Cleaner Environmental Systems 8 (2023) 100104

Contents lists available at ScienceDirect

Cleaner Environmental Systems

journal homepage: www.journals.elsevier.com/cleaner-environmental-systems

SEER: Sustainable E-commerce with Environmental-impact Rating

Md Saiful Islam [a], Adiba Mahbub Proma [a], Caleb Wohn [a], Karen Berger [b], Serena Uong [a], Varun Kumar [a], Katrina Smith Korfmacher [c], Ehsan Hoque [a,*]

[a] Department of Computer Science, University of Rochester, United States
[b] Department of Earth and Environmental Sciences, University of Rochester, United States
[c] Department of Environmental Medicine, University of Rochester Medical Center, United States

ARTICLE INFO

Keywords:
Sustainable consumption
Human behavior
Eco-friendliness rating
Environmental impact
Climate change
E-Commerce

ABSTRACT

With online shopping gaining massive popularity over the past few years, this study identifies a promising opportunity for E-commerce platforms to tackle climate change and other environmental problems. This study investigates a redesign of E-commerce platforms to bridge the existing "attitude-behavior gap" regarding environmental sustainability in online shopping. It introduces a concept design named Sustainable E-commerce with Environmental-impact Rating (SEER) – a way of communicating products' environmental impact when displaying them on E-commerce platforms. A quasi-randomized case-control experiment with 98 subjects demonstrates the efficacy and user-friendliness of the proposed concept design. The case group using SEER showed significantly more eco-friendly behavior than the control group ($p < 0.005$) and reported that the components introduced in SEER made finding eco-friendly products more convenient, simultaneously increasing their trust in the labels because of the provided explanation. In addition, SEER has been rated highly in terms of usability, with a System Usability Scale (SUS) score of 79.18. By shaping the behavior of climate-concerned online shoppers, SEER could significantly reduce total carbon emissions of online products, which are currently estimated to exceed 2.88 million tonnes (yearly) in the United States alone.

1. Introduction

In recent years, the effects of climate change and environmental pollution have become devastating, affecting communities worldwide. While awareness is increasing among the general population, many people lack the knowledge or motivation to make sustainable choices. This is specifically evident in consumer buying behavior – despite many individuals being concerned about the environment and willing to opt for greener consumption, their intentions are often not translated into appropriate actions (Young et al., 2010). This phenomenon, termed as an "attitude-behavior gap", is commonly identified in consumption behavior literature (Tanner and Wölfing Kast, 2003; Gonçalves et al., 2021). High prices, difficulty in identifying green products, not having enough time for research, lack of environmental information in the product description, and lack of trust in the "eco-friendly" labels provided by the manufacturers have been identified as the contributing factors to the attitude-behavior gap(Gleim et al., 2013; Joshi and Rahman, 2015). Individual and social factors like habit, behavioral control, social norms, and so on also contribute to the phenomenon, but their impacts are not well established (Eze and Ndubisi, 2013; Wang et al., 2014). While the factors responsible for the attitude-behavior gap are well studied, existing literature falls short when providing viable solutions or strategies to mitigate this gap.

Online shopping activities have significantly increased recently, especially after the onset of the COVID-19 pandemic(Bhatti et al., 2020). As a result, sustainable E-commerce gained attention from researchers. Cheba et al. (2021) studied E-commerce development in cities and how several associated factors may affect the environment. An alarming effect of increased E-commerce activities is the emission and pollution from trucks and cargo vehicles delivering parcels (Jaller and Pahwa, 2020). Carbon emission from packaging is also a big concern (Prasertwit and Kanchanasuntorn, 2021). Therefore, researchers have been actively trying to find solutions to make E-commerce more sustainable. Escursell et al. (2021) conducted a thorough review of state-of-the-art E-commerce packaging that may enable rethinking the whole paradigm. Prajapati et al. (2022) investigated an efficient forward and reverse logistics for a closed-loop supply chain where the product is delivered to the customer in the forward flow, and in the reverse flow, any returned item

* Corresponding author.
E-mail addresses: mislam6@ur.rochester.edu (M.S. Islam), aproma@ur.rochester.edu (A.M. Proma), mehoque@cs.rochester.edu (E. Hoque).

https://doi.org/10.1016/j.cesys.2022.100104
Received 26 April 2022; Received in revised form 30 November 2022; Accepted 20 December 2022
Available online 23 December 2022

or reusable packaging materials are picked up from the customers. Kumar et al. (2022) also studied closed-loop inventory routing for efficient management of reusable containers to reduce waste and emissions from the delivery of perishable goods. These are exciting studies and may help reduce the environmental harms of E-commerce. However, to the best of the authors' knowledge, no prior research taps into the potential opportunity of E-commerce in promoting sustainable consumption.

Prior research suggests that green consumers prefer being presented with environmental impact information in a simple, compact, and user-friendly manner (Mondelaers et al., 2009). At the same time, they often find it hard to trust "eco-friendly" labels provided by companies (Chen and Chang, 2012; Torelli et al., 2020). The increasing popularity of online shopping brings a unique opportunity - the architecture of the website makes it easy to present information through the incorporation of high-resolution images, videos, and hypertexts that can point users to further resources. E-commerce websites can facilitate additional information about a product and present it in a way that does not overwhelm consumers but is still trustworthy and well-explained. In addition, whether an additional piece of information should be presented to a consumer can be customized based on consumer preference and behavior analysis.

This study finds that online shopping websites present an excellent opportunity to convey the required information about a product's environmental impact and aid users in making more eco-friendly decisions. For example, when users search for a specific product, they can sort the results based on the eco-friendliness rating. However, the question remains – would consumers trust these ratings? To build trust, a credible explanation for the rating must be provided. There can be a summary of the product's environmental impacts that explains the rating of the product. In addition, from the description of the product, words or phrases (keywords) that are related to environmental impact can be highlighted and explained. This would also increase consumers' environmental knowledge, as they learn about the environmental impacts of various product elements, thereby raising public awareness. This paper analyzes the "attitude-behavior gap" for an online setting and proposes a concept design named **S**ustainable **E**-commerce with **E**nvironmental impact **R**ating (SEER) that would facilitate making eco-friendly choices by incorporating the features discussed above.

A quasi-randomized case-control study is conducted with 98 participants, where participants are asked to select products for a local school with a limited budget. Before the start of the study, the participants are shown a climate awareness video and how their choices can make a difference. To elicit real-life behavior, everyone gets financial rewards for saving budget while selecting the products. The participants then complete a post-study survey related to whether their attitude towards the environment has changed (both groups) and the design interface of the website (case group only). This observational study identifies that the "attitude-behavior gap" also exists in an online setting – participants who are more concerned about the environment do not choose a higher number of eco-friendly products. However, providing more information about the environment through our interface makes a difference. The purchasing behavior of *case* subjects using SEER differs significantly from the *control* subjects using a traditional E-commerce website setting ($p < 0.01$). The case group demonstrates more eco-friendly behavior than the control group ($p < 0.005$) and reports that the components introduced in SEER made finding eco-friendly products more convenient, simultaneously increasing their trust in the labels because of the provided explanation. At the same time, SEER has been rated as nearly excellent in terms of usability, as established by a score of 79.18 in System Usability Scale (Brooke et al., 1996).

In 2020, the worldwide e-retail sale was more than 4.2 trillion USD with over two billion E-commerce customers (Coppola, 2021). According to the quarterly sales report of the U.S. Census Bureau, E-commerce sales in the second quarter of 2021 accounted for 12.5 percent of total sales (Bureau, 2021). Considering this enormous growth of E-commerce, the proposed idea can have a huge impact in tackling climate change by potentially reducing harmful environmental effects from every online purchase. Adaptation of SEER will raise general awareness about climate change and individual responsibility, thus promoting sustainable products and encouraging the industry to invest more in sustainable production. Therefore, SEER can be the seer of a greener future.

The key contributions of this study are as follows:

- This study validates the existence of the "attitude-behavior" gap in online shopping and proposes a concept interface design for E-commerce platforms that can bridge the gap.
- To bridge the "attitude-behavior" gap, the proposed concept design aims to address three specific barriers – lack of trust, lack of knowledge, and inconvenience via explainable environmental rating.
- The efficacy and usability of the proposed concept design is demonstrated by a quasi-randomized case-control experiment with 98 participants from the United States.

2. Study design

2.1. Interface design

A prototype website named **S**ustainable **E**-commerce with **E**nvironmental-impact **R**ating (SEER) is developed to conduct this study. SEER targets addressing three major factors responsible for the "attitude-behavior" gap observed in sustainable consumption literature: (i) inconvenience (ii) lack of knowledge, and (iii) lack of trust. The key component of SEER is an *environmental rating* (1–5 scale) that rates a product based on its environmental impact, with a higher rating indicating higher eco-friendliness of a product. However, for facilitating green consumption behavior, both the presence of a singular rating and its credibility are important (Riskos et al., 2021; Young et al., 2010). Therefore, the second component of SEER is an *environmental concerns* statement which briefly conveys an explanation of the rating provided by discussing the product's potential impact on the environment. These explanations can help to increase trust (Pu and Chen, 2006). At the same time, SEER tries to educate people by highlighting words or phrases (keywords) that are related to the environment, simultaneously explaining what these keywords mean. This is the third component, named as *environmental keyword highlights*.

2.2. Modeling environmental sentiment and knowledge

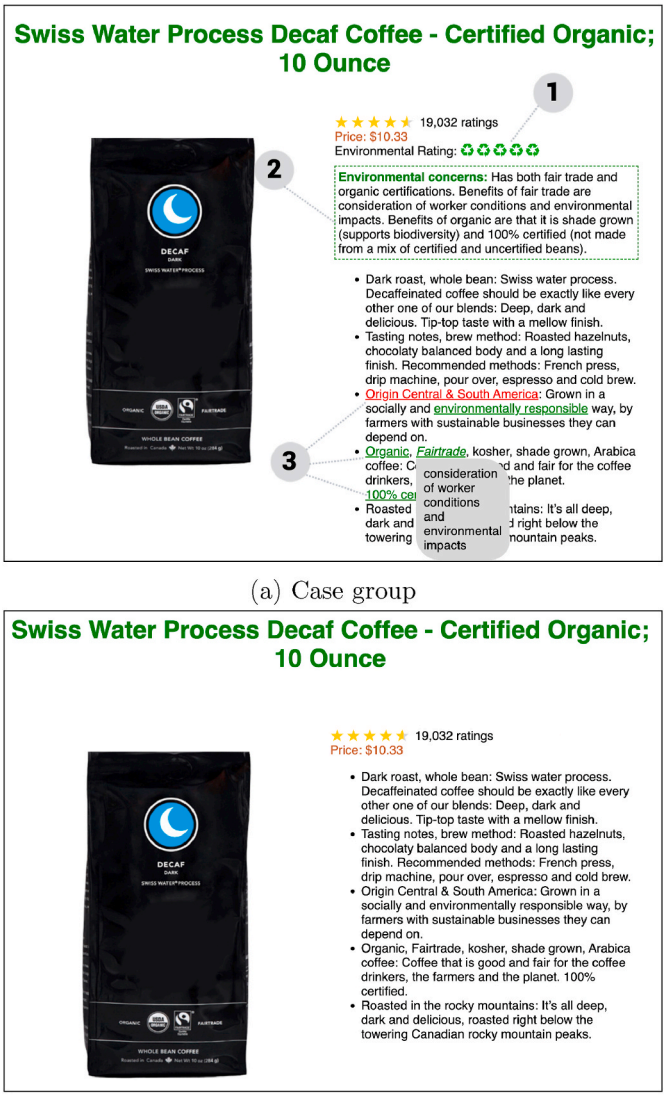
Environmental sentiment denotes the general attitude of individuals related to how concerned they are about the environment and how actively they are trying to prevent environmental harm (Kim and Choi, 2005). Generally, it is believed that favorable consumer attitudes lead to more eco-friendly consumer behavior (Minton and Rose, 1997), although there exists a gap between these two (Vermeir and Verbeke, 2006). This study adopts Lin and Huang (2012) for modeling one's environmental sentiment/concern through 10 five-point Likert scale (strongly disagree: 0, disagree: 1, neutral: 2, agree: 3, strongly agree: 4) questions. The total score from the 10 questions can be between 0 and 40. The respondents scoring less than 20 are considered less concerned with the environment than the others.

Environmental knowledge indicates an individual's ability to identify and understand concepts and behavior patterns relevant to environmental protection (Laroche et al., 2001). Both objective and subjective measures have been used to model the environmental knowledge of an individual. Objective measures assess how much an individual knows about a certain topic through a comprehensive set of multiple-choice or open-ended questions. Subjective measures, also known as perceived knowledge measures, indicate how much an individual thinks about their knowledge. This study builds on existing perceived knowledge questionnaires (Mostafa, 2007; Jaiswal and Kant,

2018) and adopts the questions to fit online shopping. Environmental knowledge is assessed by five five-point Likert scale questions (see Table 4). Each question is worth 0–4 points, and the total environmental knowledge score can be 0–20. A Higher score is an indicator of better (perceived) environmental knowledge.

2.3. Participant recruitment and pre-study survey

Amazon Mechanical Turk (Paolacci et al., 2010) is used to recruit 98 participants living in the United States. A case-control experiment is conducted by splitting the participants into two groups: case group selecting products using SEER ($N = 49$), and control group using a prototype of a traditional website ($N = 49$). Fig. 1 shows both of the websites – although the look and feel of both prototypes are the same, SEER additionally incorporates the three components proposed above.



(a) Case group

(b) Control group

Fig. 1. (a) The proposed design for displaying a product to the case group. The *environmental rating* (1) indicates how eco-friendly a product is and the *environmental concerns* (2) summarizes the possible environmental impacts of the product. Keywords related to environmental impact analysis are also highlighted with green (eco-friendly) or red (harmful to the environment) color (3). If a user hovers the mouse/pointer over the highlighted keywords, additional environmental information about the keywords is presented. (b) Traditional product display design presented to the control group. For both groups, brand names and logos are removed from all products to avoid bias towards popular brands. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

At first, the participants are asked to fill out some demographic information such as age range, ethnicity, gender, household income, the highest degree of education, and zip code. The participants then go through the environmental concerns questionnaire and they are assigned an "environmental sentiment score" based on their answers. A quasi-randomized process is used to assign a participant to either case or control group in such a way that both groups have a similar distribution in terms of the environmental sentiment score. The participants also go through five perceived environmental knowledge questions. Their environmental knowledge is measured based on these responses. The quasi-randomized assignment is successful, as similar distribution is observed in both case and control groups – not only for environmental sentiment score but also for gender, age, race, education, environmental knowledge, and income level. The detailed demographic distribution of the participants is presented in Table 1.

2.4. Experiment setup

Fig. 2 summarizes a participant's activity in this study. Both case and control groups are given the prompt that a local school is just opening, and the school needs help to purchase some products due to a shortage of school staff (note that although the school is imaginary, participants are not aware of this until the end of the experiment). The prompt includes that the school has a limited budget, and if participants can save some money from the budget, they would receive 10% of the saved money as a token of thanks. This prompt reinforces a practical scenario where saving money is important and leads to personal gains.

For investigating the influence of the proposed E-commerce redesign, it is crucial to ensure that the three components introduced in SEER are the only differences between the case and control group. Quasi-randomized assignment of users into case and control groups helped

Table 1
Demographic details of the study participants.

Variables	Options	N (number)	Case (%)	Control (%)
Gender	Female	28	46.4%	53.6%
	Male	70	51.4%	48.6%
Age	18–24	4	100.0%	0.0%
	25–34	47	46.8%	53.2%
	35–44	25	40.0%	60.0%
	45–54	12	58.3%	41.7%
	55–64	7	71.4%	28.6%
	65 and above	4	25.0%	75.0%
Race	Asian	7	57.1%	42.9%
	Black or African American	12	41.7%	58.3%
	White	78	50.0%	50.0%
	Other	1	100.0%	0.0%
Education	Below High School	1	0.0%	100.0%
	Associate	7	57.1%	42.9%
	Bachelor	54	44.4%	55.6%
	Graduate	15	66.7%	33.3%
Yearly Family Income (USD)	Below 20,000	11	45.5%	54.5%
	20,000–35,000	13	53.8%	46.2%
	35,000–50,000	16	56.3%	43.7%
	50,000–75,000	34	52.9%	47.1%
	75,000–100,000	30	36.7%	63.3%
	Above 100,000	5	40.0%	60.0%
Total	-	**98**	**50.0%**	**50.0%**

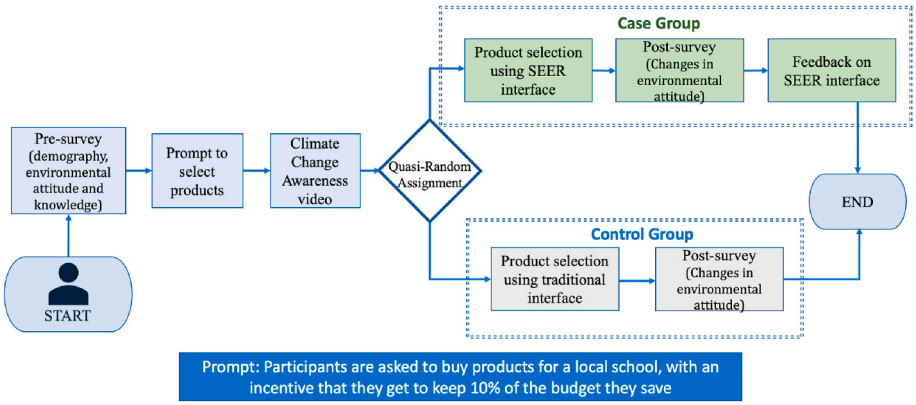


Fig. 2. A simple overview of the study design.

to keep the two groups similar in terms of demographic attributes, environmental sentiment, and knowledge. However, for someone in the case group, it is easy to guess that the study is about sustainability or eco-friendly behavior since they see the environmental cues of the products. On the other hand, a control group participant has no way of knowing what the study is about before finishing product selection. This could lead to potentially bias in the results – someone from the case group may be more eco-friendly just because they want to show the desired behavior of the study, while the control group may focus on saving money. To address this issue, all participants watch a motivational video (3-min length) explaining the adverse effects of environmental pollution and climate change and how their individual actions can make a difference. Now that everyone knows eco-friendliness is the desired behavior, it is easier to focus on the primary research question of this study: "if someone is willing to be eco-friendly, can E-commerce platforms facilitate the translation of their willingness into actions by incorporating the SEER components?"

All participants would have two possibly conflicting objectives in mind: (i) save money and get monetary benefits instantly, and (ii) invest in eco-friendly products which has no short-term benefits but will be helpful for the environment in the long run. The participants are then shown a pair of products side-by-side from 12 pre-selected product types. Between each pair, one is more eco-friendly than the other. Fig. 1 shows how each product is presented to the participants. The products are arranged in the same order, and in the same arrangement for all participants. Whether the eco-friendly product from a certain pair will be displayed on the left side or right side was pre-determined randomly (but kept the same for all participants). This avoids possible confounding factors (e.g., users being biased towards the product on the left side, being more attentive at the beginning, etc.). When selecting a product from a pair, the participants from the case group are shown three additional components (see Fig. 1) proposed in SEER – (i) environmental rating, (ii) environmental concerns, and (iii) environmental keyword highlights, along with traditionally available features: product name, an image of the product, price, user rating, number of users who rated this product, and product description. The control group has no access to SEER components but saw the traditional features.

After the participants finish product selection, they complete a post-study survey. Both case and control groups answer the same questions related to environmental sentiment as before. This time, however, the questions are asked in the future tense to determine the effectiveness of the intervention strategy in raising awareness of climate change and increasing concern for the environment among the participants. The participants from the case group answer additional questions regarding the effectiveness of the SEER components, system usability (Brooke et al., 1996), and their experience (i.e., likes, dislikes, and suggestions) of the study.

2.5. Products and their environmental impact assessment

Based on the theme of a local school, 12 types of products are selected (as displayed in Table 2) to be included in the study. Two products from each type are chosen, one being more eco-friendly than the other. A domain expert (a Professor of Environmental Science who is actively engaged in several sustainability programs) is consulted for selecting the products and generating their relevant environmental information. The name and logo of the brand of the products are removed since consumers can be biased towards certain brands (Chovanová et al., 2015; Hillenbrand et al., 2013). The price of the products is also considered as an additional context, and products are selected to evenly represent each of the four different conditions (3 product pairs from each condition):

(i) Eco-friendly product is cheaper
(ii) Both products are equally priced
(iii) Eco-friendly product is slightly more expensive (additional cost is below 5 USD)
(iv) Eco-friendly product is significantly more expensive (additional cost is at least 5 USD)

These conditions would allow this study to probe into the question of how strong the influence of price is on consumers when buying eco-friendly products.

The domain expert rated the eco-friendliness of the products on a scale of 1–5 (higher value means more eco-friendly), and provided justifications for the rating. This justification is used as the "environmental concerns" in SEER. Furthermore, three undergraduate students highlighted keywords in the product description in either red or green, where red indicated a keyword that is not eco-friendly (e.g., pollution), green being the opposite (e.g., recycled). Additional justification as to why these keywords are marked in red or green and are also available to the

Table 2
12 types of products selected for the study.

Product Type Code	Product Type
P1	Decaf coffee
P2	All-purpose cleaner
P3	Toilet paper
P4	Clubhouse playset
P5	4-in-a-row board game
P6	Copy paper
P7	Kitchen trash bags
P8	Ballpoint pen
P9	Chair
P10	Table
P11	Glue sticks
P12	File folder

case group upon hovering over the highlighted keywords.

3. Results

Participants from both case and control groups demonstrate similar distribution in terms of demographic and socio-economic factors (i.e., age, race, gender, education, and income) (Table 1). In addition, both groups have similar environmental sentiments and awareness, reducing the potential effect of unknown confounding factors. Statistical correlations between independent variables (gender, age range, level of education, yearly income range, environmental sentiment score, and knowledge) and the target variable (eco-friendliness) are studied. Gender, age range, level of education and yearly income range are categorical values, while environmental sentiment score and knowledge are numerical. For variables with categorical values, the ANOVA test is used and the *p*-values are reported wherever appropriate. For variables with numerical values, the Pearson correlation coefficient is used to report *r*. Also, to test the major hypotheses, appropriate *t*-tests are used to report *p*-values. The System Usability Scale (SUS) score is measured exactly as in literature (Brooke et al., 1996).

3.1. People have good intention

10 standard five-point Likert-scale questions (Table 3) are asked to infer the environmental sentiment of all the participants, as in prior literature (Lin and Huang, 2012). Each participant can score between 0 and 40: 20 if they are neutral on average, above 20 if they demonstrate an eco-friendly attitude, and below 20 otherwise. In general, this study finds that people have good intentions (Fig. 3a). 73 subjects (74.5%) demonstrate an eco-friendly attitude, reporting they are concerned about the environment and intend to take actions to prevent harm while 2 subjects remain neutral, and 23 do not demonstrate such an intention.

3.2. Intention does not always imply action

The eco-friendly behavior of the subjects is measured by the number of eco-friendly products they choose (0–12). This study does not find any statistically significant correlation between gender, age, level of education, or yearly income and subjects' eco-friendliness behavior. This

Table 3
Summarized responses of all the participants on the environmental sentiment questions. Here SD, D, N, A, and SA denote "Strongly Disagree", "Disagree", "Neutral", "Agree", and "Strongly Agree" respectively.

Environmental sentiment question	SD	D	N	A	SA
I make a special effort to buy paper and plastic products that are made from recycled materials (Q1)	7	17	14	41	19
I have switched products for ecological reasons (Q2)	8	9	21	41	19
When I have a choice between two equal products, I purchase the one less harmful to other people and the environment (Q3)	2	0	12	51	33
I have voted for a candidate in an election at least in part because he or she was in favor of strong environmental protection (Q4)	6	11	21	29	31
I have avoided buying a product because it had potentially harmful environmental effects (Q5)	4	7	17	35	35
I have read newsletters, magazines or other publications written by environmental groups (Q6)	9	5	14	43	27
I have signed a petition in support of protecting the environment (Q7)	17	13	17	20	31
I have given money to an environmental group (Q8)	21	14	13	27	23
I have written a letter or called the member of Congress or another government official to support strong environmental protection (Q9)	34	9	13	24	18
I have boycotted or avoided buying the products of a company because I felt that company was harming the environment (Q10)	18	11	12	37	20

Table 4
Summarized responses of all the participants on the questions asked to infer their knowledge about climate change and environmental issues. Here SD, D, N, A, and SA denote "Strongly Disagree", "Disagree", "Neutral", "Agree", and "Strongly Agree" respectively.

Environmental knowledge question	SD	D	N	A	SA
I am aware of the environmental and human effects of climate change (Q1)	0	4	13	31	50
I know that my consumption choices can make a difference (Q2)	3	5	14	45	31
When I read the description of a product, I can understand whether it is harmful for the environment (Q3)	2	4	27	37	28
It is easy for me to recognize an eco-friendly product (Q4)	1	9	20	43	25
I like to read about sustainability, climate change, and the environment often (Q5)	7	10	21	39	21

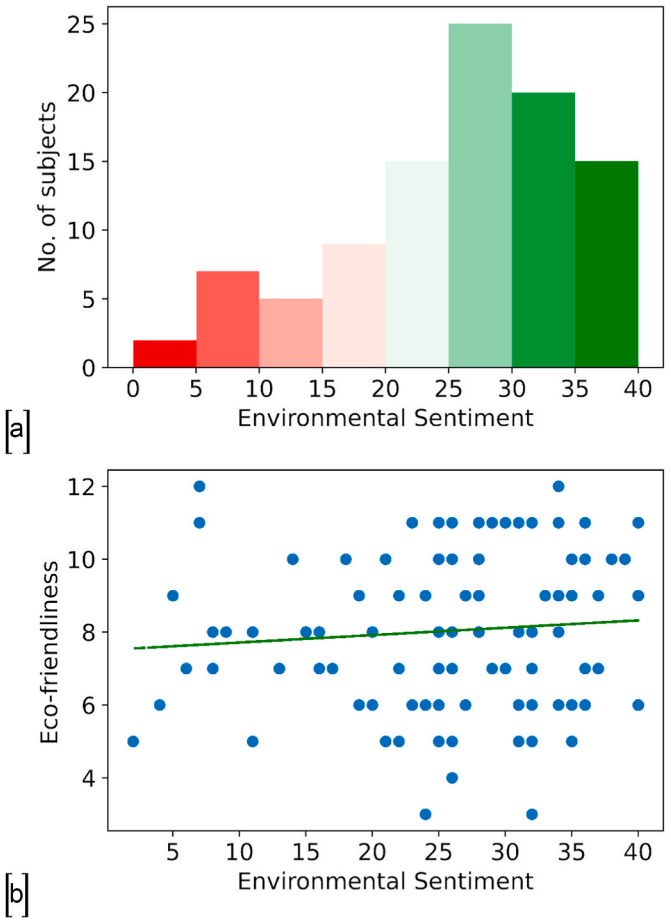


Fig. 3. Although people have good intentions, the intentions do not translate well to actual action. (a) shows the environmental sentiment of the subjects (higher value indicates greener sentiment), (b) shows the correlation between environmental sentiment and eco-friendliness as defined by their selection of eco-friendly products ($r = 0.088$; the green line indicates the trend). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

suggests these are either unrelated or may have a weak correlation, which would require a larger population to find out. However, this study validates that the *attitude-behavior gap* demonstrated in previous literature also exists in online shopping. As in Fig. 3, the correlation between one's environmental attitude (sentiment) and actual eco-friendly behavior is very weak ($r = 0.088$). In addition, the participants are split into two groups such that those scoring less than 20 are in the "less

green attitude" group, and those scoring at least 20 are in the "greener attitude" group. The behavior is marginally different between these two groups. Two-tailed *t*-test fails to reject the null hypothesis that "there is no relationship between one's greener environmental attitude and actual action" ($p = 0.75$). In addition, the study echoes prior sustainable consumption literature reporting the "attitude-behavior gap" by failing to establish that greater concern about the environment translates to more eco-friendly action ($p = 0.38$).

3.3. SEER can reduce the attitude-action gap

In the pre-survey questionnaire, the participants are asked 5 questions to estimate their knowledge about climate change and environmental issues (Table 4). Participants scoring below the median total score are regarded as part of the "less knowledgeable" group and those scoring at least the median are in the "more knowledgeable" group. Based on the one-tailed *t*-test, this study finds that subjects with higher environmental knowledge show more eco-friendly behavior than subjects who are less knowledgeable ($p < 0.0005$). This shows that environmental knowledge can be a powerful tool in increasing the purchase of eco-friendly products, which SEER tries to convey to its users.

One-tailed *t*-test reveals that the participants from the case group are significantly more eco-friendly than the control group ($p < 0.005$). Fig. 4 shows the eco-friendliness scores of case and control group participants. On average, a subject from the case group selected 8.57 eco-friendly products (mode = 11, median = 9, SD[1] = 2.13) while the average for the control group is 7.47 (mode = 6, median = 7, SD = 1.92). This experiment suggests that SEER is capable of helping consumers choose more eco-friendly products while shopping online. In the post-study survey, participants from the case group are also asked about their level of agreement on the impact of the SEER prototype and its components on their purchasing decisions. 39 participants (79.6%) at least agree (agree/strongly agree) that comparing the eco-friendliness of products is easy using SEER (29 strongly agreed), 9 participants are neutral, while only one disagrees (no strong disagreement). The proposed prototype not only increases convenience but also increases trust. 30 participants (61.2%) express that they trust the environmental labels presented in the SEER prototype more than the traditional websites they use (e.g., Amazon). The above findings indicate that SEER can reduce the "attitude-behavior" gap for online shopping by addressing two fundamental barriers: inconvenience and lack of trust in the "eco-friendly" labels.

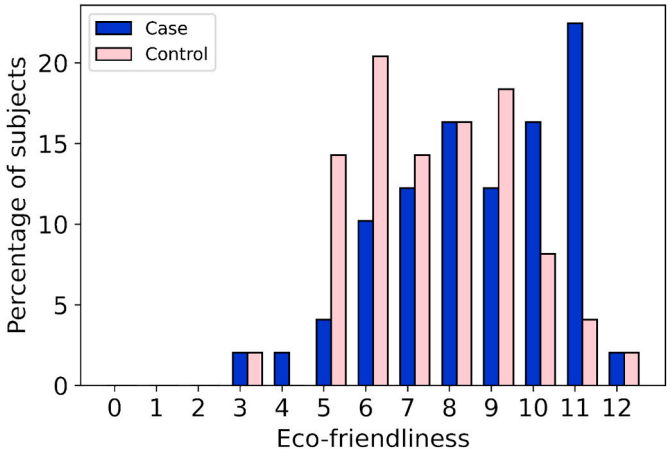


Fig. 4. The distribution of eco-friendliness in the case and control group. Eco-friendliness is measured by the number of eco-friendly products selected by a participant (out of 12; a higher score indicates more eco-friendly behavior).

[1] SD: Standard Deviation.

The individual impacts of the proposed three components are also analyzed. 41 participants (83.7%) express their agreement (28 strongly agree) that the environmental rating makes it easy to identify eco-friendly products, establishing this component as the strongest factor for convenience. The environmental impact summary is primarily responsible for building consumer trust in the provided labels, as 41 participants (83.7%) at least agree (24 strongly agree) that this component helped them trust the labels. The effect of the environmental keyword highlights is primarily to increase consumer knowledge as it describes what the words/phrases mean and how it is related to the environment. 36 participants (73.5%) from the case group self-report that they are more aware of the environment after participating in this study, 22 (44.9%) expressing that they will read more articles related to the environment.

3.4. SEER is user friendly

To evaluate the usability of the SEER interface, participants from the case group are asked 10 standard System Usability Scale (SUS) (Brooke et al., 1996) questions (Table 5). The average SUS score for SEER is 79.18 (median = 85), 68.2 being the average score for all websites (Bangor et al., 2009). The mode of the SUS score was surprising – a perfect score (100), provided by 12 participants (24.5%). Typically, a SUS score between 70 and 80 is considered good, more than 80 indicates excellent and less than 50 is not acceptable (Bangor et al., 2008). This establishes that SEER has near excellent usability and is acceptable as a user interface.

3.5. Eventually, money matters

However, the price of a product significantly affects consumption behavior (Lichtenstein et al., 1993; Ramya and Ali, 2016). As in Fig. 5, a significant negative correlation is observed between the extra price a consumer has to pay for an eco-friendly product and the number of consumers who are still willing to pick the eco-friendly product (Pearson's correlation co-efficient $r = -0.73123$ and $p = 0.007$) even while they are using the SEER prototype. On average, more than 80% of the participants purchase the eco-friendly product when it is cheaper than the non-eco-friendly product or when the prices are similar. This drops to below 60% when the eco-friendly product is slightly or substantially more expensive.

Table 5
Response of all the participants on the system usability scale questions. Here SD, D, N, A, and SA denote Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree respectively. Questions in teal color are in positive sentiment (SA is the most desired), while the questions in red color are in negative sentiment (SD is the most desired).

System usability scale questions	SD	D	N	A	SA
I think that I would like to use this system frequently (Q1)	2	0	13	39	44
I found the system unnecessarily complex (Q2)	51	14	9	11	13
I thought the system was easy to use (Q3)	0	3	9	23	63
I think that I would need the support of a technical person to be able to use this system (Q4)	51	9	14	14	10
I found the various functions in this system were well integrated (Q5)	0	1	7	46	44
I thought there was too much inconsistency in this system (Q6)	49	12	15	19	3
I would imagine that most people would learn to use this system very quickly (Q7)	0	0	9	30	59
I found the system very cumbersome to use (Q8)	47	10	9	22	10
I felt very confident using the system (Q9)	0	2	12	27	57
I needed to learn a lot of things before I could get going with this system (Q10)	48	8	15	18	9

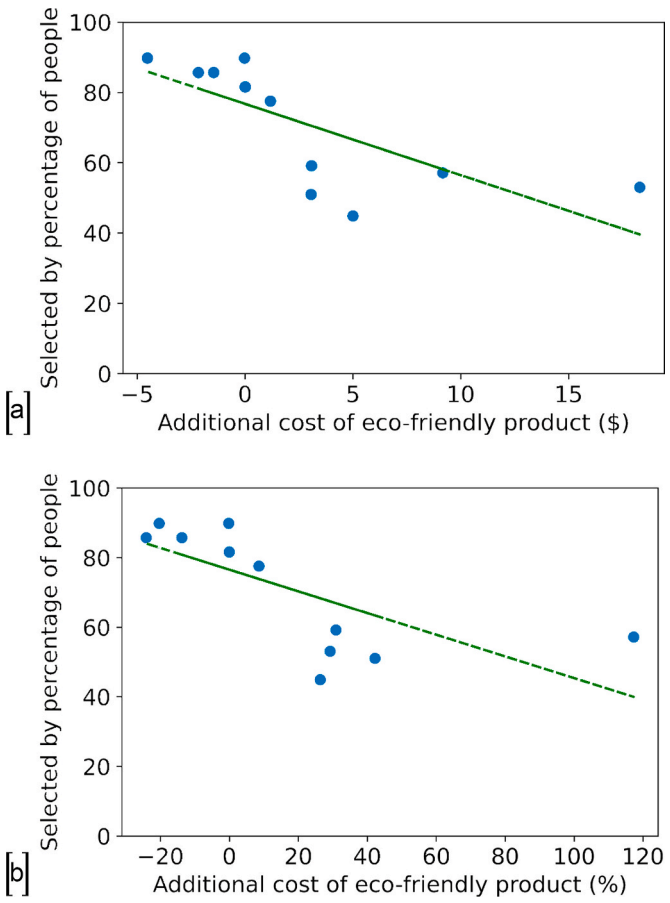


Fig. 5. Relation between eco-friendly behavior of the case group and the extra price of the eco-friendly product. The extra price is shown as an exact amount (USD) in (a) and as a percentage in (b). Negative additional cost indicates the eco-friendly product is cheaper, where most of the participants purchase it. The more the additional cost for the eco-friendly product, the less the number of participants purchasing it ($p = 0.007$). The green line indicates the trend. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

4. Discussion

4.1. Effectiveness of SEER

This study establishes that the attitude-behavior gap also holds in an online setting, and it is indeed possible to nudge people towards eco-friendly purchasing behavior by providing more information regarding the impact of the products. The proposed system SEER aims to assist people who want to make eco-friendly choices but do not end up acting on that sentiment by mitigating three specific barriers - lack of trust, lack of knowledge, and inconvenience. Results show preliminary evidence that addressing these factors indeed increases purchasing of eco-friendly products. In addition, according to the SUS score and thematic analysis of the open-ended feedback from the participants, SEER seems to be well received by the participants. A quote from a participant summarizes the contribution of this study:

> "I genuinely liked this study a great deal as I thought it was very well-designed, streamlined, easy to interact with, and quite intuitive. Moreover, I liked the conceptual framework of the website showcased in this study as it provided a realistic prototype of a highly usable and user-friendly way of comparing specific parameters of products, which is currently quite difficult, cumbersome, and time-consuming."

Thematic analysis of open-ended feedback from participants suggests that people tend to emphasize the price of the product. "I like the intention to buy at the lowest price, and to save money" - is what one of the participants said about her purchasing behavior, and it was a sentiment shared by many other participants. Quantitative analysis also shows similar results - people are less likely to buy the more expensive product when price differences are high, even if it is eco-friendly. However, aligning with prior research, a majority of the participants were willing to pay a little bit extra to purchase eco-friendly products (Mostafa, 2016; Wei et al., 2018).

4.2. Impact of particular products

It is possible that people may be more interested in buying eco-friendly for certain types of products than others as shown in Fig. 6. Some eco-friendly products are easier to identify than others, and it is seen that in such cases, both case and control groups almost equally choose the eco-friendly product. For example, in the case of the second selection (P2), one product is a plant-based cleaner while the alternative contains harsh chemicals. Being plant-based is an obvious clue, and most of the subjects (>80%) from both case and control could identify and purchase the eco-friendly product. Not all the easily identifiable eco-friendly products are popular though – for P1 (ground decaf, selected by <60% subjects), one choice is certified organic (thus easily identifiable) but 42% more expensive than the alternative. In this case, other factors such as price makes the eco-friendly option less desirable. In general, when identifying the eco-friendly product is difficult, more participants from the case group made the correct choice compared to the control. For example, in the case of P10, one product is a wooden table, and another is a plastic table. 81.6% of the subjects from the case group chose the wooden table (more eco-friendly), compared to 51% in the control group. As reported in the post-study survey, many participants from the control group found it difficult to decide whether trees cut to make the wooden table had a more negative environmental impact than the plastic alternative. It is noteworthy that, for both P2 and P10, the price of eco-friendly and non-eco-friendly products is almost the same, eliminating price as a defining factor for driving consumer decisions.

This study is valuable as a proof-of-concept. However, it is acknowledged that there may be involvement of other factors of the products. Future studies could include more than 12 product types and a deeper analysis of the relationship between product attributes and the receptivity of eco-friendly products.

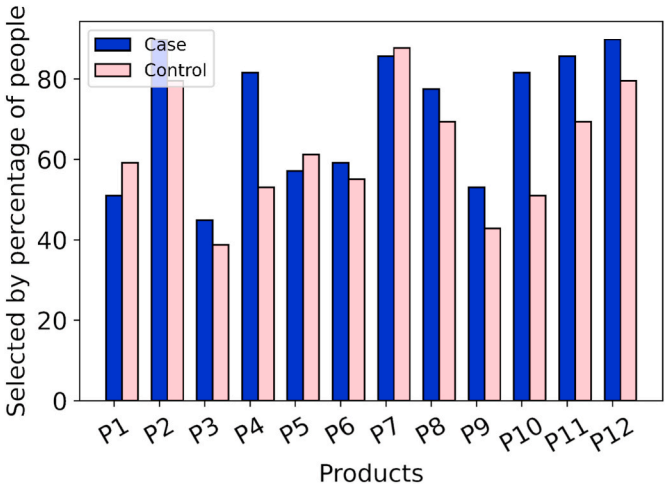


Fig. 6. Eco-friendliness in the case and control group for all the product types chosen for this study.

4.3. Managerial and policy implications

This article informs policy makers and E-commerce marketing managers about facilitating green purchase behavior. The manufacturers of eco-friendly products would benefit from this article by knowing how to provide environmental impact information of their products with appropriate justification so that consumers trust the eco-labels. Simultaneously the justifications would help the consumers learn more about associated environmental issues, and that would reinforce more eco-friendly behavior. If sales of eco-friendly products indeed increase with increased awareness, a positive feedback loop may be created, driving companies to follow more eco-friendly practices.

The E-commerce platforms can do a better job at advertising eco-friendly products by considering the proposed redesigns in this paper. They can also think about objective, transparent ways to rate the products in terms of eco-friendliness. The default design of E-commerce can remain the same, but if a user is willing to be eco-friendly and wants to use similar features proposed in this article, the E-commerce websites can facilitate that through customizing the design.

In addition to directly informing about specific purchase decisions, the proposed system in this article can be used to detect and capture eco-friendly purchases, based on which, policy makers can provide additional incentives or rewards to encourage sustainable consumption. For example, people could be given an "eco-friendliness score" or earn "green points" depending on their purchasing history, and get rewarded based on it.

However, it must be noted that the effectiveness, efficiency, and equity of such a system depend on implementation details. For example, if companies self-rate their products, the system could exacerbate "greenwashing" (Laufer, 2003). Companies may provide false information, omit harmful ingredients or practices, or use more eco-friendly keywords to inflate their products' eco-friendliness scores. It is also important to recognize that because certain eco-friendly products tend to be more expensive, any rewards associated with green purchasing patterns could exacerbate economic disparities, as lower-income consumers might not be able to take advantage of these rewards. However, companies could tie this system to justice-promoting strategies, such as making donations to climate justice or community environmental organizations with a percentage of profits from eco-friendly purchases. It must be noted that SEER does not directly address or mitigate underlying social/environmental/economic issues related to climate change; it is simply a tool to provide consumers with more information to aid in making more eco-friendly choices. Therefore, the actual impact of this system depends on actions at the policy level such as eco-friendly rating schemes, incentive structures, and tie-in policies by participating companies.

4.4. Integrating SEER components as optional information

Some participants believe that individuals cannot prevent climate change, and using a system like SEER would place the responsibility for climate change on individuals. Moreover, it can cause emotional stress for individuals who cannot afford to be eco-friendly as they can see the negative impact of their choices on the environment. To address these issues, the components proposed in SEER can be made optional so it does not burden the consumers with the information they do not want.

4.5. Immediate and long term impact

The study had an immediate impact on the subjects by increasing environmental awareness among participants. Many reported learning more about the environment, and expressed more willingness towards eco-friendly consumption in the post-study survey:

> "Thanks for the reminder, sometimes I feel like individuals cannot do much to help. I think it is easier to blame big companies for not doing enough, but it is true that consumer pressure can make a difference."

> "It is a humble reminder to think about the environment whenever we want to make a purchase"

> "I learned more about eco-friendly products and the effects of climate change. I will try to focus on buying more green products from now on."

While it is challenging to generate reliable environmental ratings and explanations, the proposed idea can potentially have a huge impact in tackling climate change by reducing carbon emissions from potentially every online purchase. According to the U.S. Department of Commerce, E-commerce retail sales for the country accounted for more than 13% of total retail sales in 2021 (First - Third quarter) (Bureau, 2021). Earlier research (Panzone et al., 2018) shows that with appropriate intervention like reminding consumers of eco-friendly behaviors, their carbon footprint can be substantially reduced. Based on consumers' self-reported answers, Panzone et al. (2018) reported a weekly reduction of 13.03 Kg CO_2e (on average) per person, including 3 Kg CO_2e reduction from a single basket of food purchases alone. In the United States, almost 25% people (about 80 million) shop online at least once a month (Optin-Monster, 2021). Since the carbon footprint of online purchases is not well studied, this article makes a modest assumption that monthly online purchases of a consumer have at least a similar carbon footprint as purchasing a food basket i.e., a consumer can save at least 3 Kg CO_2e every month. For 80 million users, the reduction is 0.24 megatons CO_2e per month (80M x 3 Kg), and 2.88 megatons per year (0.24 megatons/month x 12 months). This is equivalent to more than half a million people getting rid of their car, considering an average passenger vehicle emits 4.6 tons of CO_2 per year (EPA, 2021). The real impact of SEER in terms of carbon reduction should be even higher, as the environmental awareness from using SEER could further enable pro-environmental behaviors beyond online purchases. For example, a single action like someone recycling an aluminum can or putting an old magazine in the recycling bin instead of the garbage bin would mean a reduction of 70g and 600g CO_2e (Panzone et al., 2018).

4.6. Justification of study population

This study provides preliminary evidence that redesigning E-commerce platforms has the potential to facilitate sustainable consumption behavior. While a larger sample size would have been more representative of the US population, scaling up the study population was infeasible considering the resource constraints. Observing consumer behavior in an online shopping platform requires the users to use the system for a moderate amount of time (20–30 min), for which they receive proper compensation. Since eco-friendly products are often more expensive than less eco-friendly similar products, a crucial aspect of the study was to simulate the immediate reward people receive by purchasing cheaper products. This immediate reward was essentially given as bonus amounts based on the money the users saved from their budget after purchasing the products. These factors increased the expenditure per user recruitment (up to 20$ per participant). A realistic way to increase the population size would be an experimental setup where participation is voluntary. However, that may introduce confounding factors as the voluntary participants might be more altruistic than the general public and may lean towards more eco-friendly behavior (Xu et al., 2021). Many sustainable consumption studies that solely rely on surveys have often better statistical power, as they can scale up the sample size. However, survey responses do not always reflect real-world behavior – for example, social desirability bias (Grimm, 2010) is a common phenomenon in consumption research. To properly evaluate the influence of a proposed E-commerce platform, it is crucial for the users to interact with the platform so that their behavior can be captured at the moment

rather than relying on future promises. Considering the above-mentioned challenges, 98 is not a small population for obtaining preliminary results, especially given that we attained significant statistical evidence for all the major research questions.

Interestingly, young male consumers constitute the majority of the study population. However, this is not problematic for two reasons: (i) Young male consumers are indeed the majority among digital shoppers. According to Statista (2020), millennials (aged 25–34 years) were the largest group of digital buyers in the United States (Coppola, 2020). The second largest group consists of 35-44-year-old individuals. Also, another report from Statista (2022) mentioned that men made up the majority of E-commerce shoppers (Department, 2022). The study protocols did not impose any gender or age restrictions while recruiting via Amazon Mechanical Turk. Interestingly, young males were also the majority among the MTurkers in this study. (ii) The case and control groups have a similar distribution in terms of age and gender. So, the demographic factors should affect both groups similarly and should not influence the primary research questions studied in this paper.

5. Limitations and future work

A major limitation of this study is that the environmental impacts of the products are simply hand-annotated by an expert. However, in the real world, there are thousands of products, and it would be very difficult to manually annotate them all. Moreover, as the product life cycle is constantly changing, product ratings must be updated accordingly. This naturally brings into question – how do we generate environmental-impact information in the real world? One method could be delegating this task to the manufacturers and an independent, neutral group could monitor it. This approach brings consumer trust into question, as consumers may not trust environmental labels provided by the manufacturers (Delmas and Burbano, 2011). Another method can be an autonomous body manually generating these ratings for the most popular types of products first, and then increasing coverage with time. But, this might be difficult to scale and continuously update in light of new knowledge. One promising method seems to be crowd-sourcing, inspired by the success of Wikipedia – the encyclopedia that maintains nearly 4 million articles using crowd-sourcing, and remains as accurate as Encyclopedia Britannica (Giles, 2005). Finally, with the advances in machine learning (e.g., natural language processing), it might be possible to generate the environmental ratings and impact statements automatically. For example, a knowledge graph that captures environmental entities and their relations (Islam, 2022) might help automatically identify the related keywords and generate explanations to how those keywords interact with the environment.

In this study, the motivational climate video acted as an emotional incentive for green consumption, similar to emotional green advertising used in prior research (Matthes et al., 2014). Priming both case and control groups in this way allows to probe into the question - if someone wants to make eco-friendly purchases, how effective would the proposed design be compared to the traditional ones? In this context, priming the participants is appropriate. Future studies could be done without priming the participants to simulate a more real-life scenario, where not all people are always actively thinking about the environment.

Another potential limitation of the study is the sample size and the demography of the population. A substantial increase in the study population would enable further insights regarding whether demographical variables such as age, gender, race, etc. influence eco-friendly behavior, which is an active area of interest for the sustainable consumption research community. Moreover, all the subjects are from the United States, where literacy rate and per capita income are higher compared to many other countries. Future studies are needed to assess how receptive people will be to SEER in other countries where literacy rate is lower and/or there are financial constraints. With Amazon Mechanical Turk, it is possible to scale up the sample size and recruit participants with specific demographic attributes. However, that would increase the expense (i.e., participation fee) of the experiment substantially. A realistic way to extend the results of this study on a global scale would be creating an experimental setup where participation is voluntary. However, that may introduce confounding factors as the voluntary participants might be more altruistic than the general population, and therefore lean towards more eco-friendly behavior (Xu et al., 2021). A way forward is to gamify the study and disseminating it via social media – the experiment can be designed as an interesting game, people across the world may participate for entertainment purposes, and some participants can be selected to win rewards via lottery. Alternatively, partnering up with an E-commerce business may enable disseminating the interface to a large number of users.

This study is a proof-of-concept that shows SEER is an effective, easy-to-use, and well-received prototype for people willing to be eco-friendly. It also introduces a new interdisciplinary research direction that connects user interface design with sustainable consumption research. However, this study acknowledges that this is a complex issue with other major contributing factors such as price, availability, personal and social norms, habit, and so on, which remain to be addressed. Despite the limitations, the study will hopefully inspire future research for E-commerce re-design and encourage interdisciplinary research for promoting sustainability.

6. Conclusions

This study provides preliminary evidence that sustainable consumption can be facilitated by redesigning E-commerce platforms. The proposed prototype (SEER) attempts to address three key factors responsible for the “attitude-behavior gap” observed in sustainable consumption literature – inconvenience, lack of knowledge, and lack of trust. An environmental impact rating that evaluates a product based on its ecological impact can make it easy to search for and buy eco-friendly products. An environmental impact summary of the product that briefly explains the rationale for the rating can help gain consumer trust. Additionally, highlighting keywords related to environmental issues and explaining what these keywords mean can make consumers more aware of these issues. In a quasi-randomized case-control experiment with 98 subjects across the United States, the case group using SEER demonstrated significantly more eco-friendly consumption behavior than the control group. High system usability scale score and thematic analysis suggest that users are receptive to the proposed E-commerce redesign, as the introduced features can remind users of the carbon footprint associated with their consumption. The users found the features easy to use and expressed their willingness to use a similar platform in the real world. With further research enabling reliable generation of products’ environmental footprints, SEER has the potential to reduce approximately 2.88 million tonnes of carbon emission every year in the United States. Hopefully, this paper will open doors for further interdisciplinary research connecting UI/UX design, E-commerce platforms, and sustainability.

Ethics

All the participants who completed the study received a payment of 10$ and an additional bonus for saving their budget. The participants, at any point, were permitted to quit the study without facing any consequences. After the end of the study, all the participants were clarified that the products they purchased are not for any real school, and their choices did not cause any harm to the environment, considering some participants might feel guilty about purchasing non-eco-friendly products. The entire study was approved and supervised by the Institutional Review Board (IRB) of the University of Rochester. All researchers who conducted the study and analyzed data are certified by IRB to conduct human behavior studies.

Funding

This research was primarily supported by funding from the Goergen Institute for Data Science, University of Rochester. One of the co-authors is also supported by the National Institute of Environmental Health Sciences (NIEHS) grant P30001247.

Author contributions statement

M.S.I, A.M.P., C.W., K.B., and E.H. designed the experiment and the prototype; C.W., V.K., and S.U. implemented the prototype; M.S.I., A.M.P., and C.W. conducted the experiments; M.S.I. analyzed the results; M.S.I., A.M.P., and E.H. wrote the manuscript; K.B. and K.K. helped improve the manuscript; E.H. supervised the project. All authors reviewed the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgement

We thank Goergen Institute for Data Science for the Seed Funding of this project. We also acknowledge Liudmila Paymukhina for her valuable feedback on formulating the experiment.

References

Bangor, A., Kortum, P., Miller, J., 2009. Determining what individual sus scores mean: adding an adjective rating scale. J. Usability Stud. 4 (3), 114–123.
Bangor, A., Kortum, P.T., Miller, J.T., 2008. An empirical evaluation of the system usability scale. Int. J. Human–Comput. Interact. 24 (6), 574–594.
Bhatti, A., Akram, H., Basit, H.M., Khan, A.U., Raza, S.M., Naqvi, M.B., et al., 2020. E-commerce trends during covid-19 pandemic. Int. J. Future Generation Commun. Network. 13 (2), 1449–1452.
Brooke, J., et al., 1996. Sus-a quick and dirty usability scale. Usability evaluation in industry 189 (194), 4–7.
Bureau, U.C., 2021. Quarterly Retail E-Commerce Sales 2nd Quarter 2021. US Census Bureau News. https://www.census.gov/retail/mrts/www/data/pdf/ec_current.pdf.
Cheba, K., Kiba-Janiak, M., Baraniecka, A., Kołakowski, T., 2021. Impact of external factors on e-commerce market in cities and its implications on environment. Sustain. Cities Soc. 72, 103032.
Chen, Y.-S., Chang, C.-H., 2012. Enhance green purchase intentions: the roles of green perceived value, green perceived risk, and green trust. Manag. Decis. 50 (3), 502-520 50 (3), 502–520.
Chovanová, H.H., Korshunov, A.I., Babčanová, D., 2015. Impact of brand on consumer behavior. Procedia Econ. Finance 34, 615–621.
Coppola, D., 2020. Distribution of Digital Buyers in the united states as of February 2020, by Age Group. Statista. https://www.statista.com/statistics/469184/us-digital-buyer-share-age-group/. (Accessed 15 November 2022).
Coppola, D., 2021. E-Commerce Worldwide-Statistics & Facts. Statista. https://www.statista.com/topics/871/online-shopping/. (Accessed 15 May 2021).
Delmas, M.A., Burbano, V.C., 2011. The drivers of greenwashing. Calif. Manag. Rev. 54 (1), 64–87.
Department, S.R., 2022. E-Commerce Shoppers Mobile Audience Share in the U.S. 2022 by gender. Statista. https://www.statista.com/statistics/1343493/ecommerce-shoppers-mobile-audience-united-states-gender/. (Accessed 15 November 2022).
EPA, 2021. Greenhouse Gas Emissions from a Typical passenger Vehicle. United States Environmental Protection Agency. https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle.
Escursell, S., Llorach-Massana, P., Roncero, M.B., 2021. Sustainability in e-commerce packaging: a review. J. Clean. Prod. 280, 124314.
Eze, U.C., Ndubisi, N.O., 2013. Green buyer behavior: evidence from asia consumers. J. Asian Afr. Stud. 48 (4), 413–426.
Giles, J., 2005. Special report internet encyclopaedias go head to head. Nature 438 (15), 900–901.
Gleim, M.R., Smith, J.S., Andrews, D., Cronin Jr., J.J., 2013. Against the green: a multi-method examination of the barriers to green consumption. J. Retailing 89 (1), 44–61.
Gonçalves, J., Mateus, R., Silvestre, J.D., Roders, A.P., Bragança, L., 2021. Attitudes matter: measuring the intention-behaviour gap in built heritage conservation. Sustain. Cities Soc. 70, 102913.
Grimm, P., 2010. Social Desirability Bias. Wiley international encyclopedia of marketing.
Hillenbrand, P., Alcauter, S., Cervantes, J., Barrios, F., 2013. Better branding: brand names can influence consumer choice. J. Prod. Brand Manag. 22 (4), 303–308.
Islam, M.S., 2022. Knowurenvironment: an automated knowledge graph for climate change and environmental issues. In: AAAI 2022 Fall Symposium: the Role of AI in Responding to Climate Challenges. https://www.climatechange.ai/papers/aaaifss2022/3.
Jaiswal, D., Kant, R., 2018. Green purchasing behaviour: a conceptual framework and empirical investigation of indian consumers. J. Retailing Consum. Serv. 41, 60–69.
Jaller, M., Pahwa, A., 2020. Evaluating the environmental impacts of online shopping: a behavioral and transportation approach. Transport. Res. Transport Environ. 80, 102223.
Joshi, Y., Rahman, Z., 2015. Factors affecting green purchase behaviour and future research directions. Int. Strategic Manag. Rev. 3 (1-2), 128–143.
Kim, Y., Choi, S.M., 2005. Antecedents of Green purchase Behavior: an Examination of Collectivism, Environmental Concern, and pce. ACR North American Advances.
Kumar, M., Kumar, D., Saini, P., Pratap, S., 2022. Inventory routing model for perishable products toward circular economy. Comput. Ind. Eng. 169, 108220.
Laroche, M., Bergeron, J., Barbaro-Forleo, G., 2001. Targeting consumers who are willing to pay more for environmentally friendly products. J. Consum. Market. 18 (6), 503–520.
Laufer, W.S., 2003. Social accountability and corporate greenwashing. J. Bus. Ethics 43 (3), 253–261.
Lichtenstein, D.R., Ridgway, N.M., Netemeyer, R.G., 1993. Price perceptions and consumer shopping behavior: a field study. J. Market. Res. 30 (2), 234–245.
Lin, P.-C., Huang, Y.-H., 2012. The influence factors on choice behavior regarding green products based on the theory of consumption values. J. Clean. Prod. 22 (1), 11–18.
Matthes, J., Wonneberger, A., Schmuck, D., 2014. Consumers' green involvement and the persuasive effects of emotional versus functional ads. J. Bus. Res. 67 (9), 1885–1893.
Minton, A.P., Rose, R.L., 1997. The effects of environmental concern on environmentally friendly consumer behavior: an exploratory study. J. Bus. Res. 40 (1), 37–48.
Mondelaers, K., Verbeke, W., Van Huylenbroeck, G., 2009. Importance of health and environment as quality traits in the buying decision of organic products. Br. Food J. 111 (10), 1120–1139.
Mostafa, M.M., 2007. Gender differences in egyptian consumers' green purchase behaviour: the effects of environmental knowledge, concern and attitude. Int. J. Consum. Stud. 31 (3), 220–229.
Mostafa, M.M., 2016. Egyptian consumers' willingness to pay for carbon-labeled products: a contingent valuation analysis of socio-economic factors. J. Clean. Prod. 135, 821–828.
OptinMonster, 2021. Online Shopping Statistics You Need to Know in 2021.
Panzone, L.A., Ulph, A., Zizzo, D.J., Hilton, D., Clear, A., 2018. The impact of environmental recall and carbon taxation on the carbon footprint of supermarket shopping. J. Environ. Econ. Manag., 102137
Paolacci, G., Chandler, J., Ipeirotis, P.G., 2010. Running experiments on amazon mechanical turk. Judgment and Decision making 5 (5), 411–419.
Prajapati, D., Pratap, S., Zhang, M., Huang, G.Q., et al., 2022. Sustainable forward-reverse logistics for multi-product delivery and pickup in b2c e-commerce towards the circular economy. Int. J. Prod. Econ. 253, 108606.
Prasertwit, T., Kanchanasuntorn, K., 2021. Preliminary study of environmental impact related to e-commerce activities in Thailand. In: E3S Web of Conferences, vol. 259. EDP Sciences, 03004.
Pu, P., Chen, L., 2006. Trust building with explanation interfaces. In: Proceedings of the 11th International Conference on Intelligent User Interfaces, pp. 93–100.
Ramya, N., Ali, S.M., 2016. Factors affecting consumer buying behavior. Int. J. Appl. Res. 2 (10), 76–80.
Riskos, K., Dekoulou, P.E., Mylonas, N., Tsourvakas, G., 2021. Ecolabels and the attitude–behavior relationship towards green product purchase: a multiple mediation model. Sustainability 13 (12), 6867.
Tanner, C., Wölfing Kast, S., 2003. Promoting sustainable consumption: determinants of green purchases by swiss consumers. Psychol. Market. 20 (10), 883–902.
Torelli, R., Balluchi, F., Lazzini, A., 2020. Greenwashing and environmental communication: effects on stakeholders' perceptions. Bus. Strat. Environ. 29 (2), 407–421.
Vermeir, I., Verbeke, W., 2006. Sustainable food consumption: exploring the consumer "attitude–behavioral intention" gap. J. Agric. Environ. Ethics 19 (2), 169–194.
Wang, P., Liu, Q., Qi, Y., 2014. Factors influencing sustainable consumption behaviors: a survey of the rural residents in China. J. Clean. Prod. 63, 152–165.
Wei, S., Ang, T., Jancenelle, V.E., 2018. Willingness to pay more for green products: the interplay of consumer characteristics and customer participation. J. Retailing Consum. Serv. 45, 230–238.
Xu, Y., Li, W., Chi, S., 2021. Altruism, environmental concerns, and pro-environmental behaviors of urban residents: a case study in a typical Chinese city. Front. Psychol. 1917.
Young, W., Hwang, K., McDonald, S., Oates, C.J., 2010. Sustainable consumption: green consumer behaviour when purchasing products. Sustain. Dev. 18 (1), 20–31.