption behavior, green consumption behavior, ethical consumption behavior, etc. (Dimitrova et al., 2022). Sustainable consumption refers to the use of products and services that meet current needs while minimizing environmental impacts, promoting resource efficiency, and ensuring ethical production practices (Theocharis & Tsekouropoulos, 2025). The basis of sustainable consumption lies in the efficient use of resources, which includes reducing waste, saving energy, and using renewable resources. This approach not only reduces waste, but also promotes resource efficiency and innovation (Isaac et al., 2025). However, studies show that technological solutions alone are not enough, and to achieve sustainable consumption, increasing environmental literacy and the informed education of citizens is necessary (Mont &

Plepys, 2008). Environmental literacy enables people to consciously regulate their consumption behavior and become sensitive to the effects of consumption on the environment. In this regard, Agenda 21 of the United Nations Conference emphasizes the importance of environmental education and empowering citizens to solve environmental problems. As a result, educated and informed people, i.e., students, can apply sustainable consumption behavior in their daily lives and play an effective role in sustainable urban development (Wu et al., 2019). This awareness and education, in addition to shaping sustainable consumption behavior, can increase the demand for environmentally friendly products (Vergura et al., 2023).

Technological advances have dramatically transformed the business world. In today's society, the application of technology to innovate products and services is essential to enhance financial and sustainability outcomes (Ali & Maelah, 2025). Innovation is one of the Sustainable Development Goals (SDG 9) and is also a means to achieve other goals (Anadon et al., 2016). Despite the importance of innovation, its adoption by consumers is also crucial. The diffusion of innovations theory states that innovations are first adopted by innovators and then gradually by the majority of society, and that innovation characteristics such as comparative advantage, adaptability, ease of use, and the ability to test and observe results play a decisive role in the speed and spread of adoption (Rogers, 2003). Therefore, understanding how innovation is adopted by consumers is essential to realize its positive impact on sustainable consumption behavior.

Technological innovation: In contemporary times, technology has become a critical factor in increasing the effectiveness, productivity, and competitive advantage of companies and nations. However, challenges such as climate change, the depletion of natural resources, and pollution have increased the need to pay more attention to environmental sustainability. To achieve sustainable economic growth and improve social well-being, governments and stakeholders need to develop policies that align technological innovation with sustainability principles (Kamboj & Rahman, 2017).

Technological innovation by itself is not sufficient to achieve sustainable consumption; the details of consumption patterns and consumer behaviors are also important. This innovation can increase resource efficiency and improve environmental compatibility by providing new solutions and technologies. Furthermore, the integration of new technologies into business and marketing processes can facilitate sustainable consumption behavior and help increase efficiency and reduce waste (Isaac et al., 2025; Mahardhani, 2023). Therefore, technological innovation is considered a critical driver for sustainability, as it can lead to the development of products that have both economic performance and reduced environmental impact (Imran et al., 2021).

Given the importance of technology, educational processes have also undergone fundamental changes, and universities need strategies to facilitate continuous learning and digital behaviors to benefit from the capabilities of new technologies (Mohammadi et al., 2025). New technologies have led to educational innovation and improved learning quality, and the use of technology applications can improve learning and teaching outcomes (Sjahruddin et al., 2022).

On the basis of what has been reviewed so far, the following hypotheses are proposed:

Hypothesis 1: Technological innovation has a significant impact on sustainable consumption behavior.

Digital marketing capabilities: Technological advancements have led to the formation of numerous innovations and have provided extensive communication and distribution channels between individuals and organizations. At the same time, the development of computer technologies and increased Internet security have increased trust in online stores and the transparency of business-customer relationships (Daneshfar & Gholipour Fereydouni, 2022). Today, many people use digital technologies to save time and money. Technological innovation can improve the productivity and success of companies by increasing efficiency, expanding markets, and changing business models (Sadjadah et al., 2023). These developments have changed the way consumers interact with brands and have made digital marketing a strategic solution for

effective interaction in cyberspace. Maintaining the competitiveness of organizations requires continuous innovation, which is often accompanied by the development of digital marketing (Suharsono et al., 2023). Digital marketing, as an interactive and measurable approach, provides broad access to audiences without time and place restrictions by utilizing digital technologies (Yaghoubpour et al., 2024). From the perspective of capability theory, organizations can shape consumer behavior by empowering their digital resources and capabilities and strengthen the impact of technological innovation on sustainable consumption. In other words, the development of digital marketing capabilities can provide information, transparency, and effective interaction in such a way that consumers make more sustainable choices (Abdelkafi & Täuscher, 2016).

Research shows that digital marketing can act as a key factor in promoting sustainable consumption. Effective use of digital channels increases environmental awareness and enhances consumer engagement in sustainability activities (Ibrahim et al., 2025). The more advanced digital marketing capabilities organizations have, the greater the likelihood of influencing the sustainable consumption behavior of their audiences will be. Vanjama (2024) also states that an effective digital marketing strategy should include engaging advertising, the use of new technologies, and the implementation of sustainability values.

Digital marketing can also improve audience engagement and learning. In the field of higher education, institutions use digital marketing to attract students and increase their participation in educational processes by utilizing social media and mobile technologies. These methods allow for direct, targeted, and rapid communication with audiences, and the continuous growth of technology creates a good opportunity to improve the quality of education, develop digital skills, and strengthen the market position of institutions (Jasmine & Kissvar, 2025).

Therefore, on the basis of the brief review presented here, the following hypotheses are proposed:

Hypothesis 2: Digital marketing capabilities have a significant impact on sustainable consumption behavior.

Hypothesis 3: Technological innovations have a significant impact on digital marketing capabilities.

Hypothesis 4: Digital marketing capabilities mediate the impact of technological innovation on sustainable consumption behavior.

Green digital learning: Green digital learning is a new term that focuses on sustainable environmental attitudes and environmental awareness in digital learning processes (Junejo et al., 2025). This type of learning requires creating a learning culture, promoting innovation, and adopting environmentally friendly technologies. According to capability theory, increasing consumers' capabilities and skills enables the responsible and sustainable use of new technologies (Sen, 1999).

Incorporating environmental considerations into the curriculum, known as greening the curriculum, has significant educational and environmental benefits, and digital education has great potential to deliver this content. The more this type of content is integrated into students' education, the more environmental awareness and sustainable consumption behaviors will spread (Manasia et al., 2023). The use of advanced digital tools allows for the accurate measurement of sustainable knowledge and behavior, and is consistent with sustainability principles. This approach is applicable in various fields such as risk management, production safety, waste disposal, and industrial hygiene (Manasia et al., 2023). The diffusion of innovations theory suggests that green digital technologies are gradually adopted by users and change their behaviors and attitudes (Rogers, 2003). Therefore, integrating green digital learning in universities and educational institutions, while improving educational methods and infrastructure, provides the basis for adopting green and sustainable solutions (Tobel, 2024).

Accordingly, the following two more hypotheses are proposed:

Hypothesis 5: Green digital learning has a moderating role in the impact of technological innovation on digital marketing capabilities.

Hypothesis 6: Green digital learning has a moderating role in the impact of digital marketing capabilities on sustainable consumption behavior.

Recent research shows that sustainable consumption, technological innovation, digital marketing, and green digital learning are key factors in guiding consumer behavior and sustainable development. However, a comparative and analytical review of previous studies reveals certain gaps. Daneshfar and Gholipour (1401) showed that digital marketing and innovation have a positive and significant effect on customers' online purchase intention and digital marketing can enhance innovation. Similarly, Mousavifard and Hassani (1401) emphasized that digital marketing can increase product innovation and brand loyalty. These findings indicate that digital marketing is not only an advertising tool, but also an effective factor in facilitating innovation and consumer behavior.

Studies carried out in other countries other than Iran also emphasize the role of digital marketing in promoting sustainable consumption and green practices. Using a mixed quantitative and qualitative approach, Ebrahim et al. (2025) showed that digital campaigns focused on sustainability increase environmental awareness and green purchase intention, and introduced digital marketing as a strategic catalyst in environmental education. Yu (2025) also showed that digital marketing strategies modify sustainable consumption behavior and environmental awareness plays a mediating role. The findings of Isaac et al. (2025) and Qureshi (2025) emphasize the role of technological innovation and digital marketing in promoting sustainable consumption patterns and ethical consumer behavior, but these studies are mainly carried out in the context of enterprises and industries, and less attention has been paid to universities and academic settings.

On the other hand, studies related to green digital learning show that combining digital education with environmentally sustainable attitudes can guide students' motivation,

cognition, and behavior towards sustainable consumption (Al Halbusi et al., 2023; Budz et al., 2023). These studies show that digital empowerment and access to educational content related to sustainability have a positive impact on consumer behavior. However, existing research has often not examined the impact of digital marketing on green digital learning or the role of their interaction in strengthening sustainable consumption behavior.

Despite numerous studies, the combined effect of technological innovation, digital marketing capabilities, and green digital

learning on sustainable consumption behavior in Iranian academic environments has not yet been comprehensively investigated. By modeling these relationships, the present study tries to fill this gap, establish its scientific position among domestic and international research, and provide a basis for educational and environmental policymaking.

Therefore, the main research question of the present study is: Does technological innovation affect sustainable consumption behavior, considering the moderating role of green digital learning and the mediating role of digital marketing capabilities?

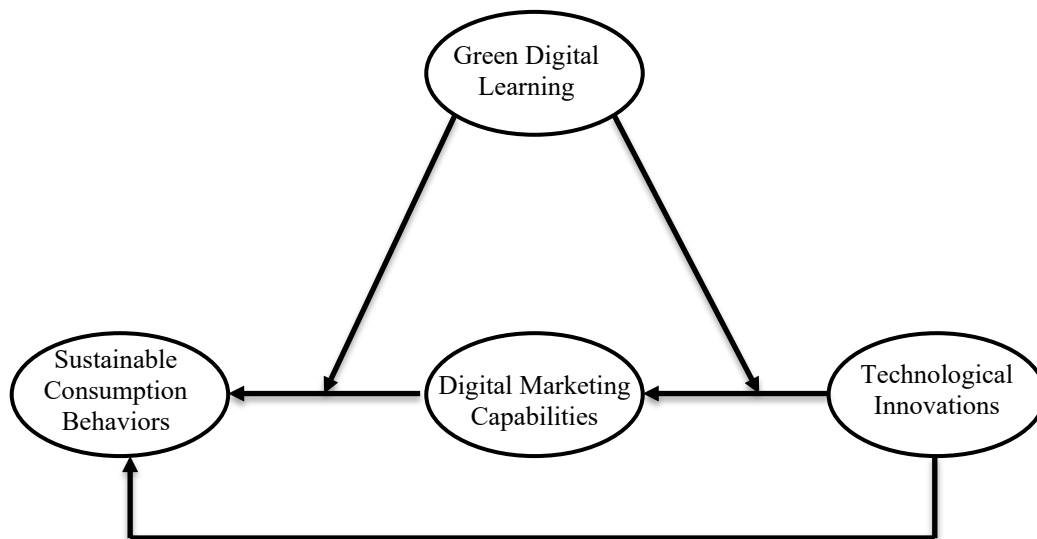


Figure 1. Conceptual model of the research (Source: Kamboj and Rahman (2017), Yu (2025))

Research Methodology

The present research was applied in terms of its purpose and quantitative in terms of its type of data collection and based on a correlational approach with an emphasis on structural equation modeling. To collect data, a standard questionnaire with a five-point Likert scale (from strongly disagree to strongly agree) was used. The statistical population included all of the students of Urmia University, approximately 12,000 people. The sample size of the research was determined based on the item-to-sample ratio. Considering the existence of 20 items in the four main constructs and the recommended ratio of 10 to 1, at least 200 people were required for the research. To increase reliability, 500 questionnaires were distributed online among different faculties using a stratified sampling method and

analyzable data were collected. The stratified method in this study was implemented in such a way that first, considering the difference in the number of students in different faculties of Urmia University, the share of each faculty in the sample size was determined based on the number of students in each faculty. Then, within the framework of the quota allocated to each faculty, the questionnaires were distributed among the students.

The questionnaire of the present study consisted of 20 items, which were used to measure the variable of sustainable consumption behavior from the standard questionnaire of Xiao and Li (2011) (*Note: Corrected Shao to Xiao to match Table 2*), technological innovation from the questionnaire of Parasuraman (2000), digital marketing capabilities from the questionnaire

of Wang (2020), and green digital learning from Al-Halbusi et al. (2023). The items are shown in Table 2. In order to analyze the data, SPSS 23 software was used to perform preliminary analyses and descriptive statistics. AMOS 24 was used to perform structural equation modeling and hypothesis testing, and James Gaskin's method in Excel 2024 software was used to assess the validity and reliability of the constructs.

To examine the reliability and validity of the constructs, the composite reliability and the average variance extracted were first calculated for each construct using the James Gaskin method in Excel software. As can be seen in Table 1, the composite reliability values of all constructs were higher than 0.7, indicating desirable reliability. Also, the average variance extracted values for all constructs were higher

than 0.5, indicating appropriate convergent validity. To examine the discriminant validity, the maximum shared squared variance and average shared squared variance indices were calculated. The results showed that the average variance extracted of each construct was greater than both the maximum shared squared variance and the average shared squared variance indices, indicating sufficient differentiation of the constructs. In general, all CR, AVE, MSV, and ASV values were within acceptable limits, and the validity of the constructs was confirmed. Also, the Cronbach's alpha value for all variables was greater than 0.7, indicating the acceptable reliability and internal consistency of the constructs. Also, the Cronbach's alpha coefficient for all items of the questionnaire was 0.938, indicating the acceptable reliability of the questionnaire.

Table 1. Validity and Reliability Results

	α	CR	AVE	MSV	ASV	Sustainable consumption behavior	Digital marketing capabilities	Technological innovations	Green digital learning
Sustainable consumption behavior	0.856	0.858	0.548	0.513	0.420	1			
Digital marketing capabilities	0.891	0.855	0.541	0.470	0.384	0.686	1		
Technological innovations	0.854	0.892	0.542	0.513	0.410	0.716	0.660	1	
Green digital learning	0.769	0.772	0.532	0.282	0.269	0.527	0.497	0.531	1

Table 2. Research Items

Variable	Item number	Question text	Source
Sustainable Consumption behavior	1	I prefer to buy green and environmentally friendly products.	Xiao & Li (2011)
	2	Even if the price of green products is higher, I still choose them.	
	3	I avoid buying products that pollute the environment.	
	4	I do not have a lifestyle of irresponsible consumption.	
	5	I usually choose cheaper products, regardless of whether they are green or not.	
Technological Innovation	6	Others come to me for advice on new technologies.	Parasuraman (2000)
	7	I am usually among the first people in my circle of friends to try new technologies.	
	8	I can learn and use new technological products and services without the help of others.	
	9	I always stay up-to-date with the latest technological	

Variable	Item number	Question text	Source
Digital Marketing Capabilities		developments in my fields of interest.	Wang (2020)
	10	I enjoy trying out new tools and technologies.	
	11	Compared to others, I have fewer problems using new technologies.	
	12	I am always eager to learn about new and different technologies.	
	13	Digital customer engagement tools (such as social media) are effective in raising consumer awareness of sustainable products.	
	14	Digital data analytics of consumer behavior is an effective tool for organizations to more accurately predict students' needs for sustainable products.	
	15	Digital sales channels (such as websites and apps) allow for transparent information about the sustainable features of products.	
Green Digital Learning	16	Digital incentive programs (such as discounts or rewards) make customers more inclined to purchase sustainable products.	Al-Halbusi, et al. (2023)
	17	Using digital platforms for supplier management makes it possible to select business partners with higher environmental standards.	
	18	The prevailing sentiment in the era of technological innovation is that green digital learning is a worthwhile investment and expense.	
	19	The ability to learn green digital is the key to improving the choice of sustainable consumption behaviors.	
	20	There are specific mechanisms for sharing green digital learning experiences in sustainable consumption behaviors.	

Research Findings

The demographic information of the respondents (500 people) is presented in Table 3. According to the table, the Faculty of Literature and Humanities has the highest percentage (20.8%) and the Faculties of

Architecture, Art, and Urban Planning and Natural Resources have the lowest percentage (3.2% each). Of the respondents, 66.6% were female and 33.4% were male. Finally, the age of most of the respondents was in the range of 18 to 25 years (70.2%).

Table 3. Demographic Data of the Study

Variables		Frequency	Percentage
Gender	Male	333	66.6
	Female	167	33.4
Age	18-25	351	70.2
	26-30	84	16.8
	31-35	49	9.8
	36-40	8	1.6
	Over 40	8	1.6
Faculty	Economics, Management and Accounting	39	7.8
	Literature and Humanities	104	20.8
	Agriculture	61	12.2
	Technical and Engineering	57	11.4
	Electrical and Computer	57	11.4
	Veterinary Medicine	29	5.8

Variables		
	Frequency	Percentage
Basic Sciences	69	13.8
Architecture, Art and Urban Planning	16	3.2
Natural Resources	16	3.2
Chemistry	26	5.2
Sports Sciences	26	5.2

Table 4. Skewness and Kurtosis (Univariate Normality)

Item	Skewedness	Kurtosis	Item	Skewedness	Kurtosis
SCB1	-0.005	-0.112	TI1	-0.142	-0.767
SCB2	-0.179	-0.113	TI2	-0.152	-0.656
SCB3	0.04	-0.211	TI3	-0.109	-0.609
SCB4	-0.029	-0.038	TI4	-0.095	-0.520
SCB5	0.098	-0.206	TI5	-0.213	-0.528
DMC1	-0.02	-0.018	TI6	-0.082	-0.533
DMC2	0.092	-0.327	TI7	-0.071	-0.617
DMC3	0.060	0.017	GDL1	0.056	-0.490
DMC4	0.024	-0.151	GDL2	0.078	-0.334
DMC5	-0.023	0.276	GDL3	0.056	-0.422

The results of the univariate normality test showed that the model items had acceptable normality in terms of univariate skewness and kurtosis. According to the rules of thumb, skewness values less than ± 3 and kurtosis values less than ± 7 indicate acceptable normality (Byrne, 2013; Kline, 2023; West et al., 1995). However, the multivariate normality test showed that the multivariate coefficient (Mardia coefficient) was 143.348. According to Kline (2011) and Byrnes (2023) rules of thumb,

a value greater than 5 indicates a violation of multivariate normality; therefore, the assumption of multivariate normality was not met. To address this issue and accurately estimate path coefficients as well as mediating and moderating effects, the bootstrapping method with 2000 resamples was employed. This method allows for the correction of effects resulting from the violation of multivariate normality, thereby ensuring the reliability of the model results.

Table 5. Measurement Model Fit Indices

Index Name	Symbol	Acceptable Value	Ideal Measurement	Measurement Model
Degree of Freedom	df	—	—	164
Chi-square	χ^2	$2df \leq \chi^2 \leq 3df$	$0 \leq \chi^2 \leq 3df$	254.726 P = 0.000
Optimized Chi-square	χ^2/df	$2 \leq \chi^2/df \leq 3$	$0 \leq \chi^2/df \leq 2$	1.553
Goodness of Fit	GFI	$80 \leq GFI \leq .95$	$0.95 \leq GFI \leq 1.0$	0.951
Root Mean of Squares Residual	RMR	$0 \leq RMR \leq 1.0$	$0 \leq RMR \leq 0.5$	0.028
Contrast Fit Index	CFI	$0.90 \leq CFI \leq .97$	$0.97 \leq CFI \leq 1.0$	0.982
Root Mean Square Error of Estimate	RMSEA	$0.05 \leq RMSEA \leq .08$	$0 \leq RMSEA \leq .05$	0.033 Pclose= 1.000
Probability of Goodness of Fit Index	PGFI	$0.50 \leq PGFI \leq .60$	$0.60 \leq PGFI \leq 1.0$	0.743
Normalized Probability of Fit Index	PNFI	$0.50 \leq PNFI \leq .60$	$0.60 \leq PNFI \leq 1.0$	0.821

According to the above table, the examined indicators were within the acceptable range.

Therefore, the condition of adequacy of fit was met.

Table 6. Results of Hypothesis Testing

Hypot hesis	Relationship	Unstandardized Coefficients	Standardized Coefficients	Standard Error	Critical Ratio	Significance Level
1	The Effect of Technological Innovation on Sustainable Consumption Behavior	0.438	0.457	0.063	934.6	0.000
2	The Effect of Digital Marketing Capabilities on Sustainable Consumption Behavior	0.531	0.625	.0057	9.358	0.000
3	The Effect of Technological Innovation on Digital Marketing Capabilities	0.400	0.355	0.069	5.784	0.000
5	The Moderating Effect of Green Digital Learning on Technological Innovation and on Digital Marketing Capabilities	0.064	0.103	0.022	2.933	0.003
6	The Moderating Effect of Green Digital Learning on Digital Marketing Capabilities and on Sustainable Consumption Behavior	0.076	0.125	0.018	4.148	0.000

Based on Table 6 and Figure 2, the first hypothesis indicates a positive and significant relationship between sustainable consumption behavior and technological innovation with a standardized coefficient of 0.457. The second hypothesis also indicates a positive and significant relationship between digital marketing capabilities and sustainable consumption behavior with a standardized coefficient of 0.625. In the third hypothesis, which deals with the relationship between technological innovation and digital marketing capabilities, it is confirmed with a standardized coefficient of 0.355. Finally, green digital learning has a positive and partial moderating

role between technological innovation and digital marketing capabilities, as well as between digital marketing capabilities and sustainable consumption behavior. All relationships are statistically significant at the 95% confidence level (significance level = 0.000). The coefficient of determination (R^2) shows how much of the variance of the dependent variable is explained by the predictors. In the research model, digital marketing capabilities have a value of 0.607 and sustainable consumption behavior has a value of 0.768, which indicates the high ability of the model to explain changes in these constructs.

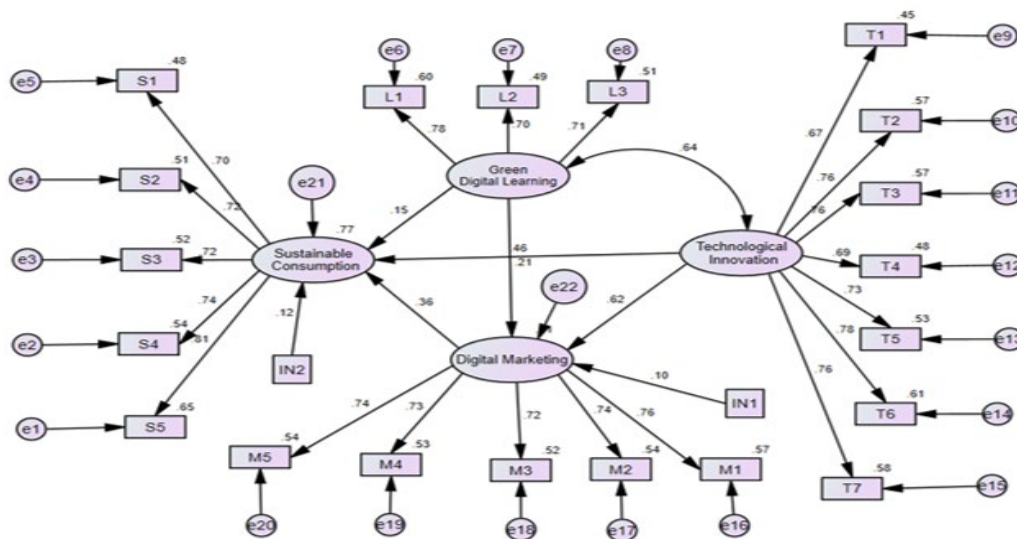


Figure 2. Research Model

Table 7. Bootstrap Test Results of the Fourth Hypothesis

Variable	Indirect standardized values	Indirect standard error	Bootstrap 95% confidence		
			Upper Bound	Lower Bound	Interval Level Significance
Digital Marketing Capabilities	0.213	0.048	0.140	0.298	0.000

The bootstrap test results show that digital marketing capabilities act as a mediating variable between innovation and sustainable

consumption. Given the values of $\beta = 0.213$ and $p = 0.000$, this mediating effect is significant.

Table 8. Summary of Hypothesis Testing Results

Hypothesis	Path	Result
1	The Effect of Technological Innovation on Sustainable Consumption Behavior	Confirmed
2	The Effect of Digital Marketing Capabilities on Sustainable Consumption Behavior	Confirmed
3	The Effect of Technological Innovation on Digital Marketing Capabilities	Confirmed
4	The Mediating Effect of Digital Marketing Capabilities on Technological Innovation and on Sustainable Consumption Behavior	Confirmed
5	The Moderating Effect of Green Digital Learning on Technological Innovation and on Digital Marketing Capabilities	Confirmed
6	The Moderating Effect of Green Digital Learning on Digital Marketing Capabilities and on Sustainable Consumption Behavior	Confirmed

Conclusion

This study was conducted to investigate the role of technological innovation, digital marketing capabilities, and green digital learning in promoting sustainable consumption behaviors. The findings of the study show that technological innovation plays a pivotal role in guiding consumer behavior. (Duplicate

sentence removed). The theoretical framework of the study is based on the theory of diffusion of innovations and capability theory. The theory of diffusion of innovations explains how the adoption of new technologies can change consumer attitudes and behaviors, and the theory of capabilities suggests that organizations can shape consumer behavior and

enhance the impact of technological innovation on sustainable consumption by empowering digital resources and skills. Green digital learning is considered a sustainable digital capability that enables the responsible use of new technologies and enhances the impact of technological innovation and digital marketing on sustainable consumption behavior.

Specifically, the results of the first hypothesis test showed that technological innovation has a positive and significant effect on consumer behavior and leads to the provision of products and services that both meet consumer needs and reduce environmental impacts. This finding is consistent with the research of Isaac et al. (2025) who have shown that technological innovation and industrial adaptation can enhance sustainable consumption patterns and sustainable lifestyles in small and medium-sized enterprises. From a practical perspective, organizations can design green products and provide environmental education campaigns by developing new technologies to strengthen consumer behavior towards sustainability.

The results of the second hypothesis test indicate that technological innovation has a positive and significant effect on digital marketing capabilities. This finding is in keeping with the findings of Mousavifard and Hassani (1401) and Ebrahim et al. (2025) and shows that organizations that employ technological innovation have a greater ability to use digital tools and channels for marketing. Digital marketing capabilities can strengthen the effect of technological innovation in shaping sustainable consumption behaviors by providing features such as rapid communication with customers, providing accurate and attractive information, and analyzing consumer behavior. These results also match the findings of Yu (2025) and Qureshi (2025) who showed that targeted digital strategies, relevant content and messages, and environmental awareness can have a significant impact on sustainable consumer behavior. By designing targeted digital strategies, organizations can use interactive tools and engaging content to increase environmental awareness and promote sustainable consumption behavior.

The mediation analysis showed that digital marketing capabilities provide an effective path

to mediate between technological innovation and sustainable consumption behavior. This means that the direct effect of technological innovation on sustainable consumption is maximized when organizations effectively utilize digital marketing capabilities. Advanced digital capabilities allow for broader consumer reach, sustainable messaging, and increased engagement, and thus technological innovation will be effective not only in product production and supply, but also in shaping consumer attitudes and behavior.

Green digital learning plays an important role as a moderating factor in these pathways. The findings show that higher levels of green digital learning enhance the effects of technological innovation on digital marketing capabilities and the effects of digital capabilities on sustainable consumption behavior. Organizations and consumers with higher green digital knowledge and skills are better able to understand digital innovations and messages and translate them into sustainable behaviors. These results are in agreement with the results of Al-Halbousi et al.'s (2023) and Budds et al.'s findings (2023) that green digital literacy and skills can guide consumer behavior towards responsible and environmentally friendly choices. Organizations and consumers with higher green digital skills are better able to understand messages and innovations and translate them into sustainable behaviors. Practically, providing green digital training and developing online educational content can enhance the impact of digital marketing campaigns and technological innovation.

The combination of the three constructs of technological innovation, digital marketing capabilities, and green digital learning provides effective pathways to promote sustainable consumption and shows that the impact on consumer behavior will be limited without simultaneously paying attention to these dimensions. By utilizing new technologies such as artificial intelligence and the Internet of Things, organizations can optimize their resource and supply chain management, reduce energy and resource consumption, and convey their sustainable messages in a more targeted manner. In addition, providing green digital training campaigns and online educational tools will increase consumers' skills and understanding of sustainable behaviors and the

effects of innovation and digital marketing on environmentally friendly choices.

This research shows that achieving sustainable consumption behavior requires simultaneous attention to technological innovation, digital marketing, and green digital learning, and this triple combination provides a comprehensive and practical framework for promoting sustainable consumption. Without simultaneously addressing these dimensions, organizations' impact on consumer behavior will be limited and environmental goals will not be fully achieved.

In line with the research findings, the following suggestions are made:

Marketing messages should emphasize the environmental, ethical, and long-term benefits of green products, highlighting that choosing these products, even at a higher price, is a responsible investment and contributes to a sustainable lifestyle. Slogans such as the following should be used: "Your choice today, a greener tomorrow," "Buy responsibly, Live sustainably." To attract consumers who care about sustainability and are interested in new technologies, organizations should design mixed marketing campaigns that emphasize the environmental benefits and technological innovation of green products; for example, introduce sustainable products that use the

latest technologies and offer a better user experience, while highlighting their long-term economic and environmental benefits. Also, using digital tools such as social media and websites, interactive educational content focused on green digital learning should be produced to increase awareness and willingness to consume sustainably and show consumers how sustainable choices can be cost-effective in the long run. Implementing digital incentive programs based on purchasing sustainable products, such as points systems or targeted discounts, can help to further encourage customers, especially those who prioritize price, and transparency in providing environmental information about products can gain their trust.

Research limitations of the present study include using a sample limited to a single geographical area and collecting data through a self-report questionnaire. Cultural and social variables that can influence sustainable consumption behavior have also not been examined. It is suggested that future research, with more diverse samples, experimental methods, and behavioral data, examine the effect of these constructs in different environments and analyze the role of other social and cultural factors in shaping sustainable consumption behavior.

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