



OPEN Modeling, development and validation of environmental behavior scale for preservice teachers

Ece Avinç  & Fatih Doğan  


This research aimed to formulate a robust and valid measurement instrument for evaluating the environmental behavior levels of prospective teachers. The study focused on detailing the analyses conducted on the Environmental Behavior Scale (EBS). Content validity was ascertained through expert assessment, while construct validity investigations were aligned with the Theory of Planned Behavior (TPB). Employing both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), the study involved teacher candidates from a Faculty of Education. EFA findings proposed an 18-item, five-factor model. This model was subsequently cross validated through CFA, exhibiting favorable fit indices. Structural Equation Modeling (SEM) was applied to unveil relationships among variables, indicating positive cognitive, affective, and behavioral responses to environmental concerns among teacher candidates. The measurement invariance of the SEM model was examined in terms of the gender variable, and it was found that the model did not change. Consequently, EBS emerges as a valuable tool for environmental education, offering insights into variables such as attitude towards behavior, perceived behavioral control, subjective norm, behavioral intention, and actual behavior in teacher candidates.

Keywords Environmental behavior, Model, Scale, Validity, Reliability

The environment, defined as the dynamic interaction between living and non-living elements, is significantly shaped by human activity¹. Human civilization has historically adapted to surviving in natural environments by meeting various needs, which have evolved alongside scientific and technological progress. However, human interventions in the environment have upset ecological equilibrium, resulting in severe global environmental challenges. Prevailing misconceptions about unlimited environmental resources and Earth's self-renewal capacity have exacerbated resource depletion and pollution, threatening human well-being². In response, efforts to mitigate environmental damage and restore ecological balance have been evident across various domains, driven by societal perceptions and behaviors³. The industrial revolution, beginning in the 1940s, notably intensified atmospheric pollution and ecological disruption, prompting global environmental initiatives (Venkataraman, 2008). Amid the escalation of environmental issues, there has been a growing emphasis on fostering knowledge, skills, attitudes, behaviors, and motivation through environmental education to empower individuals and communities to address environmental challenges effectively.

Environmental education

Environmental education aims to develop individuals' knowledge, skills, attitudes, and responsibilities in addressing environmental challenges comprehensively⁴. Originating from the Tbilisi Declaration of 1977, environmental education highlights the dynamic interaction between individuals and their environment, as emphasized by UNESCO^{5,6}. In Turkey, environmental education initiatives commenced after the 1961 constitution, with significant progress following UNESCO's International Environmental Education Program. Integration into the national curriculum occurred between 1992 and 2002, though assessments in 2009 revealed a focus on environmental protection over sustainability. Ongoing revisions include introducing Environmental Education as an elective course since 2015, aiming to rectify shortcomings⁷. The primary goal is to enhance individuals' understanding, awareness, and attitudes towards environmental issues, empowering them to contribute to solutions, as noted by UNESCO⁸. Environmental education imparts knowledge, skills, and attitudes

Department of Mathematics and Science, Faculty of Education, Çanakkale Onsekiz Mart University, Çanakkale, Turkey.  email: fatihdogan@comu.edu.tr

necessary for proactive environmental stewardship, as suggested by Tilbury et al.⁹. Its quality significantly influences various educational outcomes, including environmental knowledge, awareness, attitudes, and behaviors. Through environmental education, individuals cultivate positive attitudes and behaviors towards the environment, promoting resource-conscious practices and understanding ecosystem dynamics, as emphasized by Goldman, Yavetz, & Pe'er¹⁰. Increased insights into ecosystem dynamics and human impacts lead individuals towards more favorable behaviors in environmental preservation.

Education theory of planned behavior

Environmental attitudes, as elucidated by UNESCO⁶, encapsulate individuals' predispositions towards environmental preservation and development. These attitudes encompass cognitive, emotional, and behavioral facets, observable through verbal expressions or actions, as posited by Gifford & Sussman¹¹. Environmental behavior, influenced by attitudes and beliefs, reflects observable actions influenced by cognitive, socio-psychological, and demographic factors, as discussed by Franzen & Vogl¹² and Hwang, Kim & Jeng¹³. Environmental attitudes were defined by UNESCO⁸ as the predispositions of individuals towards protecting and improving the environment. Gifford and Sussman¹¹ suggested that these attitudes encompass cognitive, emotional and behavioral aspects and can be observed through verbal expressions or actions. Environmental behavior, which is influenced by attitudes and beliefs, reflects observable actions influenced by cognitive, socio-psychological and demographic factors, as discussed by Franzen and Vogl¹² and Hwang, Kim and Jeng¹³.

Theory of Rational Action (TRA), developed by Fishbein and Ajzen (1975), suggests that individuals shape their behaviors according to their attitudes and subjective norms. However, to overcome the limitations of this model, the Theory of Planned Behavior (TPA) was developed, and the concept of perceived behavioral control (PBC) was added to the model. PBC refers to the perceived ease or difficulty level of individuals in performing a behavior. This concept is derived from Social Cognitive Theory and explains individuals' perceptions of their competence in performing a certain behavior. Theory of Planned Behavior (TPB), built on the Theory of Rational Action, addresses the incompatibility between attitudes and environmentally beneficial behaviors. Integrating attitudes, subjective norms, and PBC as described by Ajzen and Fishbein¹⁴ and Cohen and Hanno¹⁵, TPB emphasizes intention as the primary determinant of behavior. It also includes PBC, which encompasses external factors such as resources and opportunities that the individual has. According to the Behavioral Intention Theory (BIT), whether an individual will perform a certain behavior is determined by intention. A strong intention to perform the behavior increases the probability of the behavior occurring. In literature, it is frequently emphasized that intention is one of the most important determinants of behavior¹⁶, and this concept has been tested in various fields such as technology, health, politics, marketing and psychology¹⁷. Research conducted by Ajzen and Fishbein¹⁴ shows that TPB provides a comprehensive framework for exploring the attitudes, intentions, and behavioral control of prospective teachers. This theory is a powerful model used to better understand and predict individuals' behaviors toward the environment.

Problem status

The text underscores the global significance of environmental issues, emphasizing their transnational impact on biodiversity and human survival¹⁸. It posits that mitigating these challenges necessitates conscientious resource consumption, heightened environmental awareness, and alignment with nature amidst rapid urbanization and industrialization. Education, technology, and legislation are pivotal in cultivating societal awareness and promoting sustainable behaviors¹⁹. Environmental education, spanning formal schooling and community initiatives, seeks to instill positive attitudes and behaviors towards environmental stewardship, often employing experiential learning methods²⁰. In the past years, Dunlap and Van Liere²¹ measured individuals' environmental values and perspectives on problems with the New Environmental Paradigm, while Pooley and O'Connor²² developed a scale examining the relationship between environmental education and attitudes, emotions, and beliefs. While Ardahan²³ focused on adapting scales addressing students' environmental attitudes and behaviors, there are also studies evaluating students' environmental knowledge, attitudes, and behaviors with scales aimed at environmental literacy in understanding individuals' approaches to the environment^{24–28}. Similarly, while most of the studies on environmentally friendly behaviors measure only behaviors that are beneficial or have a positive impact on the environment, and focus on environmental protection, adopting sustainable lifestyles, and encouraging these behaviors, the concept of environmental behavior addresses all behaviors towards the environment^{29–31}. Studies suggesting a low relationship between environmental awareness and environmentally friendly behaviors^{32,33} have attributed this to the fact that attitudes are object-oriented and do not focus on concrete behaviors³⁴. While it is argued that there is a similar inconsistency between attitude and behavior, the "Theory of Reasoned Action" and the Principle of Compromise developed by Ajzen and Fishbein¹⁴ to eliminate this problem, and its improved version, the Theory of Planned Behavior (TPB), which is parallel to Bandura's^{35,36} theory of "self-efficacy", was rearranged by Ajzen^{37,38} and PBC has an important place in this model.

Despite the wealth of environmental studies, research on the relationship between attitudes and behaviors within the TPB framework is scarce. Moreover, there's a dearth of scale development studies for environmental behavior within TPB, necessitating further investigation in this domain (Table 1). Universities, as potential agents of environmental change, are increasingly prioritizing environmental education, yet studies on student behavior and TPB-based scale development are limited in existing literature. Clayton³⁹ developed the Environmental Identity Scale (EIS) to measure the psychological bond that individuals establish with nature and considered environmental identity as a part of the individual's self-concept based on Social Identity Theory. Goldman, Yavetz, and Pe'er¹⁰ examined the environmental behaviors of prospective teachers in the context of the Environmental Literacy Model⁴⁰ and the Environmental Behavior Model of Hungerford and Volk²⁵. While Kışoğlu⁴¹ conducted his analyses within the framework of the Environmental Literacy Model for the Environmental Behavior Scale he developed within the scope of his study, Cömert⁴² examined the effect of the Cooperative Learning

Year	Authors	Study group	Scale	Theoretical framework
1994	Thompson, S.C.G., and Barton, M.A	Adult	Eco-centric, anthropocentric, and environmentally antipathic attitude scale	Theory of planned behavior
2003	Clayton, S	Adult	Environmental identity scale	Social identity theory
2006	Goldman, D., Yavetz, B., and Pe'er, S	Students in teacher-training colleges	Environmental behavior scale	Environmental literacy model Environmental behavior model
2009	Kıışoğlu, M	University students (teacher candidates)	Environmental behavior scale	Environmental literacy model
2011	Cömert, H	Secondary school students	Environmental behavior scale	–
2012	Yaşaroğlu, C	Primary and secondary school	Responsible behavior towards the environment scale	–
2012	Güven, E., and Aydoğdu, M	University students (teacher candidates)	Environmental problems behavior scale	–
2015	Díaz-Sieffer, P., Neaman, A., Salgado, E., Celis-Diez, J. L., and Otto, S	Completed high school, school degree, graduates of technical programs, students or graduates with ≤ 4 years of university studies, graduates with ≥ 4 years of postsecondary education and postgraduate degree master's	Human–environment system knowledge questionnaire	Model of environmental information types
2015	Sontay, G., Gökdere, M., and Usta, E	Secondary school students	Environmental behavior test	Environmental literacy model
2015	Sontay, G., Gökdere, M., and Usta, E	Secondary school students	Environmental behavior scale	Environmental literacy model
2019	Ata, E., and Yıldız, M	Primary and secondary school	Observing adults' displayed-behavior related to environment scale	Social learning theory
2022	Ardahan, F	Secondary and high school students	Environmental behavior scale	–

Table 1. Developed scale studies for behavior in the context of the environment.

approach on students' environmental knowledge, attitudes, and behaviors with an experimental design. In Yaşaroğlu's⁴³ study, the Environmental Attitude Scale (EAS) and Environmental Responsible Behavior Scale (ECB) were developed to determine the environmental attitudes and behaviors of primary school students and were examined within a framework based on environmental attitude theories. Güven and Aydoğdu³⁰ examined different dimensions of environmental behaviors with the Behavior Scale Towards Environmental Problems, which they developed to evaluate the environmental behaviors of prospective teachers. Cömert⁴², Yaşaroğlu⁴³ and Güven and Aydoğdu³⁰ did not provide information about the theoretical framework and model in their studies and stated that they created an item pool within the scope of environmental behavior based on the scales developed in the literature. Díaz-Sieffer et al.⁴⁴ analyzed the effects of environmental knowledge types on pro-environmental behaviors based on the Environmental Knowledge Types Model. The study conducted by Sontay, Gökdere, and Usta²⁸ aims to determine the relationships between the subcomponents of environmental literacy of middle school students, namely "environmental knowledge", "environmental impact", and "environmental behavior". In the study, the "Environmental Knowledge Test (ECT)", "Environmental Impact Scale (EAS)", and "Environmental Behavior Scale (ECS)", which were developed by the researchers and whose validity and reliability studies have been conducted, were used to measure these components. These scales were designed to assess different dimensions of environmental literacy. Among these studies, the only scale development study within the scope of TPB is the Ecocentric, Anthropocentric, and Environmental Antipathic Attitude Scale developed by Thompson and Barton⁴⁵. The "Environmental Behavior Scale for Middle School and High School Students" developed by Ardahan²³ was designed to measure the environmental behaviors of students and is based on the aim of environmental education to positively affect and transform individuals' environmental value, attitude, and behavior systems. The scale consists of three sub-dimensions: natural balance protection behavior, social behavior, and high-level cognitive behavior, and there is no information that it is based on any theoretical framework or model. Similarly, in the literature, Lange and Dewitte⁴⁶ examined the methods used in the measurement of environmentally friendly behaviors and evaluated the advantages and limitations of these methods and suggested the development of standardized and psychometrically sound measurement tools to increase accuracy and general validity. Within the scope of the study, it was argued that improving the psychometric properties of the tools used in the measurement of environmentally friendly behaviors would contribute to the field gaining a more solid and cumulative scientific basis. When the studies conducted in the literature were examined, it was determined that the scale developed within the scope of TPB was not encountered and the importance of psychometric analyses was emphasized. While some studies such as Ajzen and Fishbein⁴⁷, Hines, Hungerfort and Tomera⁴⁸, Diekmann and Preisendörfer⁴⁹ argue that the relationship between attitudes towards the environment and behavior concepts is generally low, there are studies such as Chaiken⁵⁰ and Frey, Stahlberg and Gollwitzer⁵¹ which claim that this situation is due to the inadequacy of statistical techniques and attitude scales³⁴. The uniqueness of the scale developed within the scope of the study according to other scientific publications in Table 1, in terms of the sample group and TPB, is revealed.

Research indicates the beneficial impact of environmental education on individuals' attitudes, behaviors, and knowledge, resulting in increased environmental awareness and engagement in pro-environmental actions. However, challenges persist, including the need for effective teacher training and addressing equity concerns⁵². Environmental education is deemed crucial for equipping individuals with skills to address environmental challenges (Geray, 1998). Informed individuals exhibit more positive environmental behaviors, in line with the TPB, which underscores behavioral intention influenced by personal attitude, subjective norm, and perceived behavioral control. This research aimed to develop a valid and reliable EBS for teacher candidates within the scope of the TPB.

Ajzen^{37,38}, (2005) and Ajzen and Fishbein (1980, 2000) defined the Theory of Planned Behavior (TPB) in detail in their studies, arguing that individuals' behaviors are not shaped solely by their own will, but that various factors are also effective in this process. The basis of PBT is the understanding that individuals make rational decisions by systematically accessing information. TPB suggests that individuals' actual behaviors are primarily determined by their behavioral intentions, and that this intention is shaped by three basic cognitive factors: attitude, subjective norms, and perceived behavioral control. While the model suggested in early studies that intentions are shaped only by attitude and subjective norms, in later studies the variable of perceived behavioral control was added, and the model was developed to explain situations that individuals cannot fully control. The PBT model provides a comprehensive framework for understanding how individuals are affected by environmental factors and cognitive processes. Considering the inconsistencies in literature and the inclusion of various dimensions specific to the field, topic or a specific concept, only these dimensions were focused on in this study^{48,53–58}. In addition, the selection of TPB within the scope of the study is the main reason for wanting to examine the change in behavior and the factors affecting the behavior under the attitude variable. This study on environmental behavior is critical in terms of providing important feedback to literature as well as experts, faculty members, and policymakers who prepare the curriculum. Accordingly, the problem sentence of the research (RQ) was determined as “Is the scale developed within the scope of the TPB to measure the environmental behavior levels of teacher candidates valid and reliable?”

The sub-problems of the research were as follows;

- **RQ1:** What are the variables in the scale developed by the TPB to measure the environmental behavior levels of teacher candidates?
- **RQ2:** How does the relationship among the variables in the scale developed by the TPB to measure the environmental behavior levels of teacher candidates?

Method

The study employs a sequential exploratory mixed method, which involves the conversion of qualitative data into quantitative data, facilitating the development of measurement tools. This approach is particularly advantageous during instrument development and aids in comprehending phenomena. First, a group of teacher candidates were asked to write essays about environmental behavior. Sentences related to environmental behaviors reflecting cognitive, affective, and behavioral areas were extracted from the compositions and relevant items were obtained from there. Then, additional attitude items sourced from the literature were integrated into the item pool based on expert panel consensus. Thus, an item pool of 25 items that could address different areas of environmental behavior was obtained. A total of 25 items underwent content validity assessment by experts, a method instrumental in transitioning qualitative investigations into statistical quantitative studies. The entire process was conducted in accordance with research and publication ethics, with ethical approval from the Çanakkale Onsekiz Mart University Ethics Committee. Data collection processes were evaluated within the scope of ethical principles and the confidentiality of personal data was taken into consideration. In addition, all participants were asked to fill out the “Voluntary Consent Form”. Thus, only the data of the participants who agreed to participate in the study with “Informed Consent” were included in the study. More detailed information is given in the following sections.

Research prospectus outlined

This research aimed to develop a valid and reliable instrument to measure the teacher candidates' behavior toward the environment. This research aimed to develop a valid and reliable instrument to measure the teacher candidates' behavior toward the environment. The study data were collected from a total of 709 1st, 2nd, 3th and 4th teacher candidates studying at the faculty of education located in the west of Turkey. Ethical approval was received for this research from Çanakkale Onsekiz Mart University Ethics Committee. (2022-YÖNP-0953, E-84026528-050.01.04-2200305079, Date: 12/15/2022, Number: 22/53). Within the scope of the research, all applications were carried out in accordance with the relevant guidelines, regulations and regulations and in accordance with research and publication ethics. In this context, the studies were carried out by obtaining “Voluntary Consent Form” and “informed consent” from the participants in the research. All participants were informed about how their personal data would be used, stored, and confidentiality. No identifying information such as name, surname, or nickname was collected from the participants. The details about the research prospectus and the steps followed to develop the instrument were presented under sub-headings (Table 2).

Research model and hypotheses

The model proposed in the study was created by considering relevant literature. The items of the draft EBS were designed according to the operational variables of the TPB model. The draft EBS draft items designed were evaluated in five categories: “Attitude towards behavior” (BA), “Perceived behavioral control” (PBC), “Subjective norm” (SN), “Behavioral intention” (BI), and “Actual behavior” (AB). Accordingly, within the scope of the TPB, the relations across the variables were revealed to determine the reflections of the behavior of teacher candidates towards the environment (Fig. 1).

In this model, literature was used when determining hypotheses. The interaction of sub-dimensions for TPB was examined. In the light of these examinations according to the TPB, an individual's intention to perform a certain behavior is influenced by three primary factors. These are attitudes, which stem from positive evaluations of the behavior's advantages and disadvantages; social norms, which include the individual's perceived approval of important reference groups; and the individual's perceived level of control over performing the behavior in question. These elements shape the individual's behavioral intention, determining the likelihood that the behavior will occur (H1-H2-H3). There are studies in the literature showing that PBC and attitude are the most

Study	Pathway	Stage	Process
Study 1	Content validity	Stage 1	The items were collected from the literature of <i>TPB</i> and the focus group interviews. The draft EBS was created with 25 items. The content validity of the draft EBS was provided by “expert opinions”
		Stage 2	CVR-CVI values of each item in the draft EBS were calculated. Items “5-12-24” were removed from the draft EBS. Face validation was performed with a group of teacher candidates
	Construct validity	Stage 3	The construct validity of the draft EBS was provided by EFA. EFA was performed on the data from 455 teacher candidates. Items “6-16-18-20”, which could not meet the construct validity assumptions, were removed from the draft EBS
	Control of test items	Stage 4	Anova Tukey’s Nonadditivity analysis was performed to investigate the control of the homogeneity and their relationship with each other of the items. Whether the phenomenon can be measured appropriately with EBS was determined by Hotelling’s T-squared analysis. The reliability of the independent rater in the measurement was performed by the intraclass correlation coefficient. The item-total Statistics, t-test results for lower–upper 27% groups, and the relationship between the total score obtained from EBS and its items was determined
Study 2	Confirmation of construct validity	Stage 5	The confirmation validity of the draft EBS was performed on the data from 254 teacher candidates. This data were obtained from a different sample from the sample group used in the pilot application
	Reliability	Stage 6	Reliability coefficients were computed for each sub-factor and overall the scale
	Modelling	Stage 7	The data model fit was tested. Measurement invariance of the proposed model was achieved in terms of gender
	Result	Stage 8	A valid and reliable EBS was prepared. The so-called form contained 18 productive Likert-type items (Appendix 1)

Table 2. The steps which were followed in the study.

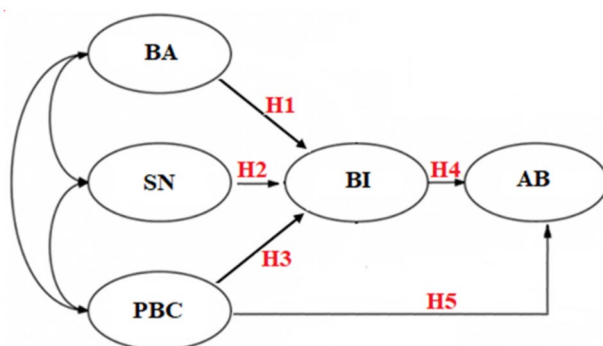


Fig. 1. Research model and hypotheses.

important sources of influence and the best predictors on behavioral intention for both situations (H1-H3)⁵⁴. For example, it was stated that individuals’ recycling intentions are affected by social norms and that these norms have a positive relationship with recycling behavior (H2)⁵⁹. Ajzen and Fishbein (1980) emphasize that the subjective norm is affected by the individual’s perceptions of approval or disapproval of important people in their environment, and it is stated that when individuals consider the thoughts of others important, the probability of exhibiting the relevant behavior increases^{60,61}. Additionally, literature in general argues that there is a significant relationship between attitudes and intentions towards environmental issues. According to TRA, the most important predictor of behavior is behavioral intention, that is, the probability of individuals to exhibit a certain behavior depends largely on their behavioral intentions (H4). In this context, individuals who intend to solve environmental problems stand out as important actors in the process⁴⁸. Individuals’ attitudes and subjective norms also affect behavioral intention and thus affect behavior (H1-H4)⁶². In this context, the model proposed in this study is shown in Fig. 1. The research model was designed using the dependent and independent variables in TPB. Accordingly, the hypotheses (H1, H2, H3, H4, and H5) were structured as follows;

Hypothesis 1 (H1) The attitudes of teacher candidates towards behavior related to the environment have a positive effect on behavior intention towards the environment (BA’s effect on BI).

Hypothesis 2 (H2) The subjective norms of teacher candidates related to the environment have a positive effect on behavior intention towards the environment (SN’s effect on BI).

Hypothesis 3 (H3) The perceived behavioral control of teacher candidates related to the environment has a positive effect on behavior intention towards the environment (PBC’s effect on BI).

Hypothesis 4 (H4) The behavior intention of teacher candidates related to the environment has a positive effect on actual behavior towards the environment (BI’s effect on AB).

Hypothesis 5 (H5) The perceived behavioral control of teacher candidates related to the environment has a positive effect on actual behavior towards the environment (PBC’s effect on AB).

TPB was reformulated specifically to account for some of the reasons why individuals may not behave as they intend. Accordingly, perceived behavioral control variables and many subjective norms such as past factors, and social and informatic beliefs were added to the RAT. Thus, more than one TPB with many independent variables in the literature was created. In the present study, it was excluded from the model as external variables may lead to Fishbein paradigms (Fishbein, 1966). Therefore, the simplest TPB was used in the creation of the research model and the establishment of the relevant hypotheses.

Study 1

Data collection process

This study focuses on developing a scale to assess the environmental behavior of teacher candidates in education faculties. Initially, 10 participants contributed to a qualitative research segment by writing essays detailing their thoughts, feelings, and behaviors regarding the environment. From these essays, sentences indicative of behavioral criteria was extracted and incorporated into the initial EBS draft. Additional criteria items were sourced from relevant databases to augment the draft EBS. The panel system facilitated language translations, ensuring the inclusion of cognitive, affective, and behavioral dimensions, including negative items for balance. The draft EBS, comprising five Likert-type items, underwent evaluation by a group of 14 experts. Furthermore, categorical variables like the "Personal Information Form" and "Not About Me" were integrated into the draft EBS to enrich its scope.

Demographic profile of the respondents

Within the scope of scientific studies, every element with common characteristics can be evaluated in the universe, which expresses a large set of generalizations about the findings of the study. Researchers can create universes of different sizes by categorizing the groups they have determined for scientific studies according to criteria suitable for their studies. The universe of this research consists of a total of 972 registered active teacher candidates, including 220 in Science Education (weighted rate 22.63%), 122 in Chemistry Education (weighted rate 22.55%), 205 in Classroom Education (weighted rate 21.09%), 201 in Preschool Education (weighted rate 20.67%) and 224 in Turkish Education (weighted rate 23.04%) at a faculty of education in the west of Turkey in the 2022–2023 academic year. Accordingly, the sample size from the universe was calculated with Eq. (1) given below⁶³. The number of teacher candidates to be sampled within the scope of the research was calculated as 275 with a 95% confidence interval. Since data will be collected from teacher candidates from five (5) different departments within the scope of the research, stratified sampling was used to minimize the disadvantages of the possibility of unequal distribution of factors that may affect the result in random selection and are divided into homogeneous strata within themselves^{64,65}. Since each department, which is similar within itself, constitutes strata (sub-universes), the proportional stratified sampling was preferred. Accordingly, each department was represented in the sample in proportion to its weight in the universe. Data were then collected by making random assignments so that each individual in the strata had an equal chance of being selected. To avoid data loss in the event that more data was collected than the required sample size within the scope of the research, the data obtained from all teacher candidates that could be reached were included in the research. Thus, both the conditions of the stratified sampling method were met, and the sample was determined by preserving the limit value. The department, class level and contact information of 972 students (teacher candidates) registered in the faculty were obtained from the Student Affairs Office. Thanks to the contact information obtained, the scale developed within the scope of the study and the informed consent form were sent to the e-mails that the students reported to the Student Affairs Office. According to the feedback obtained from the students (students who approved participation in the study), each student was given a code according to their school number. The number of students and individuals in the stratified sample were determined as a result of random selection by lottery system.

$$n = \frac{(Nt^2pq)}{(d^2(N-1) + t^2pq)} \quad (1)$$

The number of prospective teachers to be sampled within the scope of the research was calculated as 357 with a 95% confidence interval. However, 455 teacher candidates participated in EFA studies. The data was obtained through Google Forms. Accordingly, the sample of the study in the EFA phase consisted of 455 students selected by random sampling method. Accordingly, 236 (51.9%) of the 455 teacher candidates participating in the research were female and 219 (48.1%) were male. In addition, 108 (23.7%) 1st grade, 118 (25.9%) 2nd grade, 105 (23.1%) 3rd grade, and 124 (27.3%) of the research participants are students attending the 4th grade. The departments of the participants are science teaching 103 (weighted rate 22.63%), chemistry teaching 57 (weighted rate 12.57%), classroom teaching 96 (weighted rate 21.09%), preschool teaching 94 (weighted rate 20.65%), and Turkish teaching 105 (weighted rate 23.07%).

Study 2

Data collection process

CFA data was obtained from 254 participants via Google Form. Since the purpose of data collection was scale validation, questions about categorical data were not reduced in the second study. Attention was paid to the fact that the sample groups in the 1st study and the 2nd study were different. For this purpose, different departments were preferred, apart from the department where data were collected within the scope of Study 1. To avoid measurement bias in Study 2, the 'not applicable to me' option was eliminated. The data obtained were used to confirm the hypotheses⁶⁶.

Demographic profile of the respondents

The sample of the study in the CFA consisted of 254 students selected by random sampling method. Accordingly, 75 (29.5%) of the 254 teacher candidates participating in the research were female and 179 (70.5%) were male. In addition, 61 (24.0%) 1st grade, 53 (20.9%) 2nd grade, 66 (26.0%) 3rd grade, and 74 (29.1%) of the research participants were students attending the 4th grade. The departments of the participants were geography teaching 41 (16.1%), English teaching 48 (18.9%), Japanese teaching 52 (20.5%), Math teaching 60 (23.6%), and Art teaching 53 (20.9%).

Results

Overview of statistical analyses

The statistical analyses were performed in four stages. In the first step, the content validity of the draft EBS was ensured by the expert opinion of 14 people. In the second step, the factor structure of EBS was identified by EFA using the SPSS 21.0 program. This step aimed to examine the interactions between the items. The structure of the factors obtained from EFA in the third step was cross validated by CFA by using AMOS, 24.0 program⁶⁶. The convergent and discriminant validity between variables were investigated. In addition, the Cronbach's alpha coefficient was calculated for EBS. In the last step, the hypotheses belonging to the variables of the TPB model were tested⁶⁷.

Study 1

Content validity

The content validity assessment of EBS followed the guidelines proposed by Polit and Beck⁶⁸. This methodical procedure involved the creation of a content verification form and the assembly of a panel of experts from diverse fields to ensure the accurate capture of the intended attitude being measured. The item pool was derived from focus group interviews and literature reviews, followed by translation stages employing a panel system. Field experts, including scientists, linguists, pedagogues, and teachers, individually evaluated each item based on criteria such as language simplicity, relevance, and adequacy. Scoring criteria were based on item relevance and necessitated adjustments as needed. To gauge item importance and alignment with the scale, the Content Validity Index (CVI) and Content Validity Ratio (CVR) were computed using data provided by field experts. Higher validity scores indicated greater accuracy in measuring the intended phenomenon. Revision efforts, guided by expert feedback, aimed to rectify errors and maintain scale integrity. Through the computation of CVI and CVR, the content validity of the scale was further substantiated, contributing to its reliability and precision. CVR assessed the significance of each item in the measurement, while CVI evaluated the relationship of each item to the scale, as elucidated by Ayre and Scally⁶⁹. The content validity assessment of EBS incorporated established methodologies drawn from existing literature. Lynn⁷⁰ and Polit and Beck⁶⁸ provided foundational frameworks for the CVI, while Ayre and Scally's⁶⁹ recommendation set the Critical CVR ($CVR_{critical}$) at 0.51 for a panel of 14 experts. Yusoff⁷¹ proposed an expanded approach to content validity calculations, introducing the Item-level Content Validity Index (I-CVI) and Scale-level Content Validity Index (S-CVI) forms. I-CVI evaluated individual item scope, aiming for values of at least 0.78 for studies with 5 or more experts, while S-CVI/Ave and S-CVI/AU should not fall below 0.8 for scale validity (Table 3). In the study, items 5, 12, and 24 of the draft EBS showed I-CVI values below 0.78. S-CVI/Ave and S-CVI/AU ratios were 0.94 and 0.80, respectively, indicating general scale validity, as elucidated by Orts-Cortés et al.⁷². The expert opinion scores were transformed into kappa values to account for chance occurrences among participants. The Kappa index (k^*) serves as an inter-expert fit index, indicating the relevance, clarity, and understandability of the item beyond chance factors Eqs. (2) and (3). Evaluation of kappa values followed the Kappa sequence proposed by Fleiss⁷³, which categorizes items as excellent if ≥ 0.74 , good if 0.60–0.73, moderate if 0.40–0.59, and weak if ≤ 0.39 . Equations were employed to calculate k^* , ensuring consistency and reliability in the evaluation process.

$$pc = \left[\frac{N!}{A!(N-A)!} \right] 0,5^N \quad (2)$$

$$k = \frac{I - CVI - pc}{1 - pc} \quad (3)$$

Accordingly, it was calculated that the kappa values of items 5, 12, and 24 were lower than 0.48. "Microsoft Excel 2019 Software Program" was used for all calculations. As a result, three items out of the 25-item draft measurement tool submitted to the expert's opinion were removed because they could not provide sufficient CRV, I-CVI, and kappa values. Thus, EBS form containing 22 items in a five-point Likert type was prepared for construct validity.

Face validity

Following content validity calculations, face validity was assessed to determine the language simplicity and structural clarity of the draft EBS⁷¹. A panel of 30 teacher candidates evaluated the clarity of the 22-item draft EBS via Google Form^{71,74,75}. Each item was rated based on clarity levels ranging from "not clear" to "very clear." The item-level face validity index (I-FVI), scale-level face validity index using the average method (S-FVI/Ave), and scale-level face validity index using the universal agreement method (S-FVI/UA) were calculated. I-FVI reflects the ratio of respondents rating an item as clear, while S-FVI/Ave averages the I-FVI values of all items. S-FVI/UA represents the agreement among respondents on item clarity. Minimum acceptable values for I-FVI and S-FVI are 0.8. Calculations followed the methods suggested by Ozair et al.⁷⁵, yielding I-FVI, S-FVI, S-FVI/Ave, and S-FVI/UA values of 0.92, 0.93, 0.93, and 0.86, respectively. As no item fell below the acceptable

Items	Expert														Score							N _A	I-CVI	UA	CVR	p × 10 ⁻³	k*	Rating ^a
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	4	3	2	1										
Item1	4	4	4	4	4	4	4	4	3	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item2	4	4	4	4	3	2	4	4	4	4	3	4	4	4	11	2	13	0.93	0	0.86	0.850	0.93	perfect					
Item3	4	4	4	3	4	4	4	4	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item5	4	2	2	2	4	4	4	2	2	4	4	3	4	2	7	1	6	0.57	0	0.14	18.3	0.48	poor					
Item6	4	4	4	4	4	4	4	3	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item7	4	4	4	4	4	4	4	4	3	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item8	4	4	4	4	4	4	4	4	4	4	4	4	3	3	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item9	4	4	4	4	4	4	4	3	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item10	4	4	4	4	4	3	4	4	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item11	3	4	4	4	4	4	4	4	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item12	2	4	2	2	3	4	4	4	4	2	2	4	4	4	7	1	6	0.57	0	0.14	18.2	0.48	poor					
Item13	4	4	4	4	3	4	4	4	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item14	4	4	4	4	4	4	4	4	3	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item15	4	3	4	4	4	4	4	4	4	3	4	4	4	4	12	2	14	1.00	1	1.00	0.061	1.00	perfect					
Item16	4	4	4	4	4	4	4	3	4	4	4	4	4	4	12	2	14	1.00	1	1.00	0.061	1.00	perfect					
Item17	4	4	3	4	4	4	4	4	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item18	4	3	4	4	4	4	4	4	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item19	4	4	4	4	4	4	4	3	4	4	3	4	4	4	12	2	14	1.00	1	1.00	0.061	1.00	perfect					
Item20	4	3	4	4	4	4	4	4	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item21	4	4	3	4	4	4	4	4	4	3	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item22	4	4	4	2	4	4	4	4	4	4	2	4	4	3	11	1	12	0.86	0	0.71	5.55	0.86	perfect					
Item23	4	4	3	4	4	4	4	4	4	4	4	4	4	4	13	1	14	1.00	1	1.00	0.061	1.00	perfect					
Item24	3	2	4	2	2	3	4	3	4	3	2	2	2	2	3	4	7	0.50	0	0.00	209	0.37	poor					
Item25	4	4	3	4	4	4	4	4	4	4	4	4	4	4	12	2	14	1.00	1	1.00	0.061	1.00	perfect					
Interest rate	0.96	0.92	0.92	0.84	0.96	0.96	1.0	0.96	0.96	0.96	0.88	0.96	0.96	0.92	S-CVI/UA = .80							0.92	0.96					
The average proportion of items evaluated as relevant by 14 experts after removing 3 items, S-CVI/Ave														0.94														

Table 3. Expert system for the content validity of draft EBS. *N_A: According to Ayre and Scarily (2014), there is no item below 0.571 of the CVR = CVR_{critical value}; I-CVI: Item content validity index; PC: probability of random compromise; According to Fleiss⁷³, k*: kappa coefficient, S-CVI/ Ave*: Average proportion of “relevant” scores provided through experts. S-CVI/Ave average I-CVI scores of all items.

threshold, none were removed during face validity assessment. A comparative table was deemed unnecessary due to the absence of eliminated items in face validity analysis.

Measurement validity

Normality analyses of the 22-item draft EBS with content validity were performed to verify its structural validity. The normal distribution of the data was determined by kurtosis and skewness statistics from analytical methods. It is recommended that these values be between +2 and -2⁷⁶. Here the pilot study was carried out with 454 teacher candidates over 22 items. The coefficient of skewness was calculated as -0.354 ± 0.114 and the coefficient of kurtosis as -0.653 ± 0.228 . Accordingly, the results showed the data obtained from the study group had a normal distribution.

Factor load analysis

In the study, the Kaiser–Meyer–Olkin (KMO) sample adequacy test and Bartlett Sphericity Test were performed regarding the items in EBS and the conformity of the statements to the factor analysis was determined. The significant KMO coefficient in the Bartlett Test of Sphericity was also determined as 0.849 ($\chi^2 = 3781.22$, $df = 153$, $p < 0.01$) (Table 4).

The suitability of the data set for factor analysis was determined by the KMO coefficient. It was determined that the KMO value was at a very good level with 0.849⁷⁷. Statistical analyses were carried out with the SPSS-22 program. Maximum Likelihood Estimation was used as a factor extraction method as it is parallel to the Structural Equation Model (SEM). In addition, the Listwise Selection method was preferred to identify and extract missing data. The EFA of EBS revealed a five-factor structure with eigenvalues exceeding 1, accounting for 70.70% of the total variance, surpassing the 40% minimum threshold. According to Field⁷⁸, the significance of factor loadings depends on sample size, with suggested load thresholds of 0.512 for samples of 100 and 0.364 for samples of 200. The observed factor load threshold, considering standardized regression weights in AMOS output, approximated 0.696. Hair et al.⁷⁹ suggested that a sample size ranging from 100 to 150 is sufficient for EFA with a load threshold of 0.6. After the EFA process, four items were eliminated from the initial 22-item draft EBS due to load values below 0.6 and factor loads less than 0.1, resulting in a refined 18-item EBS comprising five factors. The factor loadings ranged from 0.696 to 0.879, surpassing the communality criterion of 0.3 or higher, as emphasized by Pallant⁸⁰. Factors were categorized in accordance with the TPB model and item expressions, resulting in the identification of five factors: BI, AB, BA, PCB, and SN. The scree plot corroborated the identification of five factors, as evidenced by the continued sharp decline in the slope accumulation graph up to the fifth factor. Table 5 provides an overview of the EFA outcomes for the 18-item EBS. AB pertains to considerations regarding the consequences of behavior and its potential outcomes, while PCB relates to the degree of control over behavior execution. SN signifies the perceived societal pressure to engage or abstain from behavior, while BI reflects the individual's inclination to perform a behavior. Finally, BI represents the individual's AB. Consequently, EFA affirmed that cognitive, affective, and behavioral variables are all predicted by the TPB.

Internal consistency analysis

Reliability is accepted as an indicator of how well a test or scale measures the situation it is intended to measure. A reliable test or scale should give similar results in similar situations.

Accordingly, the internal consistency and reliability analysis of EBS was performed using the equivalent halves method, item-total Statistics, t-test results for lower–upper 27% groups, Gutman lambda series. Also, the relationship between the EBS scale and its items was determined. In addition, Spearman–Brown, Guttman split-half, Cronbach's alpha, McDonald's Omega coefficients were examined to calculate the two-half test reliability coefficient of the scale. Accordingly, Item-Total correlations were calculated as item statistics for the items in EBS. Item-total correlation is used to refer to the relationship between the score obtained from each item and the total score. Accordingly, the correlation coefficients of the items were calculated and given in Table 6. In the Item-Total Statistics given in Table 6, it was seen that the item total correlation values varied between 0.937 and 0.943. Accordingly, Cronbach's alpha reliability coefficient obtained from the whole scale was found to be 0.943. The reliability coefficient obtained here was accepted to be sufficient for the scale items.

In addition, Cronbach's alpha, Split-half, McDonald's omega and Composite reliability were used to calculate the scale measurements of related to these items and the reliability of the items (Table 7). The literature generally recommends that the reliability coefficient be 0.7 and above⁶⁷. Here the reliability coefficient was found to be considerably greater than 0.7 for each sub-dimension and overall EBS. According to the data obtained from scale, Cronbach's alpha coefficients were calculated as 0.84 for BI, 0.85 for SN, 0.84 for BA, 0.83 for AB and 0.80 for PBC. Also, Cronbach's alpha coefficient for the overall scale was determined to be 0.943. However, the two-half reliability coefficients for BI, SN, BA, AB, PBC and the whole scale were 0.83, 0.84, 0.81, 0.81, 0.79, and 0.90, respectively. Also, composite reliability coefficients were found to determine the reliability of EBS and

Kaiser–Meyer–Olkin measure	0.849	
Bartlett's test	Chi-square (χ^2)	3781,22
	<i>df</i>	153
	sig. (p)	0.001

Table 4. KMO and Bartlett sphericity test findings.

Code	Items	Factor loading					Com*	Eigenvalue	Variance
		BI	AB	BA	PCB	SN			
BI1	Item1	0.838					0.729	4880	27,110
BI2	Item3	0.824					0.720		
BI3	Item2	0.822					0.697		
BI4	Item5	0.706					0.610		
BI5	Item4	0.696					0.575		
AB1	Item13		0.876				0.814	3616	20,090
AB2	Item12		0.853				0.788		
AB3	Item15		0.823				0.750		
AB4	Item14		0.800				0.676		
BA1	Item9			0.810			0.678	1698	9432
BA2	Item11			0.753			0.622		
BA3	Item10			0.719			0.621		
BA4	Item8			0.697			0.608		
PBC1	Item21				0.879		0.818	1327	7371
PBC2	Item22				0.846		0.750		
PBC3	Item19				0.829		0.739		
SN1	Item17					0.848	0.773	1206	6701
SN2	Item7					0.837	0.758		

Table 5. Results of EFA of the 18-items EBS. Total variance explained: 70.70% Com*: Communalities.

Item No	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted
Item1	69.92	142.00	0.837	0.937
Item2	69.94	142.45	0.778	0.938
Item3	70.09	140.08	0.855	0.937
Item4	70.19	144.39	0.718	0.940
Item5	70.05	142.34	0.802	0.938
Item7	70.36	146.96	0.646	0.941
Item8	70.29	144.08	0.681	0.940
Item9	70.38	145.98	0.618	0.941
Item10	70.33	144.48	0.664	0.941
Item11	70.21	143.13	0.716	0.940
Item12	70.35	144.59	0.635	0.941
Item13	70.75	145.75	0.569	0.943
Item14	70.80	148.78	0.511	0.943
Item15	70.68	144.35	0.649	0.941
Item17	70.33	147.41	0.614	0.941
Item19	70.52	145.92	0.632	0.941
Item21	70.37	144.98	0.669	0.940
Item22	70.66	147.01	0.551	0.943

Table 6. Item-total statistics.

Dimension	Number of items	Item numbers	Cronbach alpha	Split-half	McDonald's omega	Composite reliability
BI	5	Item1, Item2, Item3, Item4, Item5	0.84	0.83	0.94	0.916
SN	2	Item7, Item17	0.85	0.84	nd	0.725
BA	4	Item8, Item9, Item10, Item11	0.84	0.81	0.85	0.822
AB	4	Item12, Item13, Item14, Item15	0.83	0.81	0.84	0.754
PBC	3	Item19, Item21, Item22	0.80	0.79	0.80	0.881
All			0.94	0.90	0.95	0.893

Table 7. Reliability coefficients for EBS and its subdimensions.

were calculated to be 0.916 for BI, 0.725 for SN, 0.822 for BA, 0.754 for AB, 0.881 for PBC and 0.893 for the whole scale. Finally, McDonald's Omega reliability coefficients for BI, BA, AB, PBC and the whole scale were determined as 0.94, 0.85, 0.84, 0.80 and 0.95. However, McDonald's Omega reliability coefficient could not be calculated for the SN with two-item factor loadings. On the other hand, in the reliability series of Guttman's lambda, Guttman reliability coefficients from the starting point (λ_1) to the ending point (λ_6) were calculated between 0.891 and 0.955 for the whole scale. The reliability series obtained from λ_1 to λ_6 for BI was found to be in the range of 0.747–0.935. Additionally, the Guttman lambda series were calculated to be in the range of 0.834–0.716 for SN, 0.633–0.804 for BA, and 0.710–0.782 for PBC. Briefly, it was determined that the internal consistency and reliability of EBS was extremely high in all reliability statistics⁸¹. No item was removed from EBS due to the reliability analysis.

Whether each item discriminates individuals with the desired characteristic was examined using the t-test for independent samples, using the differences between the mean scores of the lower–upper 27% groups determined according to the total scale scores. Table 8 showed that t-test results ranged from –11.99 to –6.23. It was found that the t values for all items were statistically distinctive ($p < 0.01$ for all items). The t-test results for lower–upper 27% groups were given in Table 8. In the context of reliability of EBS, the relationship between the total score obtained from EBS and its items was calculated using the Pearson Correlation coefficient method. According to Russo⁸², correlation coefficients between 0.100 and 0.290 indicate weak relationships, between 0.300 and 0.499 indicate moderate relationships; and above 0.500 indicate very strong relationships. Accordingly, Table 8 exhibited that there are significant positive, medium and high-level relationships between the total score and the

Dimension	Items	Groups	M	SD	df	t	p value
BI	Item1	Lower (n=69)	3.73	1.33	75.00	–8.44	0.000
		Upper(n=69)	5.00	0.00			
	Item2	Lower (n=69)	3.65	1.38	77.79	–8.15	0.000
		Upper(n=69)	4.96	0.19			
	Item3	Lower (n=69)	3.55	1.39	80.47	–8.54	0.000
		Upper(n=69)	4.94	0.27			
	Item4	Lower (n=69)	3.55	1.17	97.20	–8.64	0.000
		Upper(n=69)	4.79	0.46			
	Item5	Lower (n=69)	3.59	1.27	80.30	–9.01	0.000
		Upper(n=69)	4.93	0.24			
BA	Item8	Lower (n=69)	3.34	1.18	93.45	–10.19	0.000
		Upper(n=69)	4.81	0.42			
	Item9	Lower (n=69)	3.44	1.17	108.58	–8.03	0.000
		Upper(n=69)	4.64	0.57			
	Item10	Lower (n=69)	3.40	1.16	106.10	–8.89	0.000
		Upper(n=69)	4.72	0.55			
	Item11	Lower (n=69)	1.21	1.21	91.89	–9.83	0.000
		Upper(n=69)	0.41	0.41			
AB	Item12	Lower (n=69)	3.21	1.12	90.78	–11.99	0.000
		Upper(n=69)	4.83	0.37			
	Item13	Lower (n=69)	2.85	1.10	129.38	–10.60	0.000
		Upper(n=69)	4.45	0.73			
	Item14	Lower (n=69)	3.03	1.05	138.11	–7.88	0.000
		Upper(n=69)	4.21	0.77			
	Item15	Lower (n=69)	2.86	1.07	118.58	–11.75	0.000
		Upper(n=69)	4.53	0.61			
PBC	Item19	Lower (n=69)	3.22	1.04	123.22	–8.76	0.000
		Upper(n=69)	4.44	0.63			
	Item21	Lower (n=69)	3.31	1.12	122.27	–8.04	0.000
		Upper(n=69)	4.51	0.67			
	Item22	Lower (n=69)	3.23	1.10	133.41	–6.86	0.000
		Upper(n=69)	4.29	0.77			
SN	Item7	Lower (n=69)	3.59	1.09	112.25	–6.37	0.000
		Upper(n=69)	4.49	0.57			
	Item17	Lower (n=69)	3.57	1.07	121.04	–6.23	0.000
		Upper(n=69)	4.46	0.63			

Table 8. t-test results for lower–upper 27% groups.

items. This was interpreted as another indicator of the reliability of EBS. Table 9 presents the Pearson's product moment correlation coefficients between the total score obtained from EBS and the items.

According to Split-Half reliability analyses, it was determined from Table 10 the alpha values of the first and second parts were close to each other. Also, these values, which showed that the items were consecutive and reliable, were found to be greater than 0.70. Similarly, it was determined that the correlation coefficient between the forms, the Guttman Split-Half correlation coefficient, and the Spearman-Brown reliability coefficient were calculated as 0.815, 0.895, and 0.898, respectively. Also, Cronbach α values for both parts were found to be 0.930 for the first half (nine questions) and 0.870 for the second half (nine questions).

The structural similarities, collectability, and homogeneity of the test items were checked with Tukey's Additivity Test. The test results are given in Table 11. According to the data in Table 11, it was determined that the test was collectible ($F=0.018$, $p>0.001$), the items forming EBS contained a homogeneous structure and were related to each other ($F=71.01$, $p<0.001$).

Özdamar⁸³ stated that whether a phenomenon can be measured appropriately with the measurement tool can be examined with Hotelling's T-Squared analysis. Hotelling's T-squared test was conducted to determine whether the test design was appropriate in terms of reliability analysis applications of EBS. According to the results obtained from Hotelling's T-squared test, the model of EBS was determined to be in a suitable structure ($F=29.97$, $p<0.05$). The data regarding the Hotelling's T-squared analysis of EBS is presented in Table 12.

Ridout, Demetrio, and Firth⁸⁴ established classifications for the intraclass correlation coefficient (ICC): values below 0.40 indicate poor consistency, 0.40–0.59 suggest fair consistency, 0.60–0.74 indicate good consistency, and values exceeding 0.74 represent excellent consistency. Analysis revealed that EBS demonstrated poor consistency for individual questions (ICC=0.287, $p<0.05$), yet exhibited reliable construct validity concerning mean measures (ICC=0.879, $p<0.05$). Consequently, EBS was deemed a valid and reliable scale, considering the sequence and structural characteristics of its constituent items⁸³. Intraclass correlations indicated weak consistency for single measurements (0.287) and very good consistency for average measurements (0.879), as outlined in Table 13.

Study 2

In this stage, the statistical analyses were carried out with the data of a sample group of 254 people who did not participate in the pilot study for EFA. Before starting the CFA, it was checked whether there was any missing data for each item of EBS. Instead of the determined missing data, the most repeated option in that series was selected and the missing data were removed. AMOS 24.0 program was preferred to determine the level of agreement between the five-factor structure determined as a result of the EFA and the sample data. The analysis of the data with AMOS was achieved by applying the likelihood model.

Confirmatory factor analysis (CFA)

CFA is a hybrid method combining "factor and regression analyses" widely employed in various fields such as psychology, sociology, education, political science, and marketing. It assesses the congruence between the theoretical covariance matrix, derived from the proposed model, and the observed data's covariance matrix. CFA serves to establish the construct validity of a dataset and validate hypotheses regarding variable relationships⁸⁵. Fit indices gauge the adequacy of models in explaining data, and various statistics are employed for this purpose. Rejection of a model suggests it lacks fit, while non-rejection indicates its capability to elucidate the causal structure underlying observed data. In scale development studies, particularly, CFA is crucial for refining and validating scales. CFA, a form of SEM, elucidates the relationship between observed and latent variables, offering a comprehensive understanding of multiple variables simultaneously. In scale adaptation, it aids in determining item relationships, error margins, and factor loadings, shedding light on how well sub-dimensions and item placements align with the theoretical structure⁸⁶.

First-level confirmatory factor analysis

The first-level CFA integrates the relationships between latent variables identified in EFA. A PATH diagram visually represents the model's outputs, including variables, factor loadings, unexplained variance, and goodness-of-fit values. In the diagram, rectangular shapes denote observed variables, while oval shapes represent latent variables, which are elucidated by the observed variables within the model. The CFA path diagram illustrates the 5-factor, 18-item model derived from EFA, displaying all standardized path coefficients. As a result of the CFA, it was determined that there were five items in the BI sub-dimension of EBS, four items in the AB sub-dimension, four items in the BA sub-dimension, three items in the PCB sub-dimension, and two items in the SN sub-dimension. Path coefficients of the items belonging to all sub-dimensions were found to be statistically significant. Considering the standardized path coefficients, item 3 was determined to have the highest effect on BI. Item 13 had the highest effect on AB. Item 10 had the highest effect on BA. Also, Item 21 had the highest effect on PBC. Finally, item 7 had the highest effect on SN (Fig. 2).

According to Table 14, it was determined that all standardized factor loadings were quite high. According to this, it can be said that the proposed model is within the limits of agreement at an acceptable level. According to Kline⁸⁶, if the C_{\min}/df value is below 5, it is considered acceptable, while if it is below 2, the proposed model is considered a perfect model. Accordingly, as a result of CFA, the C_{\min}/df value of the scale consisting of 18 items and five factors was found to be 1.763 (C_{\min} : 220.34 df : 125, $p<0.05$). In addition, other goodness-of-fit indices were examined to determine the degree of fit between model and data. Accordingly, RMSEA, SRMR, GFI, AGFI, NFI, CFI, and RFI values for model-data fit were determined as 0.05 (≤ 0.05 , good), 0.040 (≤ 0.05 , good), 0.91 (≥ 0.90 , acceptable), 0.90 (≥ 0.90 , good), 0.93 (≥ 0.90 , acceptable), 0.96 (≥ 0.95 , good), 0.91 (≥ 0.90 , good), respectively (Hooper, Coughlan, & Mullen, 2008). These values seem to support the proposed five-factor model theoretically and statistically. Accordingly, the results showed that the data has a good fit with the model.

Item1	Item2	Item3	Item4	Item5	Item7	Item8	Item9	Item10	Item11	Item12	Item13	Item14	Item15	Item17	Item19	Item21	Item22	SUM	
1																			
Item2	0.818**	1																	
Item3	0.829**	0.809**	1																
Item4	0.696**	0.688**	0.747**	1															
Item5	0.743**	0.677**	0.760**	0.622**	1														
Item7	0.557**	0.495**	0.557**	0.478**	0.581**	1													
Item8	0.599**	0.568**	0.627**	0.571**	0.630**	0.418**	1												
Item9	0.557**	0.453**	0.548**	0.509**	0.529**	0.446**	0.546**	1											
Item10	0.586**	0.560**	0.612**	0.533**	0.541**	0.401**	0.568**	0.609**	1										
Item11	0.634**	0.631**	0.669**	0.553**	0.627**	0.460**	0.584**	0.522**	0.613**	1									
Item12	0.529**	0.516**	0.537**	0.415**	0.494**	0.344**	0.357**	0.362**	0.384**	0.507**	1								
Item13	0.418**	0.392**	0.447**	0.346**	0.417**	0.381**	0.409**	0.331**	0.331**	0.655**	0.381**	1							
Item14	0.353**	0.366**	0.390**	0.281**	0.395**	0.401**	0.345**	0.234**	0.347**	0.457**	0.583**	0.347**	1						
Item15	0.519**	0.471**	0.522**	0.435**	0.522**	0.375**	0.492**	0.388**	0.456**	0.544**	0.545**	0.521**	0.521**	1					
Item17	0.593**	0.535**	0.554**	0.525**	0.539**	0.716**	0.393**	0.414**	0.444**	0.343**	0.336**	0.347**	0.305**	0.305**	1				
Item19	0.558**	0.480**	0.566**	0.421**	0.553**	0.440**	0.369**	0.409**	0.454**	0.495**	0.382**	0.265**	0.456**	0.418**	0.418**	1			
Item21	0.591**	0.535**	0.628**	0.460**	0.555**	0.476**	0.430**	0.394**	0.438**	0.453**	0.359**	0.327**	0.486**	0.389**	0.642**	0.642**	1		
Item22	0.508**	0.425**	0.492**	0.454**	0.503**	0.402**	0.380**	0.316**	0.362**	0.328**	0.257**	0.303**	0.392**	0.364**	0.427**	0.534**	0.534**	1	
SUM	.859**	0.808**	0.876**	0.753**	0.828**	0.686**	0.723**	0.665**	0.707**	0.683**	0.625**	0.566**	0.695**	0.657**	0.677**	0.710**	0.606**	0.606**	1

Table 9. The relationship between the EBS scale and its items. **Correlation is significant at the 0.01 level (two-tailed).

Confidence coefficients (N:18)	
Correlation Between Forms = 0.815	Equal Length Spearman-Brown = 0.898
Guttman Split-Half Coefficient = .895	Unequal Length Spearman-Brown = 0.898
$\alpha = 0.930$ (N:9 ^a) for Part1	$\alpha = 0.870$ (N:9 ^b) for Part2

Table 10. Results of split-half reliability analyses for EBS. ^aItems: Item1, Item2, Item3, Item4, Item5, Item7, Item8, Item9, Item10. ^bItems: Item11, Item12, Item13, Item14, Item15, Item17, Item19, Item21, Item22.

		^b SS	<i>df</i>	^c MS	<i>F</i>	<i>p</i>	
Between people		1881.35	253	7.43			
Within people	Between items	1090.47	17	64.14	71.01	0.000	
	Residual	Nonadditivity	0.016 ^a	1	0.016	0.018	0.894
		Balance	3885.12	4300	0.904		
		Total	3885.13	4301	0.903		
Total		4975.61	4318	1.15			
Grand Mean = 3.92		6856.96	4571	1.50			

Table 11. The ANOVA results of EBS. ^aTukey's estimate of power to which observations must be raised to achieve additivity = 0.97. ^bSS: Sum of squares. ^cMS: Mean squares.

Hotelling's T-squared	<i>F</i>	<i>df1</i>	<i>df2</i>	Sig
543.995	29.97	17	237	0.000

Table 12. Hotelling's T-squared analysis results for EBS.

	Intraclass correlation ^b	95% confidence interval		<i>F</i> Test with True Value 0			
		Lower bound	Upper bound	Value	<i>df1</i>	<i>df2</i>	Sig
Single measurements	0.287 ^a	0.248	0.331	8.232	253	4301	0.000
Average measurements	0.879 ^c	0.856	0.899	8.232	253	4301	0.000

Table 13. The ICC results of EBS. ^aThe estimator is the same, whether the interaction effect is present or not. ^bType C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance. ^cThis estimate is computed assuming the interaction effect is absent because it is not estimable otherwise.

Convergent and discriminant validity

First-level confirmatory analysis was carried out to reveal the interrelationships between the variables. Accordingly, it was determined that the correlation values between the BI, AB, AB, PBC, and SN variables were at an acceptable and significant level (Table 15). Convergent and discriminant validity are used to determine whether the observed variables are part of the latent constructs. Convergent validity is the degree to which a construct can be quantified by different models, whereas discriminant validity is the capacity of a model to measure different aspects of a construct⁷⁹. Some conditions are necessary to ensure the validity of convergent and discrimination. For convergent validity, Composite reliability (CR) should be greater than 0.7. Also, the Average shared variance (AVE) should be greater than 0.5. However, while it should be $CR > AVE$, it should be $MSV < AVE$ and $ASV < AVE$ to ensure discriminant validity. In addition, it is suggested in the literature that the square root of the AVE value should be greater than the correlation value between the variables.

When Table 15 is examined, the lowest AVE value calculated for latent variables is 0.508. The lowest calculated CR value is 0.725. This shows that convergent validity is provided for all latent variables in the measurement model. For discriminant validity, MSV and ASV values were found to be smaller than AVE values. When the square roots of AVE values and correlations between variables were examined, it showed that discriminant validity was provided for all latent variables.

Testing the structural model

In this section, it was aimed to reveal the relationships between the variables to examine the environmental behavior of teacher candidates within the scope of TPB. Accordingly, after the validation of the proposed model with first-level CFA, the effects of BA, SN, and PBC on BI, the effect of PBC on BI, the effect of BI on AB, and

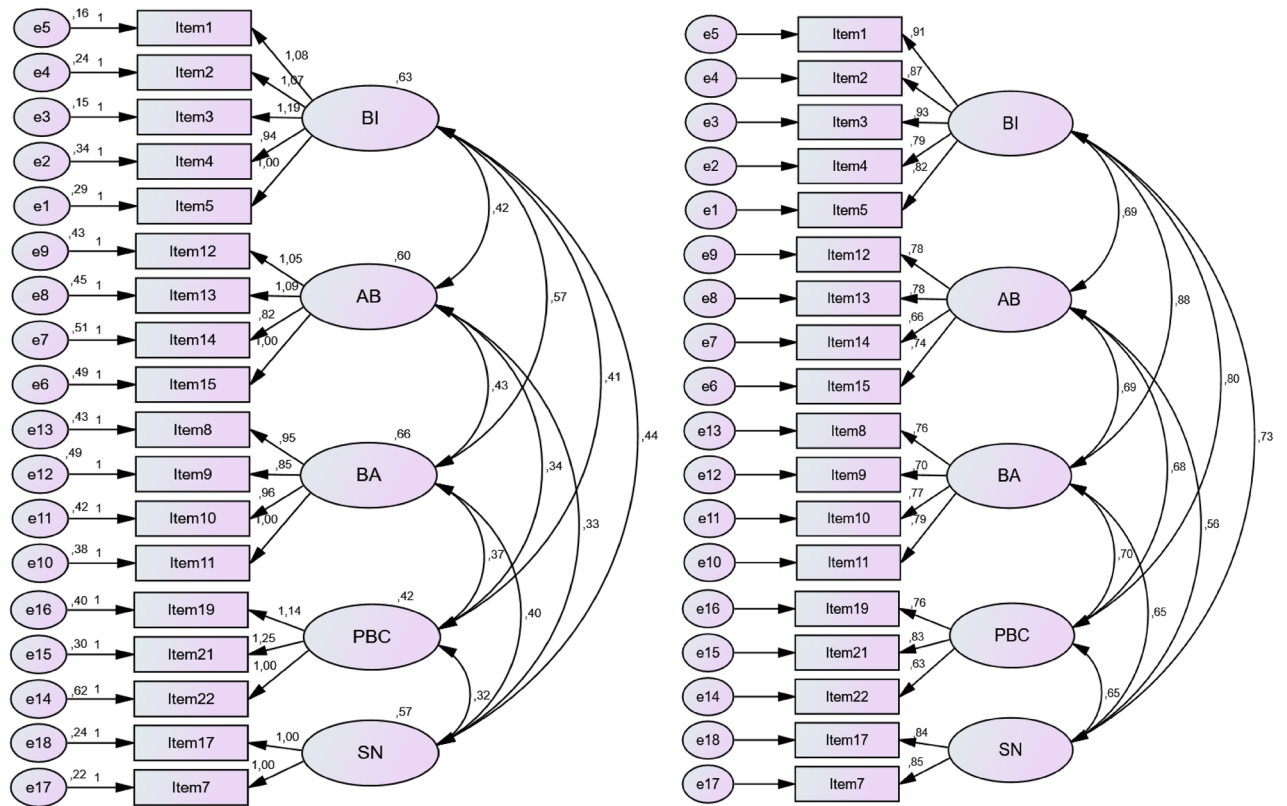


Fig. 2. The unstandardized and standardized factor loads in the path diagram of EBS.

Items	Latent variable	β_0	β_1	SE	CR	p
Item5	→ BI	0.825	1			
Item4	→ BI	0.785	0.940	0.064	14.747	<0.001
Item3	→ BI	0.926	1.185	0.062	19.214	<0.001
Item2	→ BI	0.866	1.073	0.063	17.076	<0.001
Item1	→ BI	0.906	1.075	0.058	18.513	<0.001
Item15	→ AB	0.743	1			
Item14	→ AB	0.664	0.824	0.083	9.873	<0.001
Item13	→ AB	0.783	1.088	0.098	11.146	<0.001
Item12	→ AB	0.780	1.055	0.094	11.221	<0.001
Item11	→ BA	0.794	1			
Item10	→ BA	0.767	0.959	0.075	12.836	<0.001
Item9	→ BA	0.702	0.854	0.075	11.427	<0.001
Item8	→ BA	0.759	0.949	0.075	12.636	<0.001
Item22	→ PBC	0.633	1			
Item21	→ PBC	0.827	1.252	0.125	10.035	<0.001
Item19	→ PBC	0.757	1.137	0.121	9.358	<0.001
Item7	→ SN	0.852	1			
Item17	→ SN	0.840	0.999	0.079	12.692	<0.001

Table 14. First-level confirmatory factor analysis for all sub-dimensions. *SE* standard error. β_0 : standard covarians values, β_1 : non-standardized covarians values. $*p < 0.001$ significant level.

the correlation relations between SN, BA, and PBC were examined. The relationships between the variables were tested through structural modeling. Path analysis was used to test the mutual effects of the analysis.

Figure 3 shows the non-standardized and standardized path diagram related to the SEM. As a result of the SEM analysis, it was determined that the correlation value between BA and PBC was 0.711, the correlation value between BA and SN was 0.648, and the correlation value between PBC and SN was 0.655. The C_{min}/df

	CR	AVE	MSV	ASV	MaxR (H)	BI	AB	BA	PBC	SN
BI	0.916	0.687	0.654	0.302	0.927	0.829				
AB	0.881	0.651	0.616	0.527	0.909	0.807	0.807			
BA	0.822	0.537	0.514	0.246	0.831	0.733	0.733	0.733		
PBC	0.754	0.508	0.382	0.177	0.771	0.713	0.713	0.713	0.713	
SN	0.725	0.638	0.223	0.168	0.905	0.799	0.799	0.799	0.799	0.799

Table 15. Composite reliability and explained mean–variance values of the variables.

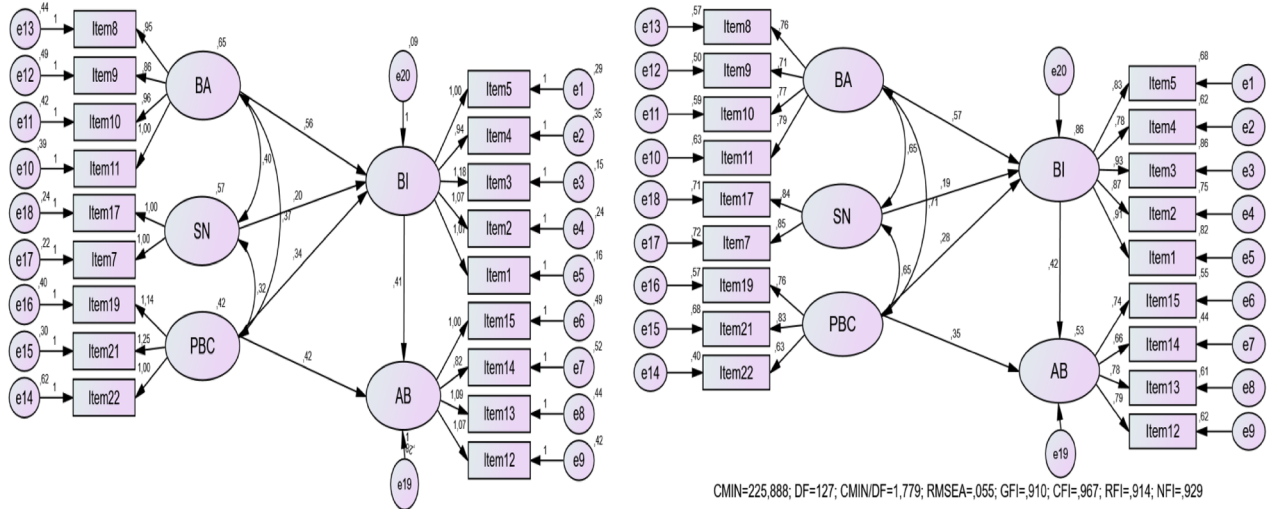


Fig. 3. Non-standardized and standardized path diagram of EBS.

(C_{min} : 225.88 df :127, $p < 0.05$), RMSEA, SRMR, GFI, AGFI, NFI, CFI, and RFI values were calculated as 1.779, 0.055, 0.042, 0.91, 0.89, 0.92, 0.96 and 0.91, respectively. The study conducted an analysis to assess the adequacy of a proposed five-factor model. Evaluation of model fit indexes indicated compliance within specified limits, with all standardized and non-standardized path coefficients demonstrating positive and significant values. These findings affirmed the accuracy of the proposed model, indicating a good fit between the model and the data. Detailed parameter estimates were provided in Table 16, revealing consistent positive and significant path coefficients. Figure 3 illustrated significant relationships at a 95% significance level. Covariances were introduced between latent variables to enhance goodness of fit values, aligning the model more closely with the data. The structural model, validated by the data, was depicted in Fig. 3 and Table 16 encompassed SEM results, including estimated parameters relevant to the proposed model.

Testing the hypotheses

The research model and proposed hypotheses underwent rigorous scrutiny through studies of construct validity, a pivotal process in assessing the robustness and integrity of the theoretical framework. Researchers meticulously examined the model to ensure its conformity with established principles and the reliability of its predictions. The comprehensive evaluation, detailed in Table 16, yielded compelling evidence supporting the accuracy and efficacy of the research model, thereby affirming the validity of all hypotheses (H1, H2, H3, H4, and H5). This validation underscores the methodological rigor employed and the solidity of the theoretical foundations, bolstering confidence in the findings and contributing to the advancement of knowledge in the field. This process reflects a commitment to scholarly rigor and enhances the credibility of the study’s outcomes, as outlined in the investigation (Table 16). Through systematic analysis, the study establishes a solid foundation for further exploration and understanding within the research domain.

Measurements invariance

EFA and CFA results revealed that EBS consists of five dimensions. In addition, measurement invariance examinations were carried out for the structural validity of the EBS. Accordingly, it was tested whether the CFA model was invariant for male and female students. Here, the Mean and Covariance Structure approach was adopted within the scope of Multi Group Confirmatory Factor Analysis. Thus, four nested hierarchical models were tested. In the first stage where structural invariance was examined, it was examined whether the groups had the same structure. Therefore, when testing structural invariance for the measurement model, free estimation of factor loadings, regression constants and error variances were allowed. Only the number of factors and loading patterns for the groups were limited. Table 17 shows that the structural invariance of EBS is ensured

Items		Latent variable	β_0	β_1	SE	CR	p	Hypotheses	Result
Item5	→	BI	0.826	1					
Item4	→	BI	0.785	0.938	0.064	14.752	<0.001		
Item3	→	BI	0.925	1.184	0.062	19.234	<0.001		
Item2	→	BI	0.865	1.072	0.063	17.088	<0.001		
Item1	→	BI	0.905	1.074	0.058	18.528	<0.001		
Item15	→	AB	0.739	1					
Item14	→	AB	0.661	0.824	0.084	9.829	<0.001		
Item13	→	AB	0.784	1.094	0.098	11.138	<0.001		
Item12	→	AB	0.785	1.068	0.095	11.226	<0.001		
Item11	→	BA	0.792	1					
Item10	→	BA	0.769	0.963	0.075	12.808	<0.001		
Item9	→	BA	0.705	0.86	0.075	11.434	<0.001		
Item8	→	BA	0.758	0.95	0.076	12.564	<0.001		
Item22	→	PBC	0.633	1					
Item21	→	PBC	0.826	1.251	0.125	10.028	<0.001		
Item19	→	PBC	0.758	1.138	0.122	9.355	<0.001		
Item7	→	SN	0.851	1					
Item17	→	SN	0.84	1.001	0.079	12.7	<0.001		
SEM									
BI	→	BA	0.566	0.556	0.073	7.654	<0.05	H ₁	Supported
BI	→	SN	0.187	0.196	0.065	3.011	<0.05	H ₂	Supported
BI	→	PBC	0.277	0.341	0.088	3.893	<0.05	H ₃	Supported
AB	→	BI	0.418	0.405	0.115	3.535	<0.05	H ₄	Supported
AB	→	PBC	0.349	0.417	0.152	2.74	<0.05	H ₅	Supported

Table 16. SEM results for the suggested model. *SE* standard error. β_0 : standard covarian values, β_1 : non-standardized covarian values. $*p < 0.001$ significant level.

	χ^2	SD	RMSEA	CFI	$\Delta\chi^2$	ΔSD^{**}	ΔCFI
Configural invariance	282.01	240	0.026	0.986	–	–	–
Metric invariance	296.46	253	0.026	0.986	14.45	13 (27.68)	0.00
Scalar invariance	353.35	271	0.035	0.979	56.89	18 (34.80)	0.01
Strict invariance	438.86	294	0.044	0.973	85.53	23 (41.63)	0.01

Table 17. Fit statistics for measurement invariance. $**$ Critical χ^2 values for ΔSD values are given in parentheses.

in terms of model fit values. In the metric invariance model, it was tested whether the measurement unit of the groups regarding the latent variable was similar. While testing metric invariance, the number of factors and the loading pattern and factor loadings were also limited. Thus, Table 17 showed that the $\Delta\chi^2$ and ΔCFI values had no significant deterioration in the model. The metric invariance between the groups was achieved. In the scalar invariance model, which is another model, it was tested whether the regression constant achieved when the score of the groups was zero was equal. In addition to factor pattern and factor loads, the regression constant was also limited when testing scalar invariance. When $\Delta\chi^2$ and ΔCFI values obtained from metric and scalar invariance were analyzed, no significant deterioration was detected in the model. In the last stage, namely the strict invariance model, it was tested whether the error variances differed in the groups. When testing strict invariance in the measurement model, error variances were limited along with all parameter constraints. The obtained $\Delta\chi^2$ and ΔCFI values showed that a significant deterioration was in the model. Figure 4 shows the fit statistics and coefficients for the invariance test.

To decide on the measurement invariance between the groups, the proposed model was compared with the more limited models and the difference values of the ΔCFI and $\Delta\chi^2$ fit coefficients were determined. The fit indices obtained from the configural invariance without any restrictions showed that this stage was achieved. Accordingly, the relationships between the characteristics measured by the questionnaire items and epistemological beliefs are similar for male and female student groups. Also, the fit indices obtained from the multi-group CFA performed for metric invariance showed that there was no distortion in the model ($\Delta\text{CFI} \leq 0.01$, $\chi^2_{(13,0.01)} = 27.68 > \Delta\chi^2 = 14.45$). The fact that metric invariance was achieved indicated that the measured constructs were the same across groups and that male and female students used the same conceptual

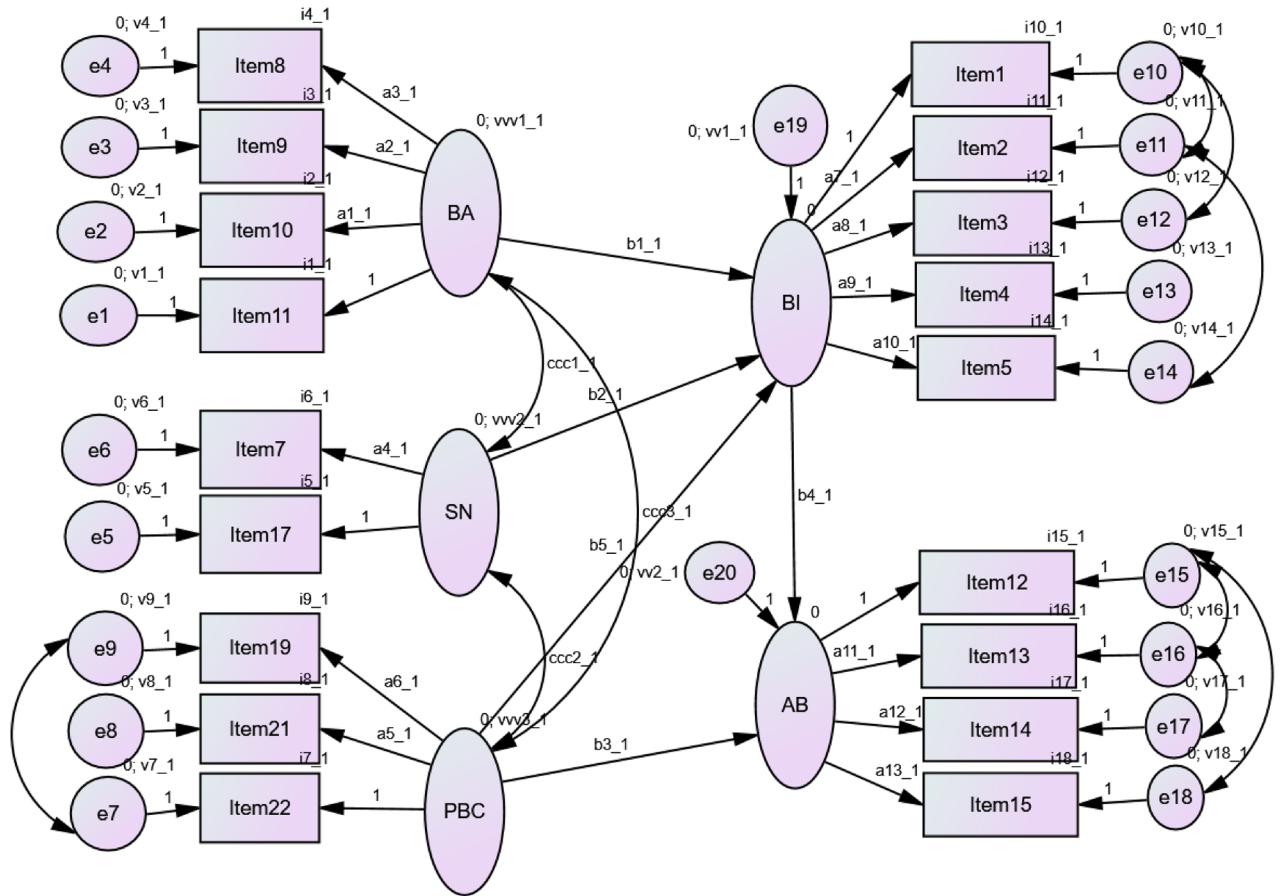


Fig. 4. Proposed path diagram for measurement invariance.

perspectives in responding to the scale items. Also, the scale invariance model revealed that the group items did not cause any bias.

Finally, strict invariance showed that the error terms for the EBS items were invariant between the compared groups. While there was a significant deterioration in terms of the $\Delta\chi^2$ value obtained from the scalar invariance and strict invariance models, no significant deterioration was observed in terms of the ΔCFI fit value. From here, it was determined that the EBS model proposed according to EFA and CFA did not create gender bias. However, as seen in Fig. 4, some modifications were made to the proposed model to avoid gender bias. These modifications include error terms $e7$ - $e9$ for PBC, $e10$ - $e11$, $e10$ - $e12$, $e11$ - $e14$ for AB, and $e15$ - $e16$, $e15$ - $e18$, and $e16$ - $e17$ for BI.

Discussion and conclusion

The main purpose of environmental education is to ensure that individuals acquire positive and environmentally friendly behaviors towards the environment. In this context, researchers have examined various variables that affect the environmental behaviors of individuals and have focused particularly on the Theory of Reasoned Behavior and the Theory of Planned Behavior. According to these theories, individuals evaluate the situations they encounter and develop positive or negative attitudes, and these attitudes shape their behaviors over time⁶². In studies in the field of environmental education, the relationship between attitudes towards the environment and behaviors has been examined, but while some studies support this relationship, others have not found a significant connection, making it difficult to reach a general conclusion and leading to the view that additional factors explaining environmental behaviors should be investigated⁸⁷. Ensuring the necessary changes in individuals' thoughts and behaviors plays a critical role in solving environmental problems. In this context, science teacher candidates have an important responsibility in gaining environmental awareness, and the need to investigate variables that encourage positive behaviors towards the environment to increase the effectiveness of environmental education has emerged. However, in the studies conducted on environmental education in literature, it has been seen that explaining behaviors only through attitudes is not sufficient. The variability of the relationship between attitudes and behaviors in different studies has limited the generalizability of this approach⁸⁸, (Dunlap, et al., 2000);^{89,90}, (Whitmarsh & O'Neill, 2010). This situation has made it necessary to investigate new variables affecting environmental behaviors and to question different relationships. On the other hand, in the studies on environmental education in the literature, it is seen that explaining behaviors only through attitudes is not sufficient. The fact that the relationship between attitude and behavior varies in different studies has made it difficult to reach a general conclusion in this field and has made it necessary to

investigate new variables that affect environmental behaviors. In this context, when the literature on the concept of environment is examined, it has been determined that the existing studies are quite limited. It is anticipated that the findings to be obtained from this research will contribute to the lack of information and will reveal the predictive power of these variables by determining the relationships between attitudes, intentions and behaviors towards the environment. Thus, it aims to contribute to the elimination of the gap in literature and to shed light on further research on this subject. In this study, it is stated that individuals' intentions to exhibit a certain behavior within the scope of TPB are affected by three basic factors, namely attitude, social norms and perceived behavioral control (PBC). Studies in literature show that attitude and PBC in particular determine behavioral intentions most strongly. In addition, it is stated that social norms have a positive effect on environmental behaviors such as recycling. According to TRA, the most important determinant of behavior is behavioral intention and the possibility of individuals to perform a certain environmental behavior largely depends on this intention. Individuals' attitudes and social norms play an important role in the adoption of environmentally friendly behaviors by affecting behavioral intention and therefore their actual behaviors. The model proposed in the study was created using the dependent and independent variables of TPB and the relevant hypotheses (*H1*, *H2*, *H3*, *H4* and *H5*) were structured accordingly.

In this context, the aim of the study is to develop the Environmental Behavior Scale (EBS) to evaluate the environmental behaviors of prospective teachers and to measure its validity. Stringent scale development processes were applied to ensure content and construct validity. Content validity was established through expert evaluations following Polit and Beck's guidelines, resulting in a refined 22-item draft after exclusion of items with kappa values below 0.48. Face validity was confirmed without item removal. Construct validity was assessed through EFA and CFA, revealing a five-factor structure consistent with TPB and explaining 70.70% variance. Reliability tests demonstrated the scale's consistency and reliability. EBS exhibited Likert-type additive scale properties and internal homogeneity among its items, affirming its utility for assessing environmental behaviors among teacher candidates. Statistical analyses, including Hotelling's T-squared statistics, ICC results, item-total statistics, and *t*-test results for lower-upper 27% groups, supported the validity and reliability of EBS. SEM analysis, based on data from 254 teacher candidates, confirmed the accuracy of the proposed five-factor model, with model fit indices indicating adequacy and significant path coefficients observed for EBS sub-dimensions. Notably, specific items within EBS significantly influenced various dimensions, such as Item 1 impacting BI, and Items 12, 11, 21, and 7 affecting AB, BA, PCB, and SN, respectively. Second-level CFA highlighted alignment between the proposed model and collected data, with introduced covariances enhancing goodness of fit values. The study revealed significant relationships between BA, SN, and PBC with BI, while PBC influenced AB. A significant regression coefficient of 0.56 between BI and AB affirmed hypotheses and suggested positive attitudes toward environmental behaviors among teacher candidates. Additionally, the measurement invariance of the model proposed by SEM was achieved in terms of gender. As a result of all analyses, a five-factor model consisting of 18 items, which are compatible with each other and prepared according to TTB, was developed. The developed scale can be applied to students studying in environmental and environmental related departments or taking various courses at universities. Additionally, by drawing on literature emphasizing the role of attitudes and beliefs in shaping environmental behavior, the EBS was developed to investigate and test hypotheses on the interaction between environmental knowledge, attitudes, and behavior. Studies by various authors, including Zheng⁹¹, Stern²⁶, Barr⁹², and others, underscored the significance of subjective norms, perceived behavioral control, and attitudes in influencing environmental behaviors, aligning with findings from the current study.

The results of the study come with some limitations. First, the lack of a control or comparison group prevents students from being evaluated comparatively in undergraduate environmental courses because they take courses with different content. While environmental courses are expected to help prospective teachers develop environmental awareness and exhibit positive behaviors with this awareness, whether such courses achieve their goals should be examined in detail. Future studies should diversify the samples and include students from various environmental courses for more definitive results. Second, the high initial scores of the students limit interpretations regarding the course's impact on value orientations. In addition, the fact that the measurement validity of the proposed model is not examined in terms of class and department variables is a limitation of EBS. Finally, factors such as the environmental knowledge shared by the faculty member with the students and the demonstration of environmentally friendly behaviors may significantly affect students' attitudes and behaviors. The study also acknowledges the potential impact of faculty orientation and item wording on students' self-evaluations and the perceived social desirability of certain beliefs. These factors remain uncontrolled and unexplored in the study, which limits the ability to compare the findings and students' orientations within and outside the course.

Suggestion

The study highlights several limitations in its conclusions. Firstly, the absence of a control or comparison group impedes a thorough assessment of students' value orientation towards social justice within the undergraduate community psychology course, especially concerning non-participants. Future research should expand sample diversity to include students from various psychology courses for more comprehensive results. Secondly, interpreting the course's impact on students' value orientation is challenged by high initial scores. Attempts to address this limitation include focusing on group medians and using nonparametric analysis techniques, though these may not fully resolve the issue's complexity. Furthermore, factors like faculty members sharing racial identities with students and advocating for social justice pedagogy could significantly influence attitudes and behaviors. Additionally, the study acknowledges the potential impact of faculty orientation and item phrasing on students' self-ratings, affecting the perceived social desirability of certain beliefs, yet remain unexplored, limiting findings and comparisons. Moreover, the Environmental Behavior Scale (EBS) emerges as a valuable tool in educational contexts, offering insights into various dimensions of environmental behavior among

teacher candidates. Its comprehensive nature allows for use across all levels of teacher education, streamlining assessment processes. Consequently, EBS serves as a valuable instrument for evaluating environmental activities within teacher education programs and experimental studies. Institutions are encouraged to evaluate student behavioral reactions, utilizing diverse activities and environments to foster positive environmental attitudes. To develop environmentally friendly attitudes and behaviors of prospective teachers, environmental awareness should be increased through value-based education programs, case studies and social responsibility projects, and behavioral intentions should be strengthened through individual goal setting, commitment mechanisms and reward systems. For real behavior to become more sustainable, behavioral monitoring and feedback mechanisms should be established, and environmental habits should be integrated into daily life through sustainable school practices and applied projects. To increase perceived behavioral control, prospective teachers should be provided with practical training where they can experience environmentally friendly behaviors, competency-based teaching strategies should be adopted and opportunities for interaction with role models should be provided. To strengthen subjective norms, social participation and cooperation should be encouraged, environmental awareness campaigns should be organized, and environmental leadership programs should be established. When these strategies are considered with a holistic approach, they will contribute to the sustainability of prospective teachers' environmentally friendly attitudes and behaviors and to their acting with environmental responsibility in educational environments. In addition, all these developments should not be evaluated only on the prospective teachers selected as a sample within the scope of the study. The scale developed within the scope of the study can be applied to different levels of education. Aligning environmental education with predetermined targets can effectively meet educational objectives across primary, secondary education, and teacher training curricula. In addition, the environmental behaviors of students from different cultures and at different levels can be examined within the scope of TPB. Thus, intercultural practices can directly affect policy makers and education policies and provide opportunities for necessary regulations. Furthermore, student-centered teaching methods hold promises in cultivating environmental consciousness within educational contexts. These recommendations underscore the importance of robust assessment tools and pedagogical approaches in advancing environmental education (EBS).

Data availability

Data supporting the findings and conclusions are available upon request from the author. All data obtained within the scope of the research will be presented as an information file upon request. If you have any questions, data requests, etc. regarding the research, you can contact the corresponding author.

Received: 16 October 2024; Accepted: 5 May 2025

Published online: 21 May 2025

References

- Yeşil, A. A conceptual review of leadership and motivation theories. *Int. Acad. J. Manag. Sci.* **2**(3), 158–180 (2016).
- Karabıçak, M. & Armağan, R. The emergence process of environmental problems, the basics of environmental management and their economic effects. *J. Süleyman Demirel Univ. Faculty Econ. Admin. Sci.* **9**(2), 203–228 (2004).
- Teksöz, G. Learning from the past: Education for sustainable development. *Boğaziçi Univ. Educ. J.* **31**(2), 73–97 (2014).
- Keleş, Ö., Uzun, N. & Varnacı Uzun, F. Evaluation of the change and permanence of teacher candidates' environmental awareness, environmental attitudes, thoughts and behaviors due to the nature education project. *Electron. J. Soc. Sci.* **9**(32), 384–401 (2010).
- United Nations Educational, Scientific and Cultural Organization (UNESCO). *The Belgrade charter: A Global framework for environmental education*. <https://unesdoc.unesco.org/ark:/48223/pf0000017772>. (Accessed 2Apr 2022). (1975).
- United Nations Educational, Scientific and Cultural Organization (UNESCO). Tbilisi Declaration. Intergovernmental conference on environmental education, organized by Unesco in co-operation with UNEP, Tbilisi, USSR, 14–26 October 1977, *Final report*. Paris: UNESCO. (1978).
- Ministry of National Education. *Secondary school environmental education course curriculum*. Ministry of National Education. (2015).
- United Nations Educational, Scientific and Cultural Organization (UNESCO). *Roadmap for implementing the Global Action Programme on Education for Sustainable Development*. UNESCO. (2014).
- Tilbury D, Stevenson RB, Fien J, Schreuder D. Education and sustainability: Responding to the global challenge. *IUCN*. (2002).
- Goldman, D., Yavetz, B. & Pe'er, S. Environmental literacy in teacher training in Israel: Environmental behavior of new students. *J. Environ. Educ.* **38**(1), 3–22. <https://doi.org/10.3200/JOEE.38.1.3-22> (2006).
- Gifford, R. & Sussman, R. Environmental attitudes. In *The Oxford Handbook of Environmental and Conservation Psychology* 65–80 (Oxford University Press, 2012).
- Franzen, A. & Vogl, D. Two decades of measuring environmental attitudes: A comparative analysis of 33 countries. *Glob. Environ. Chang.* **23**(5), 1001–1008. <https://doi.org/10.1016/j.gloenvcha.2013.03.009> (2013).
- Hwang, Y. H., Kim, S. I. & Jeng, J. M. Examining the causal relationships among selected antecedents of responsible environmental behavior. *J. Environ. Educ.* **31**(4), 19–25. <https://doi.org/10.1080/00958960009598647> (2000).
- Ajzen, I. & Fishbein, M. Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychol. Bull.* **84**(5), 888. <https://doi.org/10.1037/0033-2909.84.5.888> (1977).
- Cohen J, Hanno DM. An analysis of underlying constructs affecting the choice of accounting as a major. *Issues in Accounting Education*. **8**(2), 219–238 (1993).
- Venkatesh, V., Morris, M. G. & Ackerman, P. L. A longitudinal field investigation of gender differences in individual technology adoption decision-making processes. *Organ. Behav. Hum. Decis. Process.* **83**(1), 33–60. <https://doi.org/10.1006/obhd.2000.2896> (2000).
- Cheon, J., Lee, S., Crooks, S. M. & Song, J. An investigation of mobile learning readiness in higher education based on the theory of planned behavior. *Comput. Educ.* **59**(3), 1054–1064. <https://doi.org/10.1016/j.compedu.2012.04.015> (2012).
- Rauschmayer, F., Omann, I. & Frühmann, J. *Sustainable Development: Capabilities, Needs, and Well-being* 2011 (Routledge, 2011).
- ÇEDGM. *Turkey Environmental Atlas*. <http://www.cedgm.gov.tr/>. (2004).
- Steg, L., Perlaviciute, G. & van der Werff, E. Understanding the human dimensions of a sustainability transition. *Front. Psychol.* **6**, 805. <https://doi.org/10.3389/fpsyg.2015.00805> (2015).

21. Dunlap, R. E. & Van Liere, K. D. The “new environmental paradigm”. *J. Environ. Educ.* **9**(4), 10–19. <https://doi.org/10.1080/00958964.1978.10801875> (1978).
22. Pooley, J. A. & o'Connor, M., Environmental education and attitudes: Emotions and beliefs are what is needed. *Environ. Behav.* **32**(5), 711–723. <https://doi.org/10.1177/0013916500325007> (2000).
23. Ardahan, F. Validity and reliability study of the environmental behavior scale for middle and high school Students. *J. Glob. Sport Educ. Res.* **5**(2), 27–42. <https://doi.org/10.55142/jogser.1100042> (2022).
24. Hungerford, H. R. The development of responsible environmental citizenship: A critical challenge. *J. Interpret. Res.* **1**(1), 25–37. <https://doi.org/10.1177/109258729600100104> (1996).
25. Hungerford, H. R. & Volk, T. L. Changing learner behavior through environmental education. *J. Environ. Educ.* **21**(3), 8–21. <https://doi.org/10.1080/00958964.1990.10753743> (1990).
26. Stern, P. C. New environmental theories: Toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* **56**(3), 407–424. <https://doi.org/10.1111/0022-4537.00175> (2000).
27. Stern PC, Dietz T, Abel T, Guagnano GA, Kalof L. A value-belief-norm theory of support for social movements: The case of environmentalism. *Hum. Ecol. Rev.* 81–97. (1999).
28. Sontay, G., Gökde, M. & Usta, E. A comparative investigation of sub-components of the environmental literacy at the secondary school level. *J. Turk. Sci. Educ.* **12**(1), 19–28 (2015).
29. Atik, A. D. & Doğan, Y. Environmentally friendly behaviors of university students. *Muall. Rfat Faculty Educ. J.* **1**(1), 1–21 (2019).
30. Güven, E. & Aydoğdu, M. Development of behavior scale towards environmental problems and determination of behavior levels of teacher candidates. *Uludağ Univ. Faculty Educ. J.* **25**(2), 573–590 (2012).
31. Kırallıoğlu, F. & Ürey, M. Evaluation of environmental behavior levels of secondary school students. *J. Educ. Manage. Sci. Pract.* **3**(2), 155–171 (2023).
32. Fuhrer U. Sozialpsychologisch fundierter Theorierahmen für eine Umweltbewusstseins forschung. *Psychologische Rundschau.* (1995).
33. Lüdemann, C. Diskrepanzen zwischen theoretischem Anspruch und forschungspraktischer Wirklichkeit: eine Kritik der Untersuchung über, Persönliches Umweltverhalten. Diskrepanzen zwischen Anspruch und Wirklichkeit von Andreas Diekmann und Peter Preisendörfer. *Köln. Z. Soziol. Sozialpsychol.* **45**(1), 116–124 (1993).
34. Erten, S. Applied lesson processing teaching method with planned behavior theory. *Hacettepe Univ. Faculty Lett. J.* **19**(2), 217–233 (2002).
35. Bandura, A. Self-efficacy: Toward a unifying theory of behavioral change. *Psychol. Rev.* **84**, 191–215 (1977).
36. Bandura, A. Self-efficacy mechanism in human agency. *Am. Psychol.* **37**(2), 122 (1982).
37. Ajzen, I. From intentions to actions: A theory of planned behavior. In *Action Control: From Cognition to Behavior* 11–39 (Springer, 1985).
38. Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T) (1991).
39. Clayton, S. *Environmental Identity: A Conceptual and an Operational Definition* (The Psychological Significance of Nature/The MIT Press, 2003).
40. Dissinger, J. F. & Roth, C. E. Environmental literacy. *ERIC Clearinghouse Sci. Math. Environ. Educ.* **1**, 7 (1992).
41. Kışoğlu M. Investigating the effect of student-centered teaching on the environmental literacy level of prospective teachers. PhD Thesis. Institute of Science, Erzurum. (2009).
42. Cömert, H. *The Effects of Cooperative Learning Activities on Environmental Problems and Their Impacts on Students' Knowledge, Attitudes and Behaviors* (Istanbul University, 2011).
43. Yaşaroğlu C. Evaluation of the attitudes and behaviors of primary school first grade students towards the environment. PhD Thesis. İnönü University, Institute of Educational Sciences: Malatya. (2012).
44. Díaz-Siefer, P., Neaman, A., Salgado, E., Celis-Diez, J. L. & Otto, S. Human-environment system knowledge: A correlate of pro-environmental behavior. *Sustainability* **7**(11), 15510–15526. <https://doi.org/10.3390/su7115510> (2015).
45. Thompson, S. C. G. & Barton, M. A. Ecocentric and anthropocentric attitudes toward the environment. *J. Environ. Psychol.* **14**(2), 149–157 (1994).
46. Lange, F. & Dewitte, S. Measuring pro-environmental behavior: Review and recommendations. *J. Environ. Psychol.* **63**, 92–100. <https://doi.org/10.1016/j.jenvp.2019.04.009> (2019).
47. Ajzen, I. & Fishbein, M. The prediction of behavior from attitudinal and normative variables. *J. Exp. Soc. Psychol.* **6**(4), 466–487. [https://doi.org/10.1016/0022-1031\(70\)90057-0](https://doi.org/10.1016/0022-1031(70)90057-0) (1970).
48. Hines, J. M., Hungerford, H. R. & Tomera, A. N. Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *J. Environ. Educ.* **18**(2), 1–8 (1987).
49. Diekmann A, Preisendörfer, P. Persönliches umweltverhalten: Diskrepanzen zwischen anspruch und wirklichkeit. *Koelner zeitschrift fuer soziologie und sozialpsychologie.* (1992).
50. Chaiken, S. *The Psychology of Attitudes* (Harcourt Brace Jovanovich College Publishers, 1993).
51. Frey, D., Stahlberg, D. & Gollwitzer, P. M. Einstellung und Verhalten: Die Theorie des überlegten Handelns und die Theorie des geplanten Verhaltens. *Theor. Sozialpsychol.* **1**, 361–398 (1993).
52. Jickling, B. & Wals, A. E. Globalization and environmental education: Looking beyond sustainable development. In *CURRICULUM and Environmental Education* 221–241 (Routledge, 2019).
53. Adaryani, R. L. et al. Predicting household food waste behavior: Bringing food literacy and purchasing power into the theory of planned behavior. *J. Retail. Consum. Serv.* **82**, 104119. <https://doi.org/10.1016/j.jretconser.2024.104119> (2025).
54. Cristea, M. & Gheorghiu, A. Attitude, perceived behavioral control, and intention to adopt risky behaviors. *Transport. Res. Part F Traffic Psychol. Behav.* **43**, 157–165. <https://doi.org/10.1016/j.trf.2016.10.004> (2016).
55. Netemeyer, R. G. & Burton, S. Examining the relationships between voting behavior, intention, perceived behavioral control, and expectation. *J. Appl. Soc. Psychol.* **20**(8), 661–680. <https://doi.org/10.1111/j.1559-1816.1990.tb00431.x> (1990).
56. Wang, C. et al. Factors influencing university students' behavioral intention to use generative artificial intelligence: Integrating the theory of planned behavior and AI literacy. *Int. J. Hum. Comput. Interact.* <https://doi.org/10.1080/10447318.2024.2383033> (2024).
57. Wang, Y., Zhao, J. & Pan, J. The investigation of green purchasing behavior in China: A conceptual model based on the theory of planned behavior and self-determination theory. *J. Retail. Consum. Serv.* **77**, 103667. <https://doi.org/10.1016/j.jretconser.2023.103667> (2024).
58. Zhao, X., Fan, L. & Xu, Y. An investigation of determinants of green consumption behavior: an extended theory of planned behavior. *Innov. Green Dev.* **4**(1), 100198. <https://doi.org/10.1016/j.igd.2024.100198> (2025).
59. Shaw, P. J. Nearest neighbour effects in kerbside household waste recycling. *Resour. Conserv. Recycl.* **52**(5), 775–784. <https://doi.org/10.1016/j.resconrec.2007.11.004> (2008).
60. Miniard, P. W. & Cohen, J. B. An examination of the Fishbein-Ajzen behavioral-intentions model's concepts and measures. *J. Exp. Soc. Psychol.* **17**(3), 309–339. [https://doi.org/10.1016/0022-1031\(81\)90031-7](https://doi.org/10.1016/0022-1031(81)90031-7) (1981).
61. Rossmann, C. Ajzen (1985): A theory of planned behavior. In *Schlüsselwerke für die Strategische Kommunikationsforschung* 207–217 (Springer Fachmedien Wiesbaden, 2024).
62. Uçar, M. B. *Modeling the Environmentally Friendly Behaviors of Science Teacher Candidates* (Institute of Educational Sciences, 2015).
63. Yamane, T. *Statistics, An Introductory Analysis* 2nd edn. (Harper and Row, 1973).

64. Shi, F. Study on a stratified sampling investigation method for resident travel and the sampling rate. *Discret. Dyn. Nat. Soc.* **2015**(1), 496179. <https://doi.org/10.1155/2015/496179> (2015).
65. Singh, R., Mangat, N. S., Singh, R. & Mangat, N. S. Stratified sampling. In *Elements of Survey Sampling* 102–144 (Springer, 1996).
66. Yong, A. G. & Pearce, S. A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutor. Quant. Methods Psychol.* **9**(2), 79–94. <https://doi.org/10.20982/tqmp.09.2.p79> (2013).
67. Reynolds, C. R., Livingston, R. B. & Willson, V. *Measurement and Assessment in Education* (Allyn and Bacon, 2006).
68. Polit, D. E. & Beck, C. T. *Essentials of Nursing Research* 6th edn. (Lippincott Williams and Wilkins, 2006).
69. Ayre, C. & Scally, A. J. Critical values for Lawshe's content validity ratio: revisiting the original methods of calculation. *Meas. Eval. Couns. Dev.* **47**(1), 79–86. <https://doi.org/10.1177/0748175613513808> (2014).
70. Lynn, M. R. Determination and quantification of content validity. *Nurs. Res.* **35**(6), 382–386 (1986).
71. Yusoff, M. S. B. ABC of response process validation and face validity index calculation. *Educ. Med. J.* <https://doi.org/10.21315/eimj2019.11.3.6> (2019).
72. Orts-Cortés, M. I. et al. Content validity of the Spanish version of the practice environment scale of the Nursing Work Index. *Appl. Nurs. Res.* **26**(4), e5–e9. <https://doi.org/10.1016/j.apnr.2013.08.006> (2013).
73. Fleiss, J. L. Measuring nominal scale agreement among many raters. *Psychol. Bull.* **76**(5), 378 (1971).
74. Hadie, S. N. H. et al. Anatomy education environment measurement inventory: A valid tool to measure the anatomy learning environment. *Anat. Sci. Educ.* **10**(5), 423–432. <https://doi.org/10.1002/ase.1683> (2017).
75. Ozair, M. M., Baharuddin, K. A., Mohamed, S. A., Esa, W. & Yusoff, M. S. B. Development and validation of the knowledge and clinical reasoning of acute asthma management in emergency department (K-CRAMED). *Educ. Med. J.* **9**(2), 1–17 (2017).
76. George, D. *SPSS for Windows Step by Step: A Simple Study Guide and Reference, 17.0 Update, 10/e* (Pearson Education India, 2011).
77. Leech NL, Barrett KC, Morgan GA. *SPSS for intermediate statistics: use and interpretation*. 1st. (2007).
78. Field, A. *Discovering Statistics Using SPSS: Book Plus Code for E Version of Text* Vol. 896 (SAGE Publications Limited, 2009).
79. Hair JF, Black WC, Babin BJ, Anderson RE. *Advanced diagnostics for multiple regression: A supplement to multivariate data analysis. Advanced Diagnostics for Multiple Regression: A Supplement to Multivariate Data Analysis*. (2010).
80. Pallant, J. *SPSS Survival Manual: A Step-by-Step Guide to Data Analysis Using IBM SPSS* (McGraw-Hill Education, 2020).
81. Murphy KR, Davidshofer CO. *Psychological testing. Principles, and Applications, Englewood Cliffs, 18.* (1988).
82. Russo, R. *Statistics for the Behavioural Sciences: An Introduction* (Psychology Press, 2004).
83. Özdamar, K. *Structural Equation Modeling of Scale and Test Development* (Nisan Bookstore, 2016).
84. Ridout, M. S., Demetrio, C. G. & Firth, D. Estimating intraclass correlation for binary data. *Biometrics* **55**(1), 137–148. <https://doi.org/10.1111/j.0006-341X.1999.00137.x> (1999).
85. Tabachnick, B. G. & Fidell, L. S. *Using Multivariate Statistics* (New International Pearson, 2014).
86. Kline, R. B. *Principles and Practice of Structural Equation Modeling* 3rd edn. (The Guilford Press, 2011).
87. Stets, J. E. & Biga, C. F. Bringing identity theory into environmental sociology. *Sociol Theory* **21**(4), 398–423. <https://doi.org/10.1046/j.1467-9558.2003.00196.x> (2003).
88. DeVille, N. V. et al. Time spent in nature is associated with increased pro-environmental attitudes and behaviors. *Int. J. Environ. Res. Public Health* **18**(14), 7498. <https://doi.org/10.3390/ijerph18147498> (2021).
89. Gansser, O. A. & Reich, C. S. Influence of the new ecological paradigm (NEP) and environmental concerns on pro-environmental behavioral intention based on the theory of planned behavior (TPB). *J. Clean. Prod.* **382**, 134629. <https://doi.org/10.1016/j.jclepro.2022.134629> (2023).
90. Tian, H. & Liu, X. Pro-environmental behavior research: Theoretical progress and future directions. *Int. J. Environ. Res. Public Health* **19**(11), 6721. <https://doi.org/10.3390/ijerph19116721> (2022).
91. Zheng, Y. Association analysis on pro-environmental behaviors and environmental consciousness in main cities of East Asia. *Behaviormetrika* **37**(1), 55–69. <https://doi.org/10.2333/bhmk.37.55> (2010).
92. Barr, S. Factors influencing environmental attitudes and behaviors: A UK case study of household waste management. *Environ. Behav.* **39**(4), 435–473. <https://doi.org/10.1177/0013916505283421> (2007).
93. Ata, E. & Yıldız, M. Validity and reliability study of observation scale of adults' environmental behaviors. *OPUS Int. J. Soc. Res.* **13**(19), 1010–1027. <https://doi.org/10.26466/opus.557881> (2019).

Author contributions

Within the scope of the research, all authors (EA & FD) contributed equally to the formulation of the hypothesis for the article, planning of the methods to reach the results, supervision and responsibility for the organization and course of the article, organization and reporting of the data, taking responsibility for the logical explanation and presentation of the findings, taking responsibility for the literature review and the creation of the entire article, and reworking the article not only in terms of spelling and grammar but also in terms of intellectual content before submitting it.

Declarations

Competing interests

The authors declare no competing interests.

Ethical declaration

Research and publication ethics were followed. For this research, the ethical approval was obtained from the Ethics Committee of Çanakkale Onsekiz Mart University (2022-YÖNP-0953, E-84026528-050.01.04-2200305079, Date: 15.12.2022, Number: 22/53).

Additional information

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1038/s41598-025-01277-8>.

Correspondence and requests for materials should be addressed to F.D.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

© The Author(s) 2025