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Environmental, Social and Economic Attitudes and Sustainable Knowledge on the Sustainable Behaviour of Engineering Students: An Analysis Based on Attitudes towards Teachers

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Abstract: Education for Sustainable Development (ESD) is crucial in higher education, providing students with the knowledge, skills, and values necessary for a sustainable future. ESD seeks a holistic understanding of sustainability and promotes critical thinking and innovative approaches. Specifically, ESD is very important to address in engineering careers, as engineers will need to establish sustainable solutions in the future. For this reason, the integration of sustainability into university curricula has been studied for some time. In this way, this research analyses the perceptions (attitudes towards teachers; knowledge about sustainable development; environmental, economic, and social attitudes; sustainable behaviours) that engineering students in the Dominican Republic have towards sustainable development. A number of 626 questionnaires completed by engineering students were obtained. Subsequently, the data were analysed in SPSS and PLS-SEM. The results showed that attitudes towards teachers have an impact on engineering students' knowledge of sustainable development. In turn, the results also showed that knowledge about sustainable development influences both attitudes (economic, social, and environmental) and sustainable behaviours of engineering students. Contrary to other research, this study suggested that economic attitudes are not identified as an antecedent of sustainable behaviours among engineering students. From these results, implications and future lines of research are generated.

Keywords: sustainable knowledge; attitudes; sustainable behaviour; attitudes towards teachers; university

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1. Introduction

When presenting the relationship between education and sustainability, two concepts are discussed. On the one hand, the concept of sustainable education, which refers to the acquired knowledge that guarantees a balanced development, including socioeconomic development and human perspectives [1]. Another concept is sustainability in education, which refers to educational programs that can help protect the environment and conserve natural resources [1]. Therefore, higher education institutions are supposed to play a crucial role for sustainable development by ensuring both sustainable education and sustainability in education [1] and for this reason, Education for Sustainable Development (ESD) is of great importance in higher education, as it plays a crucial role in the transformation of societies, in the effective promotion of sustainability policies and in the achievement of the SDGs. ESD provides students with the necessary knowledge and skills to act sustainably [2]. Currently, social inequalities, economic problems, or environmental degradation have contributed to the integration of ESD in higher education [3]. In this context, ESD seeks to strengthen knowledge of sustainability from a global perspective, covering the main dimensions of sustainable development: economy, society, and environment [4]. In addition, ESD encourages students to think critically and solve global problems or challenges [5]. Therefore, including ESD in university curricula is vital for future professionals to make decisions based on sustainability [6]. However, the integration of ESD in higher education requires reviewing both existing practices and literature in relation to ESD [7].

In particular, ESD is of utmost importance for engineering students. With the increasing emphasis on sustainability, engineers are expected to contribute to sustainable designs, solutions, and project implementation [8]. Therefore, university education plays a crucial role in shaping engineering students' attitudes and beliefs towards sustainability, preparing them for their future career [8]. It is essential that engineering graduates not only possess knowledge about sustainable development, but also conviction towards it [8]. In this regard, the integration of sustainability knowledge and skills into engineering curricula has been a topic of discussion for several decades [9], but there is still a need for strategic and systemic integration [10]. Thus, it is vital to integrate both the principles of sustainability [11,12] and the Sustainable Development Goals (SDGs) [13] throughout the engineering curriculum.

The role of the engineer is vital to meet the challenges of sustainable development [14,15] and, for this reason, it is essential to include sustainability and the SDGs in engineering curricula [11,12]. The relevance of university education in sustainability and SDGs in developing countries is greater, because the engineer must understand the interconnectedness of the country's social, economic, and environmental problems, as well as adopting measures to achieve sustainable development and the achievement of the SDGs [16,17]. Therefore, understanding engineering students' perceptions on various topics, such as their attitudes towards teachers, their knowledge of sustainable development, their environmental, economic, and social attitudes, as well as their sustainable behaviours, is of utmost importance to strengthen curricula [18]. An engineering graduate is confronted with pressing issues such as climate change, resource depletion, and social inequality and, for this reason, they need to have a deep understanding of the principles of sustainable development and be able to make informed decisions that contribute to positive change [19].

In this context, the objective of this research is to analyse the attitudes of engineering students in the Dominican Republic towards sustainable development. For this, the relationship between the variables attitudes towards teachers will be analysed; knowledge about sustainable development; environmental, economic, and social attitudes; and sustainable behaviour. This research covers the need to analyse these variables in specific countries so as not to generalize the results [20]. The proposed objective is related both to the concept of sustainability in education and to that of sustainable education. Firstly, it is related to the concept of sustainability in education because the research focuses on analysing the perceptions of engineering students in the Dominican Republic towards sustainable development and, in this case, it analyses how educational programs and institutions can be aligned with the principles of environmental protection, cautious use of natural resources, and promotion of sustainable behaviours. Therefore, research on students' attitudes, knowledge, and behaviours in relation to sustainable development demonstrates a direct concern for how education can contribute to promoting sustainable practices and environmental awareness. On the other hand, this research is also aligned with the concept of sustainable education, since the analysis of the perceptions of engineering students towards sustainable development has the purpose of providing knowledge that ensures a balanced national development, covering economic, social, and social perspectives and human needs. In this way, it is investigating how education can contribute to holistic development and align with the principles of sustainable education. Thus, the importance of analysing the perceptions of engineering students in developing countries is closely linked to the need to train engineers capable of making sustainable decisions in countries with limited resources. It also highlights that the model proposed is more complex than those analysed to date in the scientific literature, starting from the analysis of students' attitudes towards their teachers, which is key to motivating students to develop sustainable knowledge and behaviour. This paper is structured, after this introduction, with a second section where the theoretical framework is presented; then the materials and methods, the results, the discussion, and, finally, the conclusions are shown.

2. Theoretical Framework

2.1. Education, Development, and Higher Education

Global development has gone through agricultural, armament, and industrialization paradigms. The fourth industrial revolution focuses on technology, encompassing digitization and artificial intelligence [21]. Technologically advanced leading nations not only earn currency but also regulate global development, surpassing previous eras. This requires educational preparation for the skill changes of the revolution [21]. Developing country governments and "development partners" view education as an "international product" that enables the advancement of society and the economy [21]. Paradigms of development and the evolution of education share intertwined paths. Initially, education was aimed at optimizing resources, which led to the development of agricultural and engineering-technology universities [21]. Thus, education in developing nations is always slow to respond to changing contemporary concepts. However, since the mid-1990s, formal education budgets in the developing world have increased by 43%, while informal and private sector budgets have risen ridiculously [22]. Currently, universities are undergoing necessary changes to face "technologization" and take advantage of other institutions and countries [21]. In this context, higher education institutions play a crucial role for sustainable development by ensuring both sustainable education and sustainability in education [23]. In other words, higher education has the mission of promoting complete national development through research and teaching, training people to acquire moral values and skills that allow them to develop a better society that is sustainable both in economic and social terms [23]. Thus, higher education institutions have contributed to the promotion of sustainability, integrating it into the governance, education, research, and operations practices of the institution. Likewise, sustainability has been included in the study plans, which is relevant, first, to foster students' understanding of sustainable development [22] and second, to achieve the SDGs of the UN [23]. In this sense, ESD has a positive impact on students [24] and is considered key to understanding and achieving the SDGs [23]. Therefore, the participation to ESD interventions may generate immediate and long-term positive effects on the student pro-environmental attitudes and behaviours [24].

According to [7], engineering curricula that integrate sustainable development content are key to fostering sustainable attitudes in the engineering profession [7]. In this regard, engineering students must learn to think long-term and consider the social environment in which they develop solutions [25]. They must understand the complexities of sustainable development issues and be equipped with the knowledge and skills to address them [25]. In this way, engineering students recognise the importance of sustainability and have a strong sense of personal responsibility for critical sustainability issues [26]. However, there is a need to enhance the level of embedding sustainability in engineering careers [27]. For this reason, engineering education should focus on developing systems of thinking and transdisciplinarity among students to effectively address sustainability challenges [28]. In this context, problem-based learning (PBL) has been identified as a valuable approach to teach transdisciplinary concepts related to sustainability [28].

2.2. Attitude towards Teachers and Knowledge about Sustainable Development

The literature suggests that students generally have positive attitudes towards sustainable development [29–31]. However, the role of the teacher is crucial in fostering university students' engagement [32], including for sustainable development [33,34]. Another study [35] found that students' attitudes about their university teachers influenced their academic performance. In this context, teacher effectiveness has always been subject to academic discussion, as student learning and performance is highly dependent on teacher effectiveness [36,37]. For its part, reference [38] examined students' knowledge, attitude, and environmental practices, finding a relationship between effective delivery by teachers and positive attitudes towards the environment on the part of students. Likewise, reference [39] affirmed that the role of the teacher is key to achieving effective knowledge about sustainable development on the part of students. However, the training of teachers in sustainability is also considered key [40,41]. Based on the above, the following hypothesis is put forward:

H1. *Attitude towards teachers influences knowledge about sustainable development.*

2.3. Knowledge of Sustainable Development and Its Relationship with Students' Environmental, Economic, and Social Attitudes

The literature has shown that education and knowledge about sustainability issues can promote positive attitudes towards the environment and pro-environmental behaviours [42–46]. In this context, it has been suggested that learning about sustainability in the classroom can promote pro-environmental behaviours [44] and generate positive changes in students' attitudes [3,7]. Specifically, ESD can improve students' understanding of the economic dimension of sustainability [47–49]. For its part, students' knowledge about sustainable development can influence students' social attitudes [7], promoting social awareness and understanding of social problems [30,45]. Therefore, ESD influences the economic, social, and environmental attitudes of students [44,45,49]. Based on the above, the following hypotheses are put forward:

H2. *Knowledge about sustainable development influences environmental attitudes.*

H3. *Knowledge about sustainable development influences economic attitudes.*

H4. *Knowledge about sustainable development influences social attitudes.*

2.4. Environmental, Economic, and Social Attitudes and Their Influence on Social Behaviour

Positive attitudes towards sustainable development are associated with pro-environmental behaviours [50]. Thus, people with more positive environmental attitudes are more likely to engage in sustainable consumption practices [51,52]. Likewise, economic attitudes also influence sustainable decision-making [17,53,54], specifically in sustainable consumption behaviours [54]. Similarly, social attitudes can influence sustainable behaviours [55,56]. Thus, people with positive social attitudes are more likely to adopt sustainable behaviours [56]. Additionally, social identities and cultural values can influence people's sustainable attitudes and behaviours [54,57]. Also, it has been discussed how knowledge acquisition influences not only attitudes towards sustainability, but also sustainable behaviours [58–60], including in university students [61]. Therefore, and based on the above, the following hypotheses are put forward:

H5. *Environmental attitudes influence sustainable behaviours.*

H6. *Economic attitudes influence sustainable behaviours.*

H7. *Social attitudes influence sustainable behaviours.*

H8. *Knowledge about sustainable development influences sustainable behaviours.*

Figure 1 shows the research model.

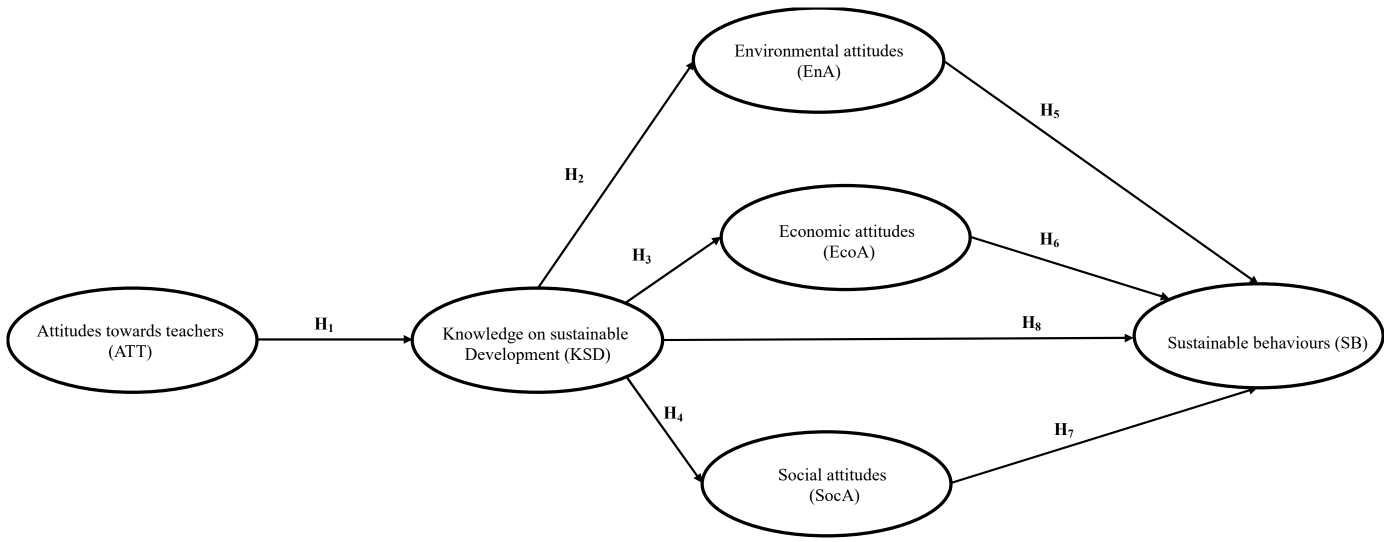

Figure 1. Proposed structural model.

3. Materials and Methods

3.1. Context of the Study

Sustainability in the Dominican Republic is a highly relevant topic and has been addressed in various fields, including tourism [62], agriculture [63], pollution [64], business management [65], and clean energy [66], among others. For this reason, engineers must be trained to offer solutions to the different problems that are being analysed in the country. Engineering university studies in the Dominican Republic do not offer a very high number of courses, especially if we focus on more specialized engineering studies. For example, Computer Systems Engineering or Industrial Engineering is part of the offer of most Dominican universities, but Civil Engineering or Mechanical Engineering is scarcer. In this regard, the Universidad Tecnológica de Santiago (UTESA) has been the institution selected to carry out this study, for the following reasons: (1) it is the largest private university in the Dominican Republic (and second largest overall) in number of graduates (+138,000), active students (+40,000), and administrative and academic employees (+2000); (2) it is a university with a face-to-face offer, but is located in seven provinces of the country (Santo Domingo, Santiago de los Caballeros, Moca, Mao, Dajabón, Puerto Plata, and Gaspar Hernández) (Figure 2); (3) it has a broad engineering offering, with programmes in Agricultural Engineering, Civil Engineering, Mechanical Engineering, Industrial Engineering, Electrical Engineering, Electronic Engineering, and Computer Systems Engineering; (4) and finally, because all curricula offer the compulsory subject "Education for the Environment", where students study sustainable development and the SDGs.

3.2. Measurements

The five-point Likert-type scales (1 = strongly disagree, 3 = neither disagree nor agree; 5 = strongly agree) were designed based on a review of the relevant literature [3,67,68]. A five-step procedure was followed to adapt the original scales to Spanish. First, two native Spanish-speaking translators (Dominicans) carried out the direct translation from English into Spanish. The two translations were then compared and a preliminary draft was produced. The preliminary draft was translated from Spanish into English by a native English-speaking translator. All translations made during the process were checked and the final version of the survey was designed in Spanish (Appendix A). To ensure the comprehension of the questionnaire and the appropriateness of its structure, a pilot test was carried out with 30 students taking the subject "Environmental Education", and no problems were detected. Simple and concise language was used, avoiding syntactic complexity to mitigate possible biases [69]. In addition, respondents' anonymity was guaranteed, it was explained that there were no right or wrong answers, and the questionnaire was kept as short as possible to encourage accurate responses [69].

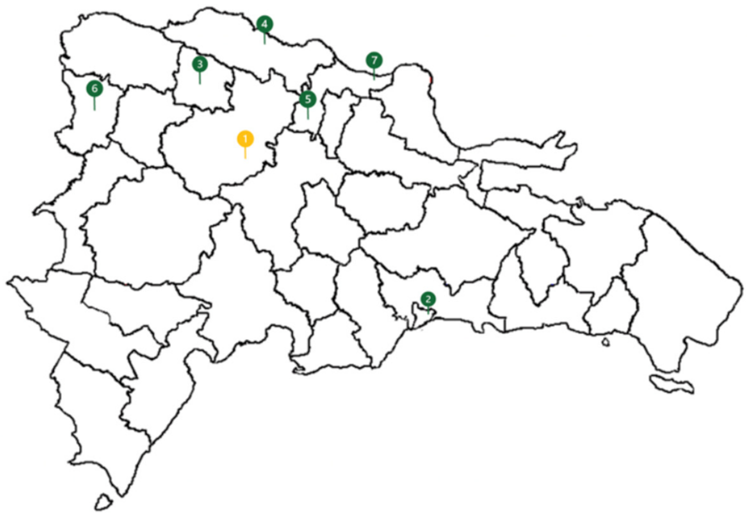

Figure 2. Areas where UTESA University is located. Note: The numbers refer to the location of the University in the Dominican Republic. The yellow color (number 1) refers to the main location of the University (Santiago de los Caballeros). The other numbers correspond to: (2) Santo Domingo, (3) Mao, (4) Puerto Plata, (5) Moca, (6) Dajabón, (7) Gaspar Hernández.

3.3. Data Collection and Sample Profile

The data collection was carried out by means of a structured self-administered questionnaire in the Spanish language, which was physically distributed to engineering students in their final year. The total number of students enrolled in engineering courses at UTESA was 8421. From September 2022 to February 2023 inclusive, trained interviewers distributed and, where necessary, assisted respondents in completing the questionnaire. A sample of 626 questionnaires was obtained, which establishes a sampling error of ±3.5%. The sample consisted of male students (74.6%), aged 19–21 (45.9%), working (65.5%), and earning less than USD 600 per month (79.2%). The degree programmes represented in the sample were Computer Systems Engineering (36.7%), Industrial Engineering (30.6%), Electrical Engineering (9.7%), Civil Engineering (8.9%), Mechanical Engineering (7.1%), Electronic Engineering (4.3%), and Agricultural Engineering (2.7%).

3.4. Verification Strategy and Preliminary Data Analysis

The data were tabulated in Microsoft Excel. During this process, quality controls were carried out to ensure the validity of the hypotheses before testing the hypotheses. First, outliers and incorrect responses (e.g., answering the same item with several options) were identified, resulting in the elimination of 5 questionnaires, leaving a total of 626 valid questionnaires as mentioned above. Subsequently, the preliminary analysis of the items (Table 1) was carried out using SPSS software (v.28.0), where the means, standard deviation, and Kolmogorov–Smirnov normality test, necessary to determine the normality or non-normality of the indicators that make up the different constructs of the model, were obtained.

Table 1. Variables used in the model.

	Mean	SD	Norm.
Knowledge about Sustainable Development—KSD			
KSD1—Helping people out of poverty is an essential condition for making the Dominican Republic more sustainable.	4.20	0.938	0.000 [C]
KSD2—Sustainable development emphasises respect for human rights.	4.09	0.886	0.000 [C]
KSD3—Ensuring a long and healthy life for all contributes to sustainable development.	4.16	0.899	0.000 [C]
KSD4—Building adequate infrastructure contributes to sustainable development.	4.17	0.891	0.000 [C]
KSD5—Sustainable development requires quality education for all.	4.42	0.832	0.000 [C]
KSD6—Sustainable development emphasises gender equality.	3.77	1.108	0.000 [C]
KSD7—Sustainable development involves a reflection on the meaning of quality of life.	4.13	0.858	0.000 [C]
KSD8—Food security is one of the goals of sustainable development.	4.23	0.865	0.000 [C]
KSD9—Estimating the monetary value of the service provided by our ecosystems (such as: neutralising air pollutants) is important for sustainable development.	4.27	0.903	0.000 [C]
KSD10—Sustainable development emphasises international cooperation.	4.11	0.890	0.000 [C]
KSD11—Poverty alleviation is an important issue in education for sustainable development.	4.21	0.888	0.000 [C]
Sustainable Behaviours—SB			
SB1—I walk or cycle to places instead of going by car.	3.36	1.383	0.000 [C]
SB2—I have taken a course in which sustainable development was discussed.	2.99	1.468	0.000 [C]
SB3—I talk to others about how to help people living in poverty.	3.59	1.231	0.000 [C]
SB4—I've been thinking about what it means to live sustainably.	3.91	1.044	0.000 [C]
SB5—Household tasks in my home are shared equally among family members, regardless of gender.	4.04	1.114	0.000 [C]
SB6—I often look for signs of ecosystem deterioration.	3.40	1.204	0.000 [C]
SB7—I volunteer to work with local charities.	3.33	1.346	0.000 [C]
SB8—I have participated in activities related to environmental sustainability.	3.55	1.351	0.000 [C]
SB9—I try to avoid buying products from companies with a poor record on corporate social responsibility.	3.37	1.243	0.000 [C]
SB10—I usually look at problems from different angles.	4.23	0.919	0.000 [C]
SB11—I have searched for information on the environment or sustainability of the university on the respective website.	3.49	1.326	0.000 [C]
SB12—I have searched for information on the new UN Sustainable Development Goals.	3.11	1.396	0.000 [C]
Environmental Attitudes—EnA			
EnA1—When people interfere with the environment, they often produce disastrous consequences.	4.19	1.057	0.000 [C]
EnA2—The quality of life of people is directly related to the protection of the environment.	4.26	0.967	0.000 [C]
EnA3—Biodiversity must be protected at the expense of industrial agricultural production.	4.00	0.965	0.000 [C]
EnA4—Infrastructure development is less important than environmental protection.	3.25	1.353	0.000 [C]
EnA5—Environmental protection is more important than industrial growth.	3.99	1.116	0.000 [C]
Economic Attitudes—EcoA			
EcoA1—Government economic policies should increase sustainable production even if it means spending more money.	3.90	1.108	0.000 [C]
EcoA2—People should sacrifice more to reduce economic differences between populations.	3.59	1.167	0.000 [C]
EcoA3—Government economic policies should increase fair trade.	4.22	0.849	0.000 [C]
EcoA4—Government economic policies must act if a country is wasting its natural resources.	4.50	0.806	0.000 [C]
EcoA5—Reducing poverty and hunger in the world is more important than increasing the economic well-being of industrialised countries.	4.01	1.107	0.000 [C]
Social Attitudes—SocA			
SocA1—Each individual must do everything to maintain peace in the country.	4.17	0.987	0.000 [C]
SocA2—Society should further promote equal opportunities for men and women.	4.51	0.782	0.000 [C]
SocA3—Contact between cultures is stimulating and enriching.	4.31	0.902	0.000 [C]
SocA4—Society should provide free basic health services.	4.54	0.837	0.000 [C]
SocA5—Society should take responsibility for the well-being of individuals and families.	3.94	1.091	0.000 [C]

Table 1. *Cont.*

	Mean	SD	Norm.
Attitudes towards Teachers—ATT			
ATT1—University teachers should use student-centred teaching methods.	4.38	0.814	0.000 C
ATT2—University teachers should promote future-oriented thinking in addition to historical knowledge.	4.49	0.794	0.000 C
ATT3—University teachers should promote interdisciplinarity between subjects.	4.06	0.940	0.000 C
ATT4—University teachers should promote the connection between local and global problems.	3.96	1.031	0.000 C
ATT5—University teachers should promote critical thinking in the classroom.	4.23	1.007	0.000 C

Notes: C: Lilliefors Signification Correction.

The results obtained in Table 1 show the non-normality of the indicators of each of the variables that make up the subsequent model. This implies that non-parametric tests such as confidence intervals have to be used when testing structural relationships between variables (hypothesis testing).

In order to evaluate the hypotheses through structural equation modelling, we used PLS-SEM, a composite-based approach, which focuses on predicting hypothesised relationships that maximise the variance explained in the dependent variables (Hair et al., 2020). First, the reliability and validity of the constructs are analysed, and then the structural model is run to test the hypotheses [70]. For this, the SmartPLS software (v.3.3.7) was used.

Due to the explanatory nature of the research [71], the focus will be on the predictive power of the model, as well as the effect size and statistical inference of structural relationships or hypothesis testing. This will be addressed in the results of the structural model.

4. Results

4.1. Reliability and Validity Analysis of the Measurement Model

The reliability and validity analysis of the items is detailed in Table 2. The reliability of the items belonging to the Mode A composites was examined through factor loadings, where values greater than 0.707 were considered to indicate that the shared relationship between the concept and its indicators is more significant than the error variability [72]. Although a heuristic rule is set at 0.707, authors such as [73] point out that the lower limit should not be so strict in the initial stages of the scale and that it could be lower, as long as this factor loading is not lower than 0.4, and should be eliminated if the factor loading is below this threshold [74]. As can be seen in Table 2, several indicators relating to the constructs Knowledge about Sustainable Development and Sustainable Behaviours had to be removed.

Furthermore, Mode B compounds have been tested for weights and significance [75]. Non-significant weights were retained in the model as long as their associated factor loadings were greater than 0.5 [74]. This situation occurs in some cases as can be seen in Table 2. Finally, the existence of possible multicollinearity between the different indicators of the Mode B composites has also been tested. This possible multicollinearity is tested by means of the Variance Inflation Factor (VIF) test, with high multicollinearity being considered to exist when the VID values exceed the threshold of 3.3 [76]. No multi-linearity issues were observed.

The internal consistency of the constructs was assessed through composite reliability [77], as this measure is less susceptible to common method bias [78]. Both the Dijkstra–Henseler coefficient (r_A) and the Dillon–Goldstein coefficient (r_C) have optimal values of 0.80 and above for composite reliability [74]. Furthermore, to analyse convergent validity, the Average Variance Extracted (AVE) was calculated for each construct, and all values exceeded the threshold of 0.50 [79]. Finally, the existence of discriminant validity was tested through the Heterotrait-Monotrait ratio, with discriminant validity being considered proven for Heterotrait-Monotrait ratio values below 0.85 [80]. Table 3 shows the results of the reliability and validity tests at the internal consistency level. The results show an excellent internal consistency or construct reliability.

Table 2. Reliability and validity at individual level.

	Loads	Weights (Sig.)	VIF
Knowledge about Sustainable Development—Mode A			
KSD5	0.666	n/a	n/a
KSD7	0.734		
KSD8	0.733		
KSD10	0.711		
KSD11	0.693		
Sustainable Behaviours—Mode A			
SD3	0.610	n/a	n/a
SD4	0.765		
SD10	0.813		
Environmental Attitudes—Mode B			
EnA1	0.620	0.409 (0.000)	1.076
EnA2	0.704	0.461 (0.000)	1.125
EnA3	0.666	0.429 (0.000)	1.114
EnA4	0.512	0.047 (0.089)	1.137
EnA5	0.508	0.243 (0.000)	1.207
Economic Attitudes—Mode B			
EcoA1	0.524	0.245 (0.000)	1.112
EcoA2	0.478	0.198 (0.000)	1.125
EcoA3	0.758	0.461 (0.000)	1.237
EcoA4	0.619	0.336 (0.000)	1.151
EcoA5	0.601	0.365 (0.000)	1.107
Social Attitudes—Mode B			
SocA1	0.610	0.314 (0.000)	1.155
SocA2	0.608	0.291 (0.000)	1.191
SocA3	0.665	0.373 (0.000)	1.171
SocA4	0.640	0.319 (0.000)	1.194
SocA5	0.562	0.318 (0.000)	1.119
Attitudes towards Teachers—Mode B			
ATT1	0.700	0.338 (0.000)	1.260
ATT2	0.837	0.526 (0.000)	1.329
ATT3	0.623	0.237 (0.000)	1.298
ATT4	0.534	0.112 (0.000)	1.332
ATT5	0.601	0.191 (0.000)	1.348

Table 3. Internal consistency of the model.

	Rho_A	Rho_C	AVE	HT-MT Ratio		
EnA	1.000	n/a	n/a		KSD	SB
EcoA	1.000	n/a	n/a	KSD		
SocA	1.000	n/a	n/a	SB	0.684	
ATT	1.000	n/a	n/a			
KSD	0.751	0.834	0.501			
SB	0.764	0.776	0.540			

Notes: EnA: Environmental Attitudes; EcoA: Economic Attitudes; SocA: Social Attitudes; ATT: Attitudes towards Teachers; KSD: Knowledge about Sustainable Development; SB: Sustainable Behaviours; n/a: Not applicable.

4.2. Analysis of the Structural Model

Due to the explanatory nature of the study and as mentioned above, the focus is on the predictive power and effect size of the variables that make up the model, as well as the hypothesis testing between the different variables that make up the model.

Thus, and as indicated in Table 4, the predictive power of the model measured through the coefficient of determination or R^2 is indicated. In this regard, the moderate predictive power [77] of the endogenous variables environmental attitudes (R^2 = 0.468), knowledge about sustainable development (R^2 = 0.389), and economic attitudes (R^2 = 0.367) should be noted. Furthermore, in terms of explained variance, and turning to the endogenous variable with more observable variables, the role of Knowledge about Sustainable Development should be highlighted as responsible for 15.87% of the variance of the endogenous variable Sustainable Behaviours.

Table 4. Predictive power and effect size.

	β	R^2	Corr.	Explained Variance	f^2 (Sig.)
Knowledge about Sustainable Development		0.389			
H1: Attitudes towards teachers	0.624		0.624	38.93%	0.637 (0.000)
Environmental Attitudes		0.468			
H2: Knowledge about sustainable development	0.468		0.468	21.90%	0.281 (0.000)
Economic Attitudes		0.367			
H3: Knowledge about sustainable development	0.606		0.606	36.72%	0.579 (0.000)
Social Attitudes		0.282			
H4: Knowledge about sustainable development	0.531		0.531	28.19%	0.394 (0.000)
Sustainable Behaviours		0.262			
H5: Environmental attitudes	0.119		0.348	4.14%	0.013 (0.229)
H6: Economic attitudes	0.075		0.387	2.90%	0.004 (0.515)
H7: Social attitudes	0.092		0.357	3.56%	0.007 (0.394)
H8: Knowledge about sustainable development	0.330		0.481	15.87%	0.082 (0.003)

This is related to the effect size, as variables with a higher percentage of variance explained represent those with larger effects. Thus, the effect generated by "Knowledge about sustainable development" on economic, environmental, and social attitudes is considered to be a large and significant effect [81]. The effect also generated by "Knowledge about sustainable development" on sustainable behaviours is small and significant, while the effect of the different attitudes (environmental, economic, and social) on sustainable behaviours is not significant. Therefore, "Knowledge about sustainable development" is the main variable that affects sustainable behaviours.

In terms of hypothesis contrast, a Bootstrap of 10,000 sub-samples [82] was used to obtain both the t-statistic and the associated confidence intervals (non-parametric test). Table 5 shows the results obtained.

Table 5. Hypothesis testing.

	β	*t* (Sig.)	IC Bootstrap 95%	
			2.5%	97.5%
H1: ATT → KSD	0.624 ***	16.153 (0.000)	0.546	0.699
H2: KSD → EnA	0.468 ***	9.823 (0.000)	0.374	0.561
H3: KSD → EcoA	0.606 ***	15.987 (0.000)	0.530	0.679
H4: KSD → SocA	0.531 ***	11.007 (0.000)	0.433	0.623
H5: EnA → SB	0.119 **	2.693 (0.007)	0.038	0.214
H6: EcoA → SB	0.075 NS	1.484 (0.138)	−0.021	0.175
H7: SocA → SB	0.092 *	1.979 (0.049)	0.006	0.190
H8: KSD → SB	0.330 ***	6.461 (0.000)	0.222	0.425

Notes: EnA: Environmental Attitudes; EcoA: Economic Attitudes; SocA: Social Attitudes; ATT: Attitudes towards teachers; KSD: Knowledge about sustainable development; SB: Sustainable Behaviours; NS: Not significant. *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

As a result of the above Table 5, 7 of the 8 hypotheses have been supported, confirming the influence of Knowledge about sustainable development on environmental attitudes (H2), economic attitudes (H3), social attitudes (H4) and also towards sustainable behaviours (H8). The hypotheses that established an influence of environmental attitude (H5), social attitude (H7) about sustainable behaviours and attitudes towards teachers about Knowledge about sustainable development (H1) were also supported. Finally, it has not been possible to confirm the influence of economic attitudes on sustainable behaviours (H6), this being the only hypothesis that was not supported in the present study.

The Figure 3 shows the final structural model.

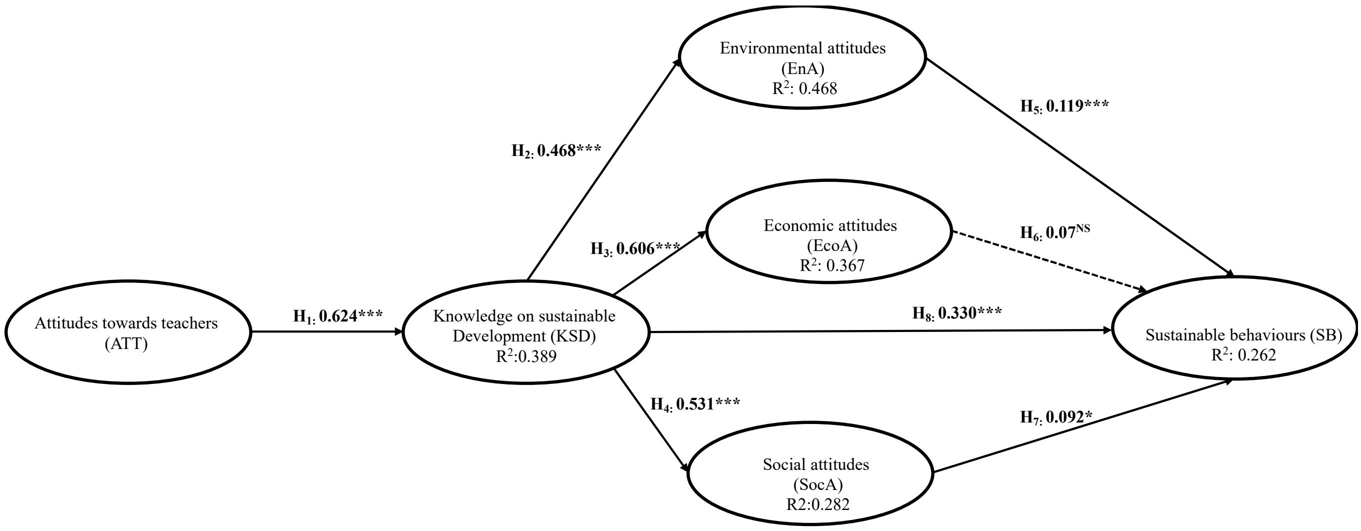

Figure 3. Final structural model. *: $p < 0.05$; ***: $p < 0.001$; NS: Not Supported.

5. Discussion

The results of the study indicate that attitudes towards teachers among engineering students contribute significantly to their knowledge towards sustainable development. This finding supports the H1 hypothesis of this research and the results of other work [3]. Attitudes towards teachers represent 38.93% of the explained variance in relation to knowledge towards sustainable development. These results suggest that engineering students' positive attitudes towards teachers can foster a more responsive, motivational, and engaged learning environment [83], leading to a deeper understanding of sustainable development [84]. Therefore, students with a positive perception of their university professors will have a greater probability of actively participating in class discussions, contributing to a greater understanding of the topic addressed [85]. Also, the accessible and close perception of students towards their teachers encourages them to seek guidance and feedback [86], which also contributes to improving learning of the topics covered [87]. Specifically, positive attitudes towards teachers specialized in sustainability encourage students to become interested in sustainable development and explore sustainable and innovative solutions [29].

This study also indicates that knowledge towards sustainable development among engineering students influences their attitudes (environmental, economic, and social) and sustainable behaviours. In this way, the hypotheses H2, H3, H4, and H8 of this research are supported. These results suggest that higher levels of knowledge about sustainable development promote more sustainable attitudes and behaviours. The variances explained for knowledge towards sustainable development are moderate to high, being 21.90% for environmental attitudes, 28.19% for social attitudes, and 36.72% for economic attitudes. Consistent with previous studies [88–90], these results indicate that if engineering students have knowledge about sustainable development, they are likely to develop more favourable attitudes towards the environment, the economy and society [61]. Specifically, students with higher levels of knowledge about sustainability could be more aware of environmental challenges and the need for conservation and sustainable management of natural resources [91]. Similarly, knowledge of sustainability influences economic attitudes among engineering students. For this reason, it is important for the student to balance economic growth with social and environmental considerations [17]. Similarly, engineering students with a deeper understanding of the social aspects of sustainability are more likely to value social equity, inclusion, and community participation [92].

This study also highlights some interesting findings regarding the relationships between social and environmental attitudes and sustainable behaviours, supporting previous studies [54,57]. While the H5 (environmental attitudes influence sustainable behaviour) and H7 (social attitudes influence sustainable behaviour) hypotheses are supported, the variances explained by these relationships are relatively low, with social attitudes explaining only 3.56% of the variance of sustainable behaviours, and environmental attitudes only 4.14% of sustainable behaviours. This suggests that other factors beyond attitudes towards social and environmental aspects may play a more important role in influencing sustainable behaviours among engineering students. Furthermore, according to other studies [58–61], it has been shown that sustainable development knowledge influences students' sustainable behaviours [59–61] (H8). In this respect, knowledge of sustainable development explains 15.87% of the variance of sustainable behaviour. Hypothesis H6 was not supported in this research and, therefore, no relationship was found between economic attitudes and sustainable behaviours. Therefore, economic attitudes are not an antecedent of sustainable behaviours among engineering students. These results add to the conclusions of previous studies [47–49], which suggests the development of more research in this context.

6. Conclusions

The present research aimed to understand the perceptions of engineering students about the relationships between attitudes towards teachers, knowledge about sustainable development, attitudes (economic, social, and environmental), and sustainable behaviours. The research was developed in the context of higher education in the Dominican Republic and, specifically, in engineering students, since these professionals will have the responsibility of making sustainable decisions in the future, and they must contribute to the sustainability of local communities, the region, or the country. Thus, this research shows that attitudes towards teachers have a positive impact on engineering students' knowledge of sustainable development. Also, it has been concluded that the knowledge about sustainability acquired by engineering students is related to attitudes (environmental, economic, and social) and sustainable behaviours.

6.1. Theoretical and Practical Implications

From a theoretical approach, this research highlights the importance of attitudes towards teachers as a key factor in the acquisition of knowledge about sustainable development. Also, it highlights the importance of knowledge about sustainable development as a key antecedent of attitudes (economic, social, and environmental) and sustainable behaviours of students. These results improve the understanding of the factors that influence the formation of sustainable attitudes and behaviours among engineering students.

From a practical approach, this study promotes implications for those responsible for educational policies at universities (Rectors, Vice-Rectors, Deans, and Professors), since it highlights the importance of designing, establishing, and developing pedagogical strategies that, on the one hand, promote positive attitudes towards teachers and, on the other hand, promote knowledge and sustainable behaviours. Also, this research reveals the importance of further integrating ESD into engineering curricula.

Specifically, the results of this research invite universities to develop specific policies to increase positive relationships between professors and students, since if students (engineering or another career) have a positive perception of their professors, they can be motivated, committed, and seek guidance. This could foster an effective and efficient learning environment, increasing interest in sustainable development and the implementation of innovative sustainable solutions. In addition, universities that do not have transversal subjects on sustainable development should consider integrating them into their undergraduate academic offer. This is important because the Dominican Republic has different challenges to work on, among them the sustainability of tourism [93], the risks in agriculture [94], the negative educational results of the Dominican students in the PISA test [95], the low use of renewable energy [96], and the pollution of beaches and rivers [64], among others, and current students will be the future decision makers.

Likewise, practical programs related to sustainability must be developed in universities, involving both engineering students and other careers. This can increase sustainable attitudes and behaviours, increasing students' awareness and understanding of sustainable development. In addition, some initiatives such as awareness campaigns, theoretical-practical workshops, and conferences by sustainability experts can help students become more aware of environmental challenges, social equity, and community participation. Implementing campus-wide sustainability initiatives, such as recycling programs, energy-saving campaigns, and sustainable transportation options, can also help create a culture of sustainable behaviour among the university community, including students, faculty, support staff, among others. To do this, collaborative actions can be developed with external institutions (such as industries, organizations, and local communities), offering students opportunities to participate in sustainable projects and initiatives outside the classroom. Additionally, it is important to establish constant monitors to evaluate the effectiveness of the sustainability initiatives implemented by the universities, which could help to measure the changes in attitudes, knowledge, and behaviours of the academic community over time, providing valuable information for continuous improvement.

6.2. Limitations and Future Research

Like any research study, the present study has limitations. The main one is its cross-sectional nature and, therefore, in future lines of research, it is recommended to develop longitudinal studies that can confirm the hypotheses and results of this work. The study is conducted within the university context of the Dominican Republic, but solely from the viewpoint of a university, which can also be a limitation when it comes to generalising results. Future research could explore other factors that may influence the sustainable attitudes and behaviours of engineering students. Furthermore, it would be interesting to investigate how specific educational interventions may influence sustainable attitudes and behaviours of engineering students.

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Appendix A

Instrument used

	1 = Strongly Disagree	2 = Disagree	3 = Neither Disagree nor Agree	4 = Agree	5 = Strongly Agree
Knowledge about Sustainable Development—KSD					
KSD1—Helping people out of poverty is an essential condition for making the Dominican Republic more sustainable	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD2—Sustainable development emphasises respect for human rights.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD3—Ensuring a long and healthy life for all contributes to sustainable development.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD4—Building adequate infrastructure contributes to sustainable development.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD5—Sustainable development requires quality education for all.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD6—Sustainable development emphasises gender equality.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD7—Sustainable development involves a reflection on the meaning of quality of life.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD8—Food security is one of the goals of sustainable development	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD9—Estimating the monetary value of the service provided by our ecosystems (such as: neutralising air pollutants) is important for sustainable development.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD10—Sustainable development emphasises international cooperation.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
KSD11—Poverty alleviation is an important issue in education for sustainable development.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Sustainable Behaviours—SB					
SB1—I walk or cycle to places instead of going by car.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB2—I have taken a course in which sustainable development was discussed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB3—I talk to others about how to help people living in poverty.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB4—I've been thinking about what it means to live sustainably	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB5—Household tasks in my home are shared equally among family members, regardless of gender	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB6—I often look for signs of ecosystem deterioration	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB7—I volunteer to work with local charities	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neither Disagree nor Agree**	**4 = Agree**	**5 = Strongly Agree**
SB8—I have participated in activities related to environmental sustainability.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB9—I try to avoid buying products from companies with a poor record on corporate social responsibility.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB10—I usually look at problems from different angles	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB11—I have searched for information on the environment or sustainability of the university on the respective website.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SB12—I have searched for information on the new UN Sustainable Development Goals.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Environmental Attitudes—EnA					
EnA1—When people interfere with the environment, they often produce disastrous consequences	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EnA2—The quality of life of people is directly related to the protection of the environment	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EnA3—Biodiversity must be protected at the expense of industrial agricultural production	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EnA4—Infrastructure development is less important than environmental protection	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EnA5—Environmental protection is more important than industrial growth	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Economic Attitudes—EcoA					
EcoA1—Government economic policies should increase sustainable production even if it means spending more money	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EcoA2—People should sacrifice more to reduce economic differences between populations	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EcoA3—Government economic policies should increase fair trade	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EcoA4—Government economic policies must act if a country is wasting its natural resources	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
EcoA5—Reducing poverty and hunger in the world is more important than increasing the economic well-being of industrialised countries	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Social Attitudes—SocA					
SocA1—Each individual must do everything to maintain peace in the country.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

	1 = Strongly Disagree	2 = Disagree	3 = Neither Disagree nor Agree	4 = Agree	5 = Strongly Agree
SocA2—Society should further promote equal opportunities for men and women.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SocA3—Contact between cultures is stimulating and enriching.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SocA4—Society should provide free basic health services.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
SocA5—Society should take responsibility for the well-being of individuals and families.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Attitudes towards Teachers—ATT					
ATT1—University teachers should use student-centred teaching methods	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ATT2—University teachers should promote future-oriented thinking in addition to historical knowledge	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ATT3—University teachers should promote interdisciplinarity between subjects	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ATT4—University teachers should promote the connection between local and global problems	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ATT5—University teachers should promote critical thinking in the classroom	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Sociodemographic Profile					
Gender ☐ Male ☐ Female					
Age ☐ 18 or under ☐ 19–21 ☐ 22–24 ☐ 25–28 ☐ 29 or more					
Do you work? ☐ Yes ☐ No					
If you work, what is your monthly salary? ☐ Less than US$200 ☐ US$201–400 ☐ US$401–600 ☐ More than US$600					
Engineering you study: ______________________					

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