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Modeling the perceptions of sustainability among students in Southern Italy: a case study

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Sustainability is a multi-layered concept, but the widespread use of this word risks losing its deep meaning and sustainability being perceived as an abstract concept. Understanding the value of sustainability for the younger generation and their awareness of its preservation is fundamental to predicting their commitment to a better future. This paper explores young people's perceptions of sustainability and their characteristics. A survey was conducted among 1,006 southern Italian high school students with a web questionnaire. The data were analyzed using CUB models, specifically designed to investigate rating data. The results show that students participating in the survey have a clear and shared knowledge of the positive, tangible benefits of sustainability for current and future generations. High levels of agreement were found for positive attributes of sustainability (increasing well-being, innovation, preserving the planet, ensuring economic development), while strong disagreement concerned negative statements about sustainability (associated costs and consumerism in developed countries). Participation in a specific educational pathway was found to be positively associated with proactive behaviors related to sustainability. Thus, planning educational activities can raise awareness of sustainable development goals and policies to educate citizens who care about their future.

keywords: Sustainability, Education for sustainable development, Questionnaire analysis, CUB regression models.

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1 Introduction

In the last years, sustainability has become a central topic in many fields, greatly expanding the three original pillars of the environmental, economic and social context towards a multifaceted concept. Some relevant definitions are considered milestones that help to clarify this idea. In 1987, the Brundtland Commission (Borowy, 2013) provided the first definition of sustainable development (Alaimo, Ciacci, & Ivaldi, 2021; Toussaint, Cabanelas, & Muñoz-Dueñas, 2022), emphasizing the importance of ensuring global equity for future generations and achieving sustainable growth through technological and social change. This approach focuses on three core aspects of sustainable development: maintaining environmental and ecological well-being, promoting economic prosperity, and ensuring social equity (Ariffin & Ng, 2020). These principles are reflected in the 17 Sustainable Development Goals (SDGs) outlined in the UN2030 Agenda (UN General Assembly, 2015a), which serve as a roadmap for policy makers at the local and international levels (Alaimo et al., 2021). Solow (1991), who focused on the development of a representative agent's utility in the context of economic theory, defined sustainability as "an obligation to conduct ourselves so that we leave to the future option or the capacity to be as well off as we are". The author emphasizes that an economy is sustainable only if the utility of the representative agent remains at least unchanged, pointing to the welfare of future generations. However, the current widespread use of the concept of sustainability could raise a cultural problem as the term sustainability is probably losing its deep meaning (Maggino, 2022). The risk is that sustainability is considered an abstract concept. Sustainability concerns current generations as they are resource consumers, but the impacts of their actions will be borne by future generations. There is an urgent need to spread awareness of individuals playing a key role in consumerism as we exploit some limited natural resources beyond their rate of regeneration.

Current and future collective well-being comes from individuals' awareness to be the main actors in a sustainable world (Güney, 2015). Only a few years ago people tended not to care much about what was happening far from where they lived and what was foreign to them (Calculli, D'Uggento, Labarile, & Ribecco, 2021; Piscitelli & D'Uggento, 2022). Some recent events have taught us that today we live in a globalised world where borders no longer exist, so that events of planetary proportions such as the Covid 19 pandemic, environmental disasters, wars, or climate change affect the lives of every one of us. Against this background, this paper explores how young people, the protagonists of the future, perceive sustainability and its impact on the current and next generation. A large Italian university conducted a survey to understand young people's perception and knowledge of the phenomenon among high school students and to find out to what extent their opinion is influenced by sociodemographic characteristics. Investigating high school students' perceptions of sustainability is critical because youth is a formative time for the development of civic awareness, critical thinking, and ethical values. By understanding their views, we can uncover gaps in knowledge and attitudes so that educators and policy makers can develop targeted interventions. High school students also exert influence in their families and communities, making them key players in spreading sustainable practices. Early engagement with sustainability can promote long-term commitment to

sustainable behaviors and is in line with global goals such as the SDGs. The aim of this study is to answer the following research questions with respect to the targeted audience:

RQ1) Do young people know about and care about sustainability?

RQ2) What are the factors that influence students' perceptions of sustainability?

RQ3) Can specific forms of sustainability education improve the cultural background and lifestyle of students?

To explore these issues, CUB models (Piccolo, 2003; Piccolo & Simone, 2019a) were implemented to assess the level of agreement or disagreement (feeling) with some statements useful to understand students' viewpoint on sustainability and uncertainty about their evaluation process (Piccolo, Simone, & Iannario, 2019). This study could be an interesting assessment of how young people perceive the impact of sustainability on their daily lives and to what extent they are aware of the phenomenon. The role of some covariates is also explored to assess whether and to what extent they are significant for the different perceptions and opinions of the students. This paper could enrich the literature by highlighting the central role of schools and universities in promoting sustainability awareness and ethical values. It establishes a link between sustainability education and international frameworks such as the World Commission on Environment and Development (WCED) (Borowy, 2013) and UNESCO's Education for Sustainable Development (ESD) initiatives (UNESCO, 2021), thus providing a global contextualization. Furthermore, it highlights the central role of young people as future leaders and agents of change in sustainability efforts. The paper could also outline the responsibility of educators and institutions in integrating sustainability into curricula and offers practical guidance for educational policy. Building on these themes, this study focuses on high school students to fill a critical gap in understanding their perceptions and prepare them to become advocates for sustainable development.

The paper is organized as follows: section 2 frames the background of education for sustainability as a discipline that should be addressed in educational pathways. In section 3, we present the survey with the main characteristics of the respondents (sections 3.1 and 3.2) followed by a description of the methodology used for data analysis (section 3.3). Section 4 reports the main findings of the statistical analysis in terms of estimated CUB model parameters. Finally, in section 5, we discuss the main implications of the results with some final remarks dealing with positive suggestions for school program planning.

2 Literature review

2.1 Role of Education in Sustainability

Sustainability has become a multi-layered concept, encompassing various fields and involving experts from different disciplines as well as interdisciplinary approaches. Education is a crucial player in promoting sustainable development and the resulting behaviors

throughout a person's life. Therefore, schools and universities are the places where sustainability should be addressed (Ramakrishna, 2021). Schools have the opportunity to influence the development and acquisition of the foundations for the formation of civic awareness in the first phase and later for the development of critical thinking and respect for universally shared ethical values. Higher education plays a key role in promoting the sustainability agenda and the debate on how to implement sustainability by integrating this theme into undergraduate and postgraduate programs. This raises critical questions about whether young people are sufficiently aware of sustainability issues and whether they value these concerns (RQ1). Due to the importance of this topic, many scholars have debated the integration of sustainability into students' curricula (Aleixo, Leal, & Azeiteiro, 2021; Zguir, Dubis, & Koç, 2022). Thürer, Tomašević, Stevenson, Qu, and Huisingh (2018) produced a useful review by categorizing some selected works in the field of engineering education into the following thematic groups: exploring students' and teachers' knowledge and value frameworks; exploring the influence of stakeholders (i.e. accrediting institutions, industry partners, relatives and society); the use of competencies to evaluate implementations. In light of these discussions, it becomes important to explore the factors-such as familial, social, or institutional influences-that shape students' perceptions of sustainability (RQ2). Michalos et al. (2015) stated that, even though the formation of attitudes and values might go beyond the traditional goal of formal education, improving students' knowledge base could contribute to the adoption of more sustainable choices and actions. They demonstrated that students who knew the term "sustainable development" showed a stronger knowledge, more positive attitudes and were more likely to adopt sustainability-related behaviors.

2.2 International Sustainability Initiatives

The milestones of the path to integrating sustainable development concepts into higher education are the initiative taken by the World Commission on the Environment and Development (WCED) in 1983 and, later, in 1992, the United Nations Conference on the Environment and Development held in Rio de Janeiro: both events gave the direction to address educational paths in sustainable development but further push to translate it into actions was needed. The United Nations Decade for Education for Sustainable Development, from 2005 to 2014, provided a strong impulse for integrating sustainability into education, including higher education. This captured the attention of some motivated educators to address sustainability in their courses, curricula, research, outreach, and on-campus greening activities (Murphy et al., 2009; Zguir, Dubis, & Koç, 2021). Targeted education for sustainable development at secondary school level faces challenges due to the lack of curricula covering related topics, which leads to limited awareness among students. the introduction of specific courses or activities in these schools could have a positive effects on both students and society. The implementation of such initiatives is crucial order to rise a generation of students who are better equipped to contribute to Sustainable Development Goals (Hoque, Yasin, & Sopian, 2022). However, as emerged even in more recent studies (Zguir et al., 2022), the fuel of this process is the educators' commitment to the issue: first, there is a significant difference in teachers' perceptions

depending on their subject of teaching and specialization; second, there should be an involvement of their institutions in addressing sustainable themes; third, teachers have to be aware of sustainability concepts and skilled to integrate them into their teaching fields, if they are not naturally congruent with them. Therefore, any education initiative towards these directions is useful to accelerate the debate on sustainability in schools and universities, to produce a transdisciplinary integration of sustainability values into curricula and to empower teachers in being driving agents of change along with families and larger networks. This aligns with the need to explore whether specific forms of sustainability education can shape students' cultural awareness and foster sustainable lifestyles (RQ3).

2.3 Importance of Youth Engagement

However, it is worth mentioning that the complementary agents in this change are the youths. They play a relevant role in demanding education in sustainability, spreading awareness, knowledge, and commitment to sustainable behaviors. According to some scholars (Leal Filho et al., 2018, 2019; Reza, 2016) the link between sustainability values and higher education consists in taking the roots, through educational paths, for future leaders to play a crucial role in meeting actual sustainability challenges. To pursue these goals, the dissemination and activation of educational systems promoting sustainable development should be carried on worldwide (Laurie, Nonoyama-Tarumi, Mckeown, & Hopkins, 2016; Mula & Tilbury, 2011; Sarabhai, 2015; UNESCO, 2020). Given the globalization of the modern world, it is crucial to empower learners and teachers and to provide them with the right skills and competencies to adopt sustainable behaviors and make informed decisions (Bourn, Hunt, & Bamber, 2017; Brown, 2014). It is well known that among the Sustainable Development Goals (SDGs) of United Nations (UN General Assembly, 2015b), Goal 4 deals with the provision of quality education and also in the other SDGs, the Education for Sustainability (EFS) requires students to achieve skills, knowledge and environmental behaviors as well as their communities (Laurie et al., 2016; Sarabhai, 2015; UNESCO, 2020). However, Goal 4 aims to ensure the same learning opportunities for all students to equip them with proper qualifications. There are various initiatives launched by the UN and UNESCO through programs such as the Decade of Education for Sustainable Development (ESD) and afterward the Global Action Program on ESD (GAP) from 2015 to 2019 and finally the framework Education for Sustainable Development - Towards achieving the SDGs (or ESD for 2030), assessed in the Berlin declaration on education for sustainable development (UNESCO, 2021). ESD for 2030 is the call to all member states in the UN to embed sustainability concepts within educational programs and learning plans (Zguir et al., 2022) containing tangible engagements among learners to address the urgent environmental, climate, social, sanitary, and economic crises the world is currently facing (RQ3). These are the reason why it is interesting to investigate people's opinions, especially those of youths who are future citizens, to understand the level of their commitment to sustainability values (Ariffin & Ng, 2020). The United Nations in UN General Assembly (2015b) defines youths as agents of change able to face sustainability challenges and Agenda 21 highlighted their

role in decision-making about environment and development, whose participation could increase their knowledge and skills, opportunities, and sense of community as a social network. The results of this study could provide useful hints to policymakers and educational institutions in planning better programs to promote sustainable development and, in general, support decision-making processes related to preserving it. Innovation in education and specific curricula should deal with both implementing ESD in formal education and engaging students in informal education such that sustainable values are embedded in their daily lives, and become positive models for their less committed peers, parents and friends.

3 Methodological framework

3.1 The survey

From January to February 2021, an ad hoc survey was conducted using a web-based questionnaire administered with the Google Forms app of the Google Drive Office Suite. The online survey allowed us to collect a consistent amount of information in a relatively short period of time (Evans & Mathur, 2018). For our local analysis, a convenience sample of Apulian students was obtained, using a non-probabilistic sampling technique which is particularly suitable for exploratory analyses (Golzar, Noor, & Tajik, 2022). The respondents were students from certain Apulian high schools participating in the National Project for Scientific Degrees – Statistics section (PLS-Statistica), which is founded by the Italian Ministry of University and Research (PLS, 2021). Student participation was on a voluntary basis, with anonymity guaranteed by a formal consent.

Convenience sampling is commonly employed in web surveys across various contexts, as well as in clinical (Elfil & Negida, 2017) and qualitative research (O. Robinson, 2013), and more generally in those circumstances where it is not feasible for the entire population to participate in a study, or when all members of the target population cannot be identified (Emerson, 2021). However, non-probabilistic sampling methods are less objective than probability methods, as they do not provide equal chances for all members of the target population to be included in a study. This approach heightens the risk of bias and limits the generalizability of the results (Andrade, 2021). Despite the limitations of the technique, several remedial actions can be implemented to preserve internal validity of some results (Andrade, 2018; Rocco, 2019). For instance, one approach to improving convenience sampling is to include as many participants as possible, thereby enhancing the robustness of the dataset and reducing biases introduced by a limited sample size. Although the results of convenience sample analysis can only be applied to the group of study participants and the associations and effects found cannot be generalized to a larger population, convenience samples are less costly, faster, and easier than other forms of sampling (Stratton, 2021). When no other sampling method is feasible, convenience samples can be used to develop hypotheses and objectives that are then used in more rigorous research studies (Etikan, Musa, & Alkassim, 2015).

The participants in our survey predominantly attend a Gymnasium and, despite constituting a convenience sample, can be considered representative of their peers in terms

of gender distribution (55.0% female and 45.5% male) when compared to the reference population of Italian students attending the same type of high school (54.6% female and 45.7% male) (Italian Ministry of Education and Merit, 2024). In addition, a convenience sample was chosen in our study due to the constraints in identifying/accessing the entire target students' population of Apulia region, as highlighted in research scenarios where logistical limitations or time-sensitive conditions prevail. Thus, any student from the participating schools could take part in the survey, as the survey link was made widely accessible within their schools, including being posted on the school websites. Participants self-selected whether to participate in the survey or not, as they were encouraged to do so by their teachers. The questionnaire consisted of 42 questions divided into five main sections. The first section was designed to collect relevant sociodemographic information. Following the SDGs in the UN Agenda, subsequent sections explored respondents' opinions on affordable, reliable, and sustainable energy (section 2), perceptions of life underwater (section 3), and life on land (section 4). The last section (section 5) is devoted to respondents' perceptions of public policies and economic initiatives that support sustainable development. Based on the purpose of this study, a selection of questions is considered for analysis to explore students' actual perceptions of sustainability. In section 2, they were asked to express their agreement with a set of 11 statements on the topics using a 4-points Likert scale (Likert, 1932) with "1" representing "strongly disagree" and "4" representing "strongly agree". While this approach deviates from the common practice of using an odd-numbered scale used in most social research (Kusmaryono, Wijayanti, & Maharani, 2022), it was chosen to prevent respondents from selecting a neutral middle option on a 5-point Likert scale. This strategy forces respondents to select a direction, thus potentially reducing neutral bias. Kankaraš and Capecchi (2024) argue that while using scales with a neutral mid-point may improve the psychometric properties of the measurement tool, it also has potential limitations. Specifically, some respondents may use the neutral option as an 'escape' mechanism, especially when answering socially sensitive questions. This highlights the trade-off between enhancing reliability and the risk of respondents using inappropriately the neutral option. During the questionnaire implementation phase, the students participating in the PLS project took part in various thematic focus groups in order to select the most suitable items from a large number of proposed items. The selection criterion was applied using Cronbach's α. The full list of the 11 statements considered for the sustainability perception analysis can be found in Table 1. To assess the student focus on the topic, some of the statements were assigned negative polarity so that the higher scores indicated respondents' unfavorable perceptions (J. D. Robinson, 2020). To ensure consistency with the other items, the following data manipulation changed the polarity of these response items to a positive tone. For the set of 11 items defining perceptions of sustainability, a value of $\alpha = 0.72$ was obtained. This value may be considered adequate, according to the commonly accepted threshold of 0.7 within the field of research instruments in Science Education (Taber, 2018).

Table 1: List of items used in the analysis of the sustainability perceptions and corresponding acronyms. (*) indicates that the items were turned to positive polarity.

Item	Acronym
1. It does not guarantee economic development (*)	ecoDEV
2. It is only about the environment	ENVonly
3. It implies constant and growing well-being	groWB
4. Does not meet the needs of current generations (*)	meetNE
5. Saves the planet	prePLA
6. It involves costs	COST
7. It is a fantasy (*)	noFANT
8. It affects only future generations	NEXTGonly
9. Affects present and future generations	ACTNEXTG
10. Affects only rich countries	DEVConly
11. Involves innovation	INNOV

3.2 The analysis of rating data

The collected rating data are investigated using CUB (Combination of a Uniform and a Binomial random variables) models, which were first introduced by Piccolo (2003). The original proposal evolved through numerous variations, shaping a broad class of statistical models that align with a new scientific paradigm and have since appeared in the literature in diverse forms and extensions (Grilli, Iannario, Piccolo, & Rampichini, 2014; Iannario, Manisera, Piccolo, & Zuccolotto, 2012; Piccolo, 2018). For a comprehensive review on this class of models, see Piccolo and Simone (2019a), as well as relevant discussions by Bartolucci and Pennoni (2019), Colombi, Giordano, and Gottard (2019), Agresti and Kateri (2019), Proietti (2019), Kenett (2019), Grilli and Rampichini (2019), Manisera and Zuccolotto (2019), Tutz (2019), Piccolo and Simone (2019b); more recently, Manisera and Zuccolotto (2022). CUB models have been widely applied across several fields, including sensory analysis (Iannario et al., 2012), consumer research (Capecchi & Iannario, 2016), marketing, especially the analysis of the perceived variety of choice satisfaction (Brentari, Manisera, & Zuccolotto, 2018; Manisera, Zuccolotto, & Brentari, 2020) and also for evaluating sport performance (Fin, Iannario, Simone, & Piccolo, 2017). The basic idea of CUB models is to transform the decision-making process into a formalized structure that describes, analyzes, and predicts real-world phenomena based on ratings. While traditional models such as Ordinal Regression are grounded in the multinomial distribution (Tutz, 2022), this probabilistic approach to modeling respondents' evaluations provided by some raters over a set of items involves a mixture of two distributions:

a Uniform distribution and a Shifted Binomial distribution. In the realm of mixture models, commonly used to analyze ordinal/rating data (Agresti, 2010; Breen & Luijkx, 2010; Yao, 2012), CUB models offer a viable alternative by combining different probability distributions to represent the response behavior across different categories (Piccolo et al., 2019). These models offer a flexible and parsimonious approach, effectively capturing observed data with easily interpretable parameters. They represent a simplified decision-making process that underpins ordinal evaluations, while also addressing the uncertainty inherent in ratings. In this context, the uncertainty arises not from a stochastic component linked to the sampling process, but from a variety of factors. This include limited information, personal interest, fatigue, and other influences that may affect the evaluation process. This aspect makes it particularly useful in practical applications where capturing these factors is crucial. More thoroughly, the CUB framework posits that a rater's evaluation of an item is influenced by two latent factors: personal agreement or disagreement with the item, termed *feeling* and the degree of uncertainty in their response, termed *uncertainty* (D'Elia & Piccolo, 2005; Golia, 2015). The outcome of selecting an item from a set or assigning a value within an ordered response scale is contingent upon 1) a highly subjective judgment influenced by various underlying factors, as well as 2) an inherent uncertainty in the decision-making process that reflects the rater's indecision. The first factor relates to the individual's understanding of the topic, familiarity, group membership, and similar influences, while the second stems from various circumstances such as time pressure, limited information, incomplete understanding, or lack of motivation. This approach replicates the psychological process underlying rating, with the final score being a combination of selectivity and uncertainty (D'Elia & Piccolo, 2005). Implementing CUB models only requires Likert scale ratings, making additional questions about response uncertainty unnecessary. The proposed statistical method, which models the respondents' decision-making process within a parametric framework, can incorporate covariate effects, allowing for the consideration of various aspects and potential influencing factors. It effectively addresses inferential challenges related to accurate and consistent maximum likelihood estimates (ML) and determining the minimum sample size needed for unbiased parameter estimates (Iannario, 2012b; Iannario, Monti, Piccolo, & Ronchetti, 2017). CUB models perform similarly to supervised learning methods in predicting responses using explanatory variables, while also achieving a form of unsupervised learning by leveraging inherent model components using data (Piccolo & Simone, 2019a). Furthermore, to facilitate effective applications of CUB models and their variants, exploiting their capabilities from both computational and graphical perspectives, the R packages `CUB` (Iannario, Piccolo, & Simone, 2024) and `FastCUB` (Simone, 2024) have been developed to support the estimation, implementation, and variable selection of these models, with `FastCUB` specifically designed for identifying the optimal subset of covariates for both the feeling and uncertainty parameters.

In the following sections, we consider the CUB specification that models the two latent components, allowing for the dependence between ratings and potential drivers, termed CUB(p,q), and the simplest case without covariate effects, termed CUB(0,0). The most straightforward way to account for the combined effects of feeling and uncertainty in the rating process is to use a finite mixture that balances these two components. In the

CUB framework, a shifted Binomial random variable and a discrete Uniform random variable are used to model feeling and uncertainty, respectively (Piccolo, 2003). In this model, the ordinal response of the i-th respondent represents the realization of a discrete random variable ($R_i, \quad i = 1, 2, \ldots, n$) and can assume one of a fixed number of ordinal categories or the ratings ($r = 1, 2, \ldots, m$). In the CUB(p,q) framework, R_i can be modelled conditionally to the influence of p and q covariates on uncertainty and feeling, respectively, as follows:

$$Pr(R_i = r|\boldsymbol{\theta}; y_i; w_i) = \pi_i \binom{m-1}{r-1} \xi_i^{m-r} (1-\xi_i)^{r-1} + (1-\pi_i)\frac{1}{m} \tag{1}$$

where $\boldsymbol{\theta} = (\pi_1, \ldots, \pi_n, \xi_1, \ldots, \xi_n)$, $y_i = (1, y_{i1}, \ldots, y_{ip})'$ and $w_i = (1, w_{i1}, \ldots, w_{iq})'$ are the vectors of p and q covariates related to the measure of uncertainty $(1 - \pi_i)$ and the preference towards the item $(1 - \xi_i)$ of the i-th respondent. For this model, a larger value of ξ_i implies a greater concentration of responses toward the lower end of the scale. Therefore, when the scale assigns higher values to a positive evaluation, lower ξ_i suggests a more favorable inclination in the i-th observation regarding the topic at hand. For instance, when respondents are asked to rate their agreement with a particular statement, ξ_i can be understood as a measure of agreement or, if assessing a service or product, as an indicator of satisfaction. Following this interpretation, ξ_i is referred to as the "feeling" parameter. We also observe in Equation1 that $(1 - \pi_i)/m$ is the constant proportion of probability uniformly spread over the support, and we can define this quantity as "uncertainty" share. Thus, the parameter π is inversely related to the uncertainty.

In Equation 1, the two systematic components can be specified as:

$$\begin{cases} \text{logit}(1-\pi_i) = log(\frac{1-\pi_i}{\pi_i}) = -y_i\beta \\ \text{logit}(1-\xi_i) = log(\frac{1-\xi_i}{\xi_i}) = -w_i\gamma \end{cases} \quad \Longrightarrow \quad \begin{cases} 1-\pi_i = \frac{e^{-y_i\beta}}{1+e^{-y_i\beta}} \\ 1-\xi_i = \frac{e^{-w_i\gamma}}{1+e^{-w_i\gamma}} \end{cases} \tag{2}$$

Regression vector parameters β and γ are associated with the uncertainty and the feeling, thus the respective signs of the elements of these vectors correspond to the direction of the effects for the relative covariates. To synthetize the n responses given to a certain item in terms of uncertainty and feeling, we define two average measures (i.e., arithmetic, geometric mean) of subjects-related model parameters in Equation 1 as

$$\pi = average(\pi_i) \qquad \text{and} \qquad \xi = average(\xi_i) \tag{3}$$

The latter definition allows to specify the baseline CUB(0,0) model without covariates, given by

$$Pr(R = r|\boldsymbol{\theta}) = \pi \binom{m-1}{r-1} \xi^{m-r} (1-\xi)^{r-1} + (1-\pi)\frac{1}{m} \tag{4}$$

Models in Equations 1 and 4 are well defined since $\pi_i \in (0, 1]$ and $\xi_i \in [0, 1]$ and the full identifiability is achieved for any $m > 3$. Moreover, with $\pi_i \to 0$ ($\pi_i \to 1$), the random variable R_i converges to a discrete Uniform (shifted Binomial) distribution,

suggesting a completely random (thoughtful) choice. In the case of $\xi_i < 0.5$ (> 0.5), the probability distribution of R_i shows a negative (positive) skewness, with respect to the midpoint $(m+1)/2$, suggesting that respondents' ratings are chosen from the end (beginning) of the rating scale (Iannario, 2012a). The CUB random variable converges to the Normal distribution with increasing m and with $\xi_i \to 1/2$, however the kurtosis tends toward 3 only at $m > 10$ (Piccolo & Simone, 2019a).

The estimation of CUB models is based on maximum likelihood (ML) which ensures asymptotically efficient estimates. For models in Equations 1 and 4, optimization of the likelihood is achieved using the EM (Expectation-Maximization) algorithm as exploited by D'Elia and Piccolo (2005) and implemented by Piccolo (2006). The goodness of fit of the estimated model can be assessed by comparing the observed frequencies (f_r) and the expected probabilities, $\hat{P}_r = P_r(\hat{\pi}, \hat{\xi}) = P_r(R = r|\boldsymbol{\theta} = \hat{\boldsymbol{\theta}})$ (D'Elia & Piccolo, 2005). Thus, a normalized dissimilarity index, *Diss*, is given by

$$Diss = \frac{1}{2}\sum_{r=1}^{m} |f_r - \hat{P}_r| \qquad \in [0,1] \tag{5}$$

With $Diss < 0.1$, the estimated CUB model is considered compatible with a good fitting (Iannario, 2009). The estimated measure of uncertainty $(1-\hat{\pi})$ and the preference towards the item $(1-\hat{\xi})$ associated to the feeling could be usefully represented in the parameter space (given by a unit square): on the vertical axis, values of $(1-\hat{\xi})$ close to 1 indicate a high degree of agreement/liking with respect to the analysed item; on the horizontal axis, values of $(1-\hat{\pi})$ close to 1 indicate a propensity for respondents to make a random choice.

Finally, to assess the contribution of each covariate in the model outlined in Equation 1, a comparison between individual covariate models and the baseline CUB(0,0) can be implemented to identify which factors have the most relevant impact on the outcome variable. To this end, a measure of the Explanatory Power of covariate (*EPcov*) can be obtained as follows:

$$EPcov = \frac{(loglik_{cov} - loglik_{00})}{(loglik_{sat} - loglik_{00})} \tag{6}$$

where $loglik_{cov}$ is the log-likelihood of the CUB model which includes the i-th covariate, $loglik_{00}$ is the log-likelihood of the CUB(0,0) model and $loglik_{sat}$ is log-likelihood of the CUB(p,q) model.

4 Results

4.1 Sociodemographic characteristics of respondents

After considering all complete responses, we obtained a final convenient sample of 1,006 respondents. Our typical respondent is a high school student, aged between 14 and 19 years, with a slightly higher proportion of females compared to the male group. The sociodemographic profile of the respondents indicates a family background with low

educational levels of both parents, although a non-negligible percentage of respondents have parents with bachelor's or master's degrees (Table 2).

Table 2: Sociodemographic characteristics of respondents.

Variable		N	%
Gender	Female	553	55.0
	Male	448	44.5
	Other	5	0.5
Age (classes)	14-16 years	566	56.26
	17-19 years	440	43.74
Father's highest educational level	Primary school	479	47.61
	Middle school	127	12.62
	High school	39	3.88
	Bachelor's and master's degrees	361	35.88
Mother's highest educational level	Primary school	457	45.43
	Middle school	171	17.00
	High school	28	2.78
	Bachelor's and master's degrees	350	34.79
Father's profession	Businessman	171	17
	Homemaker	7	1
	Independent contractor	138	14
	Private sector employee	320	32
	Public sector employee	312	31
	Retired	21	2
	Unemployed	37	4
Mother's profession	Businesswomen	66	7
	Housewife	381	38
	Independent contractor	80	8
	Private sector employee	190	19
	Public sector employee	253	25
	Retired	3	0
	Unemployed	33	3
Participation in education training courses (PCTO/ PLS)	Yes	438	43.54
	No	568	56.4

Parents' occupational status reflects the historical differences between roles within the Italian family, with fathers being mainly responsible for income and economic support and mothers being the main caregivers of children and homemakers, with less importance given to career development (Bombi et al., 2011). Finally, the results show that the majority of students surveyed (56.46%) have not participated in professional training activities supported by the Ministry of Education (namely PCTO) and/or university

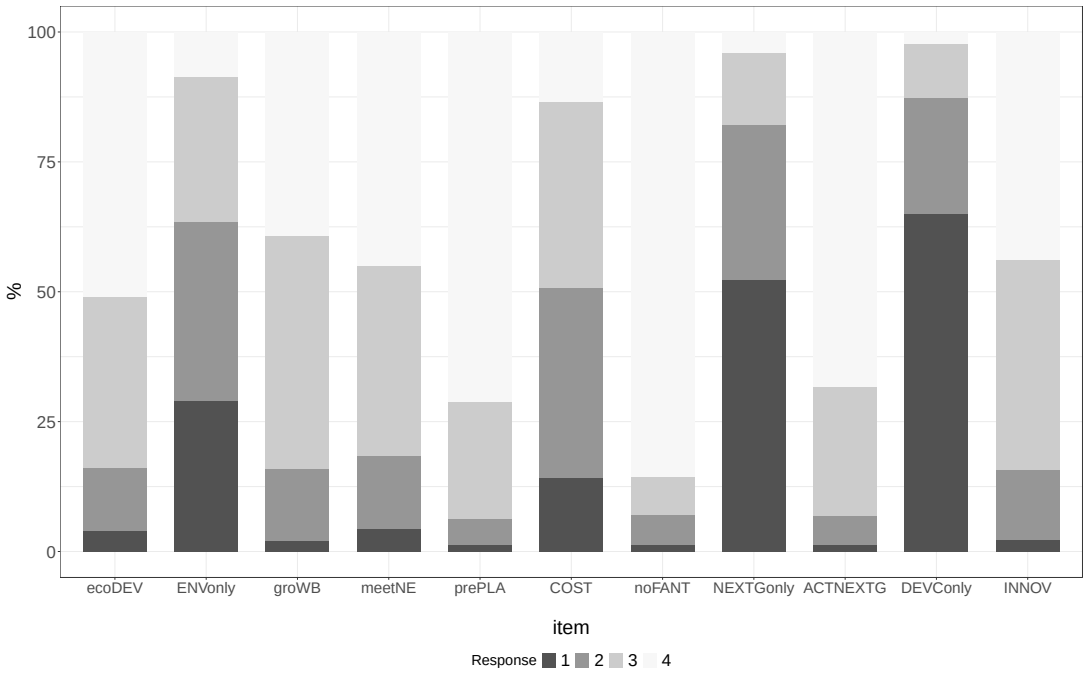

Figure 1: Frequency distributions of ratings for 11 relevant items regarding students' actual perceptions of sustainability based on a 4-point Likert scale (1= "strongly disagree"; 4= "strongly agree"). The acronyms correspond to the list of items in Table 1.

career guidance initiatives for scientific courses (PLS) (MUR, 2021).

The frequency distributions of the relevant items of the questionnaire concerning students' actual perception of sustainability are shown in Figure 1. The distribution of the ratings for the 11 items showing a tendency to think positively and an attitude oriented toward sustainability is skewed toward high values considering a 4-point Likert scale (agree/disagree). This is evident, for instance, when students were asked their opinion on the importance of sustainable development for the preservation of the planet and the progress of society. For the respondents, sustainable development is a concrete goal ("it is not a fantasy"), a process that strives to meet the needs of current and future generations, taking into account economic, social and environmental factors.

4.2 Main findings from the ratings analysis

In order to investigate the students' actual perceptions of sustainability, the CUB(0,0) models in Equation 4 were fitted considering all 11 relevant items in Table 1. Additionally, the CUB(p, q) models in Equations 1 - 2 were fitted specifying the same items as dependent on respondents' characteristics. We evaluated the effects of the covariates type of school, gender, age and participation to training courses on the ratings. The CUB models were implemented using the `CUB` package, developed specifically for the R language by Iannario et al. (2024) (R Core Team, 2023).

4.2.1 Results from estimated Baseline model

The estimates of feeling and uncertainty for the CUB(0,0) model, along with the associated standard errors and p-values, are shown in Table 3.

Dissimilarity indices were also computed for each statement examined, which yielded very low values, suggesting an excellent fit of the estimated models to the data. To better understand the results presented in Table 3, Figure 2 graphically shows the relationships between feeling and uncertainty for all statements, displaying the feeling and uncertainty levels across different sustainability-related items. The shapes in this figure were chosen to represent the possible combinations of the estimated values for both feeling and uncertainty for all the items considered. Thus, stars identify the items associated with high estimates of feeling and low estimates of uncertainty; solid triangles correspond to items with high estimates of feeling and moderate estimates of uncertainty; the plus sign indicates moderate estimates of both feeling and uncertainty; crosses stand for low estimates of feeling and high estimates of uncertainty; and finally, the dot represents an item characterized by low estimates of feeling and high estimates of uncertainty.

The level of agreement of the 11 items appears quite differentiated: it is very high for the 7 items in the upper part of the graph, ranging from 0.7 to almost 1, and gradually decreases for the remaining 4 items on the right (see Figure 1). In particular, the first group contains statements that refer to decidedly positive characteristics of sustainability such as creating growing well-being, innovation, preserving the planet for the benefit of current and future generations, and ensuring economic development. Overall, sustainability is believed to bring tangible benefits to people, and students

Table 3: Students' perceptions of sustainability: CUB(0,0) estimates and dissimilarity indices. Standard errors are in parentheses; * indicates p-values < 0.05. The acronyms correspond to the list of items in Table 1

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	$(1-\hat{\pi})$	$(1-\hat{\xi})$	*Diss*
ecoDEV	0.155*	0.818*	0.022
	(0.028)	(0.010)	
ENVonly	0.262*	0.353*	0.060
	(0.050)	(0.014)	
groWB	0.010*	0.740*	0.025
	(0.021)	(0.009)	
meetNE	0.152*	0.783*	0.012
	(0.029)	(0.011)	
prePLA	0.065*	0.900*	0.014
	(0.016)	(0.007)	
COST	0.108*	0.494*	0.001
	(0.056)	(0.011)	
noFANT	0.135*	0.983*	0.023
	(0.016)	(0.004)	
NEXTGonly	0.181*	0.175*	0.050
	(0.031)	(0.011)	
ACTNEXTG	0.061*	0.890*	0.015
	(0.016)	(0.007)	
DEVConly	0.161*	0.109*	0.054
	(0.027)	(0.010)	
INNOV	0.042*	0.763*	0.003
	(0.022)	(0.009)	

mostly agree with the statement "It is not a fantasy". At the same time, the uncertainty related to these items, measured by the quantity $(1 - \hat{\pi})$, is extremely low, confirming the respondents' clear vision of sustainability. The second group is composed of only one item, related to the statement "It involves costs" which can be considered to lead respondents to different interpretations, in fact, uncertainty grows slightly.

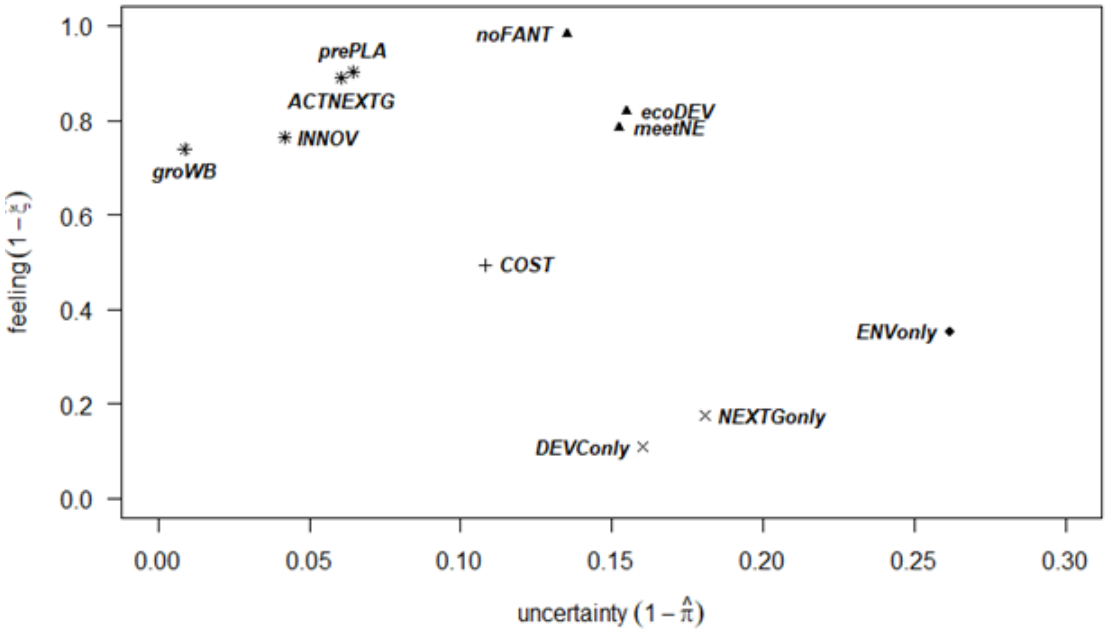

Figure 2: Visualization of the parameter space of the estimated CUB (0,0) distributions for the relevant items on students' perceptions of sustainability. Shapes represent the combination of values associated with the estimates of feeling and uncertainty for all items: '$*$' stands for high estimates of feeling and low estimates of uncertainty; '▲' corresponds to high estimates of feeling and moderate estimates of uncertainty; '$+$' indicates moderate estimates of both feeling and uncertainty; '$\times$' stand for low estimates of feeling and moderate estimates of uncertainty; and finally, '•' represents low estimates of feeling and high estimates of uncertainty. The acronyms correspond to the list of items in Table 1.

On the right side of Figure 2, the third group consists of 3 items with a very low feeling, not exceeding 0.3, and higher uncertainty than the previous two groups. These items concern statements that limit the impact of sustainability only to environmental issues or to future generations or, even worse, only to developed countries. Figure 3 gives evidence of the high goodness of fit of the estimated CUB(0,0) distributions. The graphical inspection suggests that the observed and predicted relative frequencies for the ratings of all sustainability-related items closely overlap, indicating a very good fit between the expected and actual data.

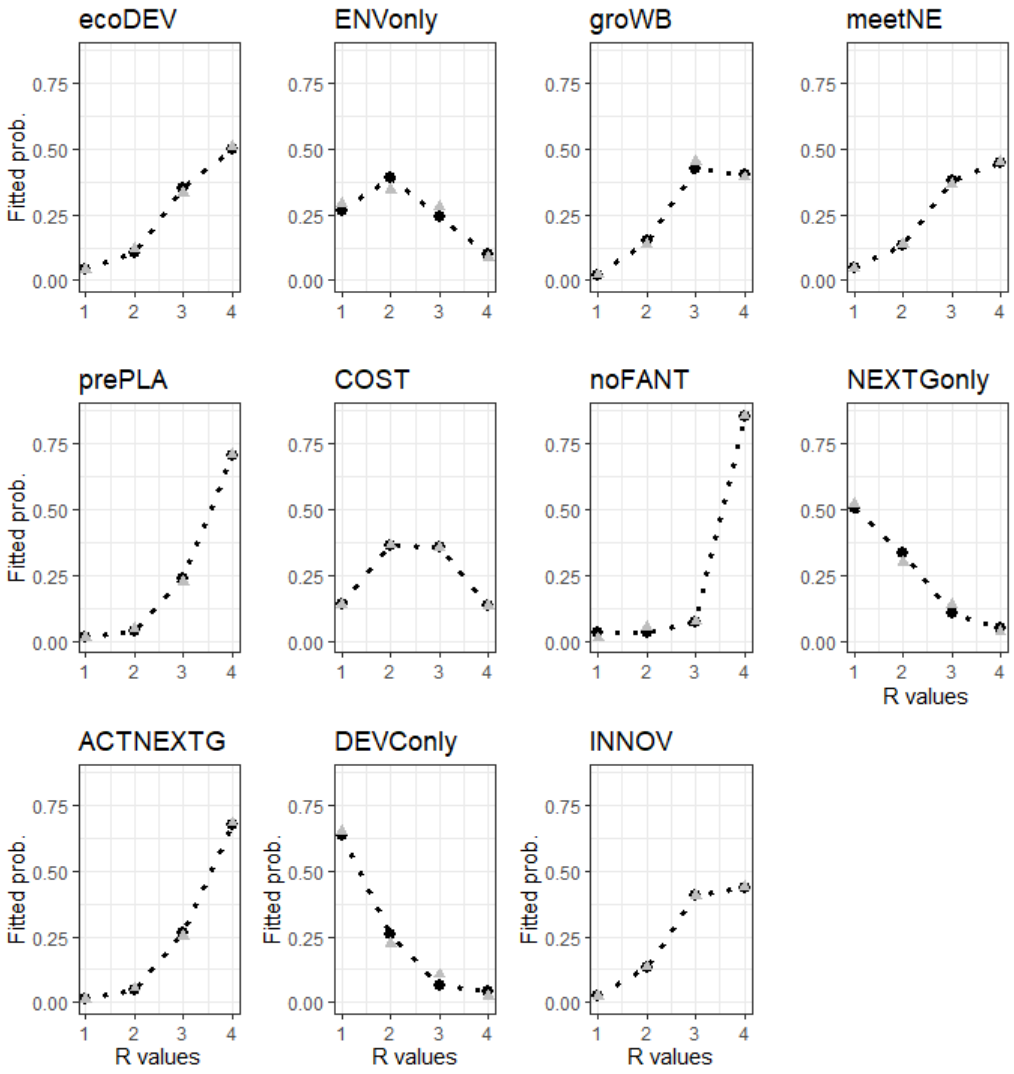

Figure 3: Observed and predicted relative frequencies plots for the ratings of all sustainability-related items.
Estimated CUB(0,0) distributions (black dots) and observed frequencies distributions (grey triangles). The acronyms correspond to the list of items in Table 1.

4.2.2 Results from estimated Covariates model

To analyse the influence of covariates on the 11 items, logistic functions were used, as described in Section 3.2. For the sake of simplicity, we considered the following set of dichotomous covariates for the analysis: school (0= other schools; 1=if he/she is a gymnasium student), gender (0=if she is female; 1=if he is male), age (0= if he/she is

14-16 years old; 1= if he/she is 17-19 years old) and course (0= if he/she does not take any educational training courses; 1= if he/she takes educational training courses such as PCTO or PLS). To investigate whether and how students' perceptions of sustainability are influenced by personal characteristics, CUB(4,4) models were estimated for all ordinal response variables related to sustainability as a function of these characteristics. The estimates of the model parameters are reported in Table 4. The results suggest significant effects of the covariates gender and age on certain items of the feeling component. Men are less inclined than women to perceive sustainability as a process that only affects the environment (ENVonly), that sometimes involves costs (COST), and that also only affects the next generation (NEXTGonly). In addition, the effect of age is negatively associated with the cost of achieving a sustainable future in older students compared to younger students. In terms of uncertainty, a negative significant effect is found for the covariate associated with taking a course such as PCTO. This suggests that trained students tend to have more consistent responses regarding sustainability's role in economic development, suggesting that training provides clarity and reduces uncertainty in their perceptions. The same consideration may be expressed with respect to the significant effect of age on the item about defining the sustainability as a concrete process (noFANT). Therefore, older students tend to express less uncertainty in their belief that sustainability is not a mere fantasy but a real, pressing issue. Uncertainty instead is almost 0.35 higher for males than females with the item that restricts sustainability to rich countries (DEVConly).

Regarding the explanatory power of the covariates, Table 5 presents the $EPcov$ values derived from Equation 6, based on comparisons between estimated individual models and the baseline CUB(0,0). Results reveal the different explanatory power of the respondents' personal characteristics in shaping their sustainability-related ratings. Gender consistently emerges as the most influential factor, with the highest explanatory power across most items, except for the noFANT and INNOV items. This suggests that gender plays a significant role in determining how respondents rate sustainability topics, possibly reflecting different perspectives or experiences between genders. School and age follow in influence, but their impact varies by item. The findings highlight that while personal characteristics like gender can significantly affect sustainability-related evaluations, other factors, such as school and age, may have a more nuanced or less consistent effect on the ratings. These insights can help tailor future surveys or interventions to better understand and address the diverse viewpoints present among different demographic groups.

Table 4: Effects of covariates on students' perceptions of sustainability. CUB(4,4) estimated parameters. Standard errors are in parentheses; * indicates p-values < 0.05. The acronyms correspond to the list of items in Table 1

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	Feeling $(1-\hat{\xi})$					Uncertainty $(1-\hat{\pi})$				
	$\hat{\gamma}_0$	$\hat{\gamma}_{gymn}$	$\hat{\gamma}_m$	$\hat{\gamma}_{17-19}$	$\hat{\gamma}_{pcto}$	$\hat{\beta}_0$	$\hat{\beta}_{gymn}$	$\hat{\beta}_m$	$\hat{\beta}_{17-19}$	$\hat{\beta}_{pcto}$
ecoDEV	-1.614*	0.07	0.579*	-0.174	-0.059	2.416*	-0.063	-0.254	0.227	-1.042*
	(0.157)	(0.147)	(0.145)	(0.144)	(0.148)	(0.588)	(0.506)	(0.509)	(0.479)	(0.515)
ENVonly	0.874*	0.068	-0.719*	0.055	-0.043	0.547	0.908	0.659	0.589	-0.332
	(0.142)	(0.123)	(0.122)	(0.116)	(0.120)	(0.553)	(0.610)	(0.713)	(0.628)	(0.606)
groWB	-0.941*	-0.111	0.200*	-0.154	-0.203*	22.434	3.161	0.559	-10.148	-10.148
	(0.103)	(0.097)	(0.097)	(0.095)	(0.095)	(195.744)	(5.745)	(1.510)	(153.312)	(121.708)
meetNE	-1.195*	-0.225	0.319*	-0.163	-0.081	2.886*	-0.473	-0.663	-0.647	-0.361
	(0.133)	(0.129)	(0.128)	(0.130)	(0.128)	(0.652)	(0.502)	(0.481)	(0.485)	(0.472)
prePLA	-2.352*	-0.234	0.228	0.21	0.046	2.990*	-0.304	-0.232	-0.103	-0.013
	(0.627)	(0.555)	(0.540)	(0.545)	(0.540)	(0.627)	(0.555)	(0.540)	(0.540)	(0.545)
COST	0.208	0.095	-0.365*	-0.291*	0.132	4.439	-1.59	-2.382	1.3	-0.892
	(0.105)	(0.102)	(0.102)	(0.095)	(0.101)	(3.196)	(1.857)	(1.758)	(1.232)	(1.705)
noFANT	-4.291*	-0.012	0.446	0.444	-0.409	2.894*	-0.154	-0.729	-0.810*	-0.368
	(0.501)	(0.486)	(0.489)	(0.496)	(0.544)	(0.372)	(0.305)	(0.306)	(0.302)	(0.302)
NEXTGonly	1.814*	0.137	-0.832*	0.16	-0.07	2.316*	-0.372	-0.554	-0.409	-0.008
	(0.176)	(0.160)	(0.160)	(0.158)	(0.151)	(0.548)	(0.468)	(0.478)	(0.462)	(0.457)
ACTNEXTG	-2.344*	-0.064	0.291	0.222	0.043	2.284*	0.056	0.159	1.073	-0.332
	(0.199)	(0.165)	(0.165)	(0.161)	(0.158)	(0.614)	(0.572)	(0.570)	(0.636)	(0.541)
DEVConly	2.357*	-0.111	-0.303	-0.062	-0.155	2.380*	0.312	-1.358*	-0.425	0.415
	(0.234)	(0.221)	(0.232)	(0.217)	(0.215)	(0.538)	(0.498)	(0.514)	(0.459)	(0.475)
INNOV	-1.272*	-0.095	0.116	0.036	0.138	1.468	0.438	0.383	8.335	11.313
	(0.130)	(0.107)	(0.105)	(0.100)	(0.101)	(0.813)	(0.849)	(0.881)	(38.679)	(136.526)

Table 5: The Explanatory Power of covariates (*EPcov*) obtained by comparing the estimated individual models for each sustainability-related item with the baseline CUB(0,0), accounting for the respondents' personal characteristics. The acronyms correspond to the list of items in Table 1

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Items	*EP*			
	school	gender	age	course
ecoDEV	0.372	0.842	0.263	0.320
ENVonly	0.443	0.919	0.193	0.220
groWB	0.476	0.573	0.473	0.449
meetNE	0.510	0.818	0.315	0.273
prePLA	0.707	0.705	0.593	0.500
COST	0.439	0.728	0.478	0.275
noFANT	0.110	0.394	0.558	0.236
NEXTGonly	0.306	0.972	0.159	0.148
ACTNEXTG	0.521	0.699	0.602	0.428
DEVConly	0.396	0.922	0.293	0.271
INNOV	0.518	0.495	0.493	0.496

5 Discussion and final remarks

Summary of Findings. In order to achieve the goal of this study, which stems from the research questions posed in Section 1, our results show that overall awareness of the actual perceptions of sustainability among surveyed adolescents is well developed, which is in line with recent research (Adamczyk & Adamczyk-Kowalczuk, 2022). These findings suggest that participants in our survey have a clear and shared knowledge of the positive achievements of sustainability for the planet and its inhabitants, current people, and future generations. Thus, our first hypothesis RQ1 (the concept of sustainability is well known) is confirmed. According to the recent specific literature focused on young people (Adamczyk & Adamczyk-Kowalczuk, 2022), still rare but showing a strong growing tendency in recent years, they care more about global than local threats and about future threats than present ones, as important decisions about their professional and social life are related to the future. The younger generation's awareness of the importance of sustainability as a priority bodes well for the future, as today's young citizens are more likely to be future politicians, decision makers, and managers in private and public organizations. Undoubtedly, some respondents believe that sustainability has real costs when considering, for example, activities related to recycling or proper disposal of pol-

luting materials, but these costs can be better considered as investments in a sustainable future. Depending on the two possible interpretations, the values of feeling (Figure 2) express that respondents are divided in their opinion on this statement. The perception of sustainability as a cost factor significantly influences attitudes and behaviors toward sustainable practices, often due to the immediate costs of adopting eco-friendly technologies like energy-efficient appliances or electric vehicles, and higher prices of green products. This perception is also linked to a lack of awareness of the long-term economic benefits of sustainability, such as reduced energy costs, improved resource efficiency, and mitigation of climate risks. In addition, socio-economic factors and experience with sustainability education significantly influence people's perception of costs (Hoque et al., 2022). Moreover, our questionnaire aimed to measure the potential uncertainties in the evaluations, then the same statements were introduced, expressing both a negative and a positive connotation of sustainability. They could be considered quite provocative, because the intentional introduction of the adverb "only" in some items (such as ENVonly, NEXTGonly and DEVConly in Table 1) made the limitation associated with its meaning perceived in a contrasting way. In fact, in relation to these points, the respondents showed the higher disagreement and some uncertainty more likely due to the contradictory statements. In particular, the statements related to creating growing well-being, innovation and protecting the planet (growWB, INNOV and prePLA, respectively), showed lower levels of uncertainty and higher levels of feeling. When examining the role of factors affecting the two latent components in students' judgments, we found a significant influence of age, gender and specific educational pathways (RQ2). While research on young people's perceptions of sustainability has progressed in recent years, in the specialized literature there is still a lack of comprehensive assessment of the influence of gender on these perceptions. Olsson and Gericke (2017) investigated the potential existence of a gender gap in environmental education by examining the difference between men's and women's sustainability awareness. They quantified the possible gender effect of a teaching approach focused on Education for Sustainable Development (ESD) by conducting a survey among 2,413 Swedish students aged 12–19. The findings of this study indicated t a gender gap in students' awareness of sustainability that increases across the age range. Conversely, Parente, Kesharwani, and Reitz (2021) conducted a survey of Generation Z students to assess their perceptions of social norms and their personal commitment to various environmentally conscious behaviors. They analyzed the discrepancy between the perception of others' sustainable actions and individuals' own engagement in these activities, concluding that gender was not a significant factor. Our findings showed that gender was the most relevant factor in shaping respondents' sustainability-related ratings (Table 5). Older male students seemed to have a more concrete idea of the importance of sustainable development both in the present and in the future. Together with the age and gender factors, the participation to educational programs has different impacts on the feeling and uncertainty components, as discussed in the next subsection.

Implications for Education. Educational programs play a pivotal role in transforming perceptions of sustainability by offering a thorough understanding of its economic,

social, and environmental dimensions. Incorporating cost-benefit analysis into the curriculum helps emphasize the long-term advantages and societal value of environmentally conscious decisions. By addressing these interconnected aspects, such initiatives foster critical thinking and informed decision-making regarding sustainable practices. Real-world examples of successful sustainable initiatives can dispel the myth that sustainability is overly expensive. These educational efforts should develop critical thinking and a systems perspective in students, enabling them to see sustainability as an innovative and collective growth opportunity rather than a burden (Aleixo et al., 2021). By addressing cost misconceptions, educational programs can foster informed, positive attitudes and encourage sustainable practices that benefit individuals and society. In our analysis, the importance of training on education for sustainability is confirmed by the significant effect of the covariate regarding participation in training courses on the relationship between economic development and sustainable processes (RQ3). The negative effect of this covariate for the groWB item ($\hat{\gamma}_{pcto} = -0.203$), indeed highlights that young people who engage in educational programs tend to have heightened sensitivity and a more critical outlook on sustainability. This is further supported by the role of training in reducing uncertainty ($\hat{\beta}_{pcto} = -1.042$ for the ecoDev item), emphasizing the importance of targeted sustainability education. Such programs not only enhance participants' confidence and their ability to critically analyze sustainability issues, but they also reduce ambiguity and promote informed decision-making. Participants often perceive sustainability not merely as a process of development but as one deeply tied to continuous and equitable well-being. However, this perspective also underscores a critical tension: development and sustainability do not always align (Eisenmenger et al., 2020). While sustainable actions are often framed as balancing social, economic, and environmental objectives, these dimensions are frequently unevenly prioritized in practice, particularly in global policies that place disproportionate emphasis on economic metrics such as GDP (Hariram, Mekha, Suganthan, & Sudhakar, 2023). To help young people understand these complexities, several initiatives and workshops have been proposed globally. For instance, the "International Workshop on Environment, Sustainability, & Education" promoted by Columbia University (USA), included a series of meetings where participants from around the world had the opportunity to share their research, discuss ongoing work, and network with others interested in the intersection of environment, sustainability, and education (Teachers College, Columbia University, 2024). Undoubtedly, educators can play a crucial role in influencing young people's perceptions as they advance, support, and enrich their social and cultural backgrounds. Teachers can guide students in developing and executing projects that address environmental, social, and economic challenges related to sustainability. By incorporating hands-on activities, such as designing eco-friendly products, organizing community clean-ups, or exploring renewable energy solutions, educators can facilitate meaningful learning experiences that encourage critical thinking, creativity, and the ability to analyze complex sustainability challenges (Singha & Singha, 2024).

Limitations and Recommendations. This study offers an exploratory approach to understand the perceptions of sustainability among young people. The use of a con-

venience sample limits generalizability as it focused on exploring the phenomenon at a local level rather than extending the findings to a wider population. However, the large number of responses collected, along with the socio-demographic homogeneity compared to Italian peers, provide valuable insights into the specific context of sustainability perceptions. Specifically, this study underscores the importance of patterns for educating future citizens who are aware of the values of sustainability and behave in an environmentally conscious manner. This begins in school and can be reinforced in University programs to continue into adulthood (Schubert, Kroll, & Chavez, 2023). The education system may be able to change individuals' attitudes not only about environmental concerns, but also about their responsibilities as members of a community. This endeavor is shared by the main goals of the SDGs in the UN Agenda. Their implementation can also be supported by planning specific educational programs at ES, which are included in the curricula for high school students and delivered by qualified teachers. Education should provide younger generations with management skills and cooperative methods to develop decision-making skills for evaluating sustainability in all areas and also project government and economic activities that include opportunities for individual action by young people (Ziesemer, Hüttel, & Balderjahn, 2021). Schools and universities have the opportunity to influence the formation of civic awareness and critical thinking about the implementation of sustainability, thus contributing to the spread of sustainable behaviors. Educational initiatives on these topics, introduced as specific subjects such as environmental education and sustainable development, allow students to become aware of their role in the future society as active citizens. In fact, joint research projects on these topics can stimulate the modernization of Italian schools, where students could experience more focused teaching. High schools and their students, participating in PLS project, have the opportunity to share the experience of developing knowledge together with universities, that is useful for dealing effectively with sustainable development issues.

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