sustainability

MDPI

Article

Sustainable Economic Development Education: The Use of Artificial Neural Networks for the Profile Estimation of Students from Developing Countries

Miguel Ángel Solano-Sánchez [1,*], Cándida María Domínguez-Valerio [2], Ana Lendínez-Turón [3] and Minerva Aguilar-Rivero [4]

[1] Department of Applied Economics, Faculty of Social Sciences (Melilla Campus), University of Granada, 52005 Melilla, Spain
[2] Department of Business Administration, Faculty of Economics and Social Sciences, Universidad Tecnológica de Santiago, UTESA, Santiago de los Caballeros 51000, Dominican Republic; candidadominguez1@docente.utesa.edu
[3] Department of Developmental and Educational Psychology, Faculty of Education and Sports Sciences (Melilla Campus), University of Granada, 52005 Melilla, Spain; analendinez@ugr.es
[4] Department of Applied Economics, Faculty of Labour Sciences, University of Córdoba, 14001 Córdoba, Spain; u52agrim@uco.es
* Correspondence: msolano@ugr.es

Abstract: Environmentally friendly behaviour and the equitable and sustainable use of natural resources can contribute to solving various environmental, economic, and social problems in different countries. The analysis of the perception of young students is important because schools are suitable for educating future generations and shaping their attitudes to also include a greater concern for the environment. This research aims to determine the degree of influence that a series of Likert-type questions of knowledge, attitudes, and behaviours about sustainable development has on a series of items of the student profile (gender, age, course, and household members) in a developing country. For this, an artificial neural network is used that allows us not only to quantify the degree of influence but also to obtain an estimation of the student's profile according to the responses obtained on sustainable development. The network developed allows us to obtain, through a determined collection of answers to questions about sustainable development, the estimation of a specific profile of a student from a developing country. This can be useful to educational communities interested in optimising economic resources through sustainable development, allowing them to know which issues they should focus more (or less) on according to the profile of the student they are targeting.

Keywords: sustainability; sustainable development; sustainable economy; economic resources; education; developing countries; students; multilayer perceptron; artificial neural networks

Citation: Solano-Sánchez, M.Á.; Domínguez-Valerio, C.M.; Lendínez-Turón, A.; Aguilar-Rivero, M. Sustainable Economic Development Education: The Use of Artificial Neural Networks for the Profile Estimation of Students from Developing Countries. *Sustainability* **2022**, *14*, 1192. https://doi.org/10.3390/su14031192

Academic Editors: Francisco Zamora-Polo and Jesús Sánchez Martín

Received: 29 December 2021
Accepted: 18 January 2022
Published: 21 January 2022

1. Introduction

Fair consumption, responsible production, environmentally friendly behaviour, and the equitable and sustainable use of natural resources can contribute to solving various environmental, economic, and social problems in different countries [1], such as pollution, climate change, the loss of flora and fauna, and job creation, among others. All socio-economic and environmental problems affect developing countries, in so far as they increase social inequalities and poverty [2].

Issues such as the aforementioned mobilised international organisations, and thus the term sustainability emerged: a type of development that can meet the needs of present generations without compromising the needs of future generations [3]. The complexity of sustainability from a socio-economic and environmental perspective requires the implementation of strategies to face all the challenges involved in achieving it [4]. Education is

one of the main channels to face a region's socio-economic and environmental problems, especially to improve its sustainability in the short, medium, and long term [5].

The literature has revealed the importance of evaluating attitudes, behaviours, knowledge, and intentions to participate in sustainable initiatives [6,7]. Different theoretical backgrounds, such as the New Environmental Paradigm [8], the Scale of Attitudes and Environmental Knowledge of Children [9], and the Model of Ecological Values [10], have been used to develop different instruments that can evaluate aspects related to sustainable development.

Other instruments to measure students' attitudes [11], intentions to act [12], and knowledge about sustainability [13] have also been developed. Other scales measure students' competencies, attitudes, and sustainable behaviours, which are based on several UNESCO documents [14,15]. Currently, there is no consensus in the literature on the use of a common tool that measures environmental and sustainable development attitudes due to the different theoretical backgrounds that underlie the different approaches [16]. Thus, there is a growing interest in quantitative research which measures competencies, attitudes, and beliefs in education for sustainable development [17].

The analysis of the perception of young students is vitally important [18] because schools are suitable for educating future generations and shaping their attitudes to also include a greater concern for the environment. Previous literature has shown the need to investigate the perception of sustainability in younger generations, as they are the agents of change who will be affected by the environmental problems created by current human activities [7]. Today's students will have a great influence on the future state of the environment, which makes the incorporation and institutionalisation of sustainability matters in education highly relevant [19]. The importance of understanding students' attitudes and behaviours towards the environment and finding effective ways to influence these behaviours through education is, therefore, indisputable [19].

Analysing students' perceptions of sustainable development in developing countries such as the Dominican Republic is of great importance because these young people will become the leaders who will have to develop strategies and actions in their professional and personal lives. Being able to analyse students' perceptions and propose alternatives to improve their perception towards sustainability is essential because there is evidence that knowledge about sustainability fosters good attitudes and behaviours in students, as well as increasing their intention to engage in sustainable actions [20–24]. One of the challenges teachers face regarding education for sustainable development is the inclusion of even more content in an already overloaded curriculum [25]. Therefore, knowing the weaknesses of students concerning education for sustainable development is relevant to plan and implement effective actions that could strengthen existing weaknesses without burdening the curricula.

This research aims to determine the degree of influence that a series of Likert-type questions on knowledge, attitudes, and behaviours about sustainable development has on a series of items of the student profile (gender, age, course, household members) in a developing country. For this, an artificial neural network (ANN) is used that allows not only to quantify this degree of influence but also to obtain an estimation or "composite picture" of the student's profile according to the responses obtained on sustainable development. The application of ANNs in the estimation of sociodemographic profiles is recent and their presence is still scarce in the literature [26–28].

To achieve the aim proposed, this work is structured as follows: first, a literature review regarding attitudes and behaviours towards sustainability is made; second, the methodology section explains the questionnaire procedure and the statistical instrument employed. The results in this regard are presented in the next section, followed by a discussion comparing the latter with the literature revised; finally, the conclusions, including theoretical and practical implications, as well as limitations and future lines of research, are exposed.

2. Literature Review

Attitude is the composition of beliefs, values, and feelings [29]. Emotions and attitudes can affect students' perceptions of their behaviour regarding sustainability [30,31]. People's attitudes towards sustainability can be attributed to participation in environmental organisations [32]. Thus, people's attitudes determine their intentions and behaviours [22]. According to Çimer and Aydin [33], the development of individuals' attitudes towards sustainability influences their intentions and sustainable behaviours. Therefore, individual sustainable attitudes affect the intention to participate in actions related to sustainable development [24–34]. A person with sustainable attitudes can help motivate one or more people to do so [35]. Kagawa [36] indicates that students are more likely to undertake sustainable activities, such as recycling; saving energy and water; using public transportation; and buying organic, fair trade, and healthy products.

Sustainable behaviour directly influences attitudes [37,38]. People's attitudes towards sustainability can be attributed to spending time outdoors [32]. It has been shown that attitudes towards the environment have a significant and positive relationship with the sustainable behaviours of college students [39]. Therefore, people who have positive attitudes towards sustainability and the environment are more likely to develop sustainable behaviours [24]. Ajzen [40] showed that behaviours are manifestations of individuals' final attitudes. Steg et al. [41] confirmed that aspects such as value and environmental attitude influence people's sustainable behaviours. Some studies indicate that there is a relationship between behaviour in favour of the environment and environmental attitudes [20]. People who care about the environment and natural resources tend to adopt sustainable attitudes since they believe that protecting the environment is the right thing to do [42]. The intention to adopt sustainable behaviours should increase when students have favourable attitudes towards sustainable development; that is, when students think that behaving sustainably is positive, their attitude towards sustainability will be more favourable [6].

The main determinant of a behaviour is the intention to act accordingly [43]. Thus, sustainable behaviour directly influences people's intentions [37]. People who favour the environment through their behaviours also show greater support for activities and actions in favour of the environment and sustainability [24]. Therefore, people's behaviours concerning sustainability influence their intentions to participate in actions related to sustainable development [24]. The intention to participate in actions derived from sustainable development should then increase when students get involved and show sustainable behaviours [6]. Favourable sustainable behaviours can optimise the intention to participate in aspects related to sustainable development [21].

Environmental knowledge and attitudes in favour of the environment are highly interconnected [19,44]. According to Michalos et al. [14], knowledge and attitudes are strengthened by education programs. Knowledge about sustainability improves students' attitudes and environmental awareness through a transformative learning process [23]. Thus, school sustainability programs can affect students' knowledge and, in turn, their environmental attitudes [45]. People's attitudes towards sustainability can also be attributed to the education received [32,46]. Therefore, student training can play an important role in attitudes towards sustainable development [22]. Aminrad et al. [47] indicated that there is a relationship between students' knowledge and attitudes towards environmental education, although it is weak. Other studies have indicated that increasing a person's knowledge about the environment leads to a change in their sustainable attitudes [48]. Pooley and O'Connor [30] considered that the domain of attitude is affected by the knowledge domain.

Knowledge about sustainability impacts students' environmental behaviours [23,44]. An increase in a person's knowledge about the environment leads to a change in their sustainable behaviours [48]. Kaiser et al. [49] concluded that environmental knowledge accounts for 40% of the variation in ecological behaviour intentions. Brody and Ryu [50] found that postgraduate education on sustainability could significantly increase the degree to which students act sustainably; that is, knowledge can improve student behaviours in their day-to-day lives. Boyes et al. [51] state that environmental education has great

potential to encourage students to change their behaviours, developing actions such as eating less meat, or paying more for renewable electricity. Esa [52] indicated that students with environmental knowledge integrated sustainable actions into their daily behaviours. According to Michalos et al. [15], knowledge could explain a part of people's behaviours. Best and Mayerl [53] indicated that knowledge is a direct determinant of behaviour.

3. Data and Methodology

3.1. Sample Selection

The educational centre chosen was the Elsa Brito de Domínguez Polytechnic Institute, located in the city of Santiago de los Caballeros. This centre was recommended by the Ministry of Education of the Dominican Republic for the following reasons: (a) it has a heterogeneous population of students, as they come from various marginalised neighbourhoods in the city; (b) it was built in 2019 under a sustainability approach; (c) it has the highest population of secondary students in the region (1611); and (d) it has the largest offering of secondary education programs in the region: electricity, mechatronics, electronics, nursing, informatics, and accounting and finance.

3.2. Instrument Selection, Design, Validation, and Data Collection

The measurement instrument selected to collect data was a questionnaire divided into five sections: (a) attitudes towards sustainable development; (b) behaviours towards sustainable development; (c) knowledge about sustainable development; (d) intention to participate in actions in favour of sustainable development; and (e) sociodemographic profile. All sections, except for the sociodemographic profile, were measured through a 5-point Likert scale (1 = "Strongly disagree", 3 = "Indifferent", 5 = "Strongly agree").

Since there is no consensus in the literature regarding the use of a common tool that measures attitudes, behaviour, knowledge, and intention [16], an instrument was built based on previous studies [6,7,14,15,17,19,21,54,55]. To validate the questionnaire, the following process was followed: (a) the items were classified into constructs (attitude, behaviour, knowledge, and intention to participate), and repeated or similar items were eliminated; (b) researchers selected items for each construct; (c) the selected items were translated from English to Spanish by two translation companies; (d) both translations were compared and a single document was formulated; (e) the document was translated to English by two translators; (f) the translations received were consolidated to produce a final draft of the Spanish version. Clear and concise language was used, necessary to guarantee questionnaire validity [56].

Once the questionnaire was designed, the instrument was submitted to a pre-test of 15 students to determine aspects such as correct variable selection, presentation fluidity, estimated completion time, the order of the instructions, and the clarity of the statements [57]. Then, the questionnaire was applied to the students, guaranteeing their anonymity so possible biases could be controlled [56]. Survey collection was carried out through August, September, and October 2018. A total of 600 surveys were filled in, of which 328 were valid.

3.3. Multilayer Perceptron Development

Rumelhart and McClelland [58] define the ANN as a network that comprises a series of nodes—or process elements (PE)—with a certain information storage capacity. These PE are composed by an input vector $(x_1, x_2, \ldots, x_n)$ with their corresponding synaptic weights $(w_1, w_2, \ldots, w_n)$, which are then applied to those input vectors using a propagation rule (based on its corresponding linear combination). An activation function is applied to this result determining the value of these PEs, grouped in layers, such as input, intermediate layers (or hidden layer), and output.

Thus, an MLP is used, taking the Likert's answers obtained in the survey as the input values, and the outputs to the estimations that the MLP draws up on the different items of the students. The data is previously coded to obtain numerical values as a response. The data on the Likert scale (rank scale) have been transformed into quasi-quantitative

form-values: 1, 2, 3, 4, and 5. Different topologies and activation functions are tested in the network development process, finally preserving the ANN that presents a greater degree of adjustment in terms of coefficient of determination (R^2) and mean absolute percentage error (*MAPE*). The software used is SPSS Statistics v.23.

4. Results

4.1. Data and Variables

The different items of the students' sociodemographic profiles are presented in Table 1. Regarding gender (GEN), a slight majority of women are observed in the sample. Almost all of them are between 15 and 18 years old (AGE). The course (COU) they attend is quite distributed among second, third, and fourth years. According to the number of cohabitants in the household (HOU), practically the entire sample contains two or more cohabitants, with more than half of the respondents living in a house with between two and four members. The average profile corresponds to a student around 17 years old, in the second or third year, and living in a household with between two and four members.

Table 1. Sociodemographic items of the students.

Items	%
Gender (GEN)	
Male	38.41%
Female	61.59%
Age (AGE)	
Less than 15 years old	31.71%
16–18 years old	65.24%
19–20 years old	2.74%
More than 20 years old	0.31%
Bachelor course (COU)	
First year	0.31%
Second year	39.63%
Third year	34.15%
Fourth year	25.91%
Household members (HOU)	
1 member	0.61%
2–4 members	56.40%
More than 4 members	42.99%

The structure of the model proposed, including the collection of Likert-type questions of five points made to the students, is shown in Figure 1. The questions asked are divided into four blocks, with sustainable development as the guiding thread. Thus, the first of the sections refers to knowledge of the issue raised, the second to attitude, the third to issues related to behaviour, and the last to the intention to participate in the process of sustainable development. All of the questions include at the end the dominant option obtained in the survey between brackets (Figure 1). Generally, they arouse broad agreement, except for Q12, which reflects a moderate attitude towards water consumption.

Figure 1. Model of proposed structure.

4.2. Multilayer Perceptron Performance

The architecture of the ANN achieved is presented in Table 2, and graphically, in Figure 2. The input layer is made up of the different neurons that correspond to the questions asked in the survey and the input values which are incorporated, which have to be standardised before incorporating them into the network. Subsequently, these values are multiplied by their respective synaptic weights (Figure 2) that take values higher or lower than zero, giving rise to the different values of the hidden layer, to which a hyperbolic tangent activation function is applied (Table 2). These values are in turn multiplied by the synaptic weights from the hidden layer to the output layer, giving rise to the different output values, corresponding to the items of the students' profiles. The values that do not require additional modifications as identity function (that is, without transformation) are applied. However, they should invert their standardisation to reflect the estimations as specified in Table 2 (dependent variables).

The errors made by the network during its elaboration, as well as the time taken until its complete development, are presented in Table 3. For its generation, the sample is randomly divided into the training and the testing group following an approximately 70%–30% partition (Table 3). The training group is used to develop the network, using a scaled conjugate gradient algorithm to determine the synaptic weights values (and consequently determining errors), while the test group is used to take the error made as a reference. When it is not possible to further reduce the error in the test group, the training group stops its work and the network development is concluded, letting SPSS automatically compute the maximum number of epochs to reach the stopping rule.

Table 2. Network architecture.

Input Layer	Covariates	Q01 Q02 Q03 Q04 Q05 Q06 Q07 Q08 Q09 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24
	Number of Units (excluding bias)	24
	Rescaling Method for Covariates	Standardised
Hidden Layer	Number of Hidden Layers	1
	Number of Units in Hidden Layer (excluding bias)	6
	Activation Function	Hyperbolic Tangent
Output Layer	Dependent Variables	GEN, male = 1 GEN, female = 2 AGE (from 1 to 4) COU (from 1 to 4) HOU (from 1 to 3)
	Number of Units	5
	Rescaling Method for Scale Dependents	Standardised
	Activation Function	Identity
	Error Function	Sum of Squares

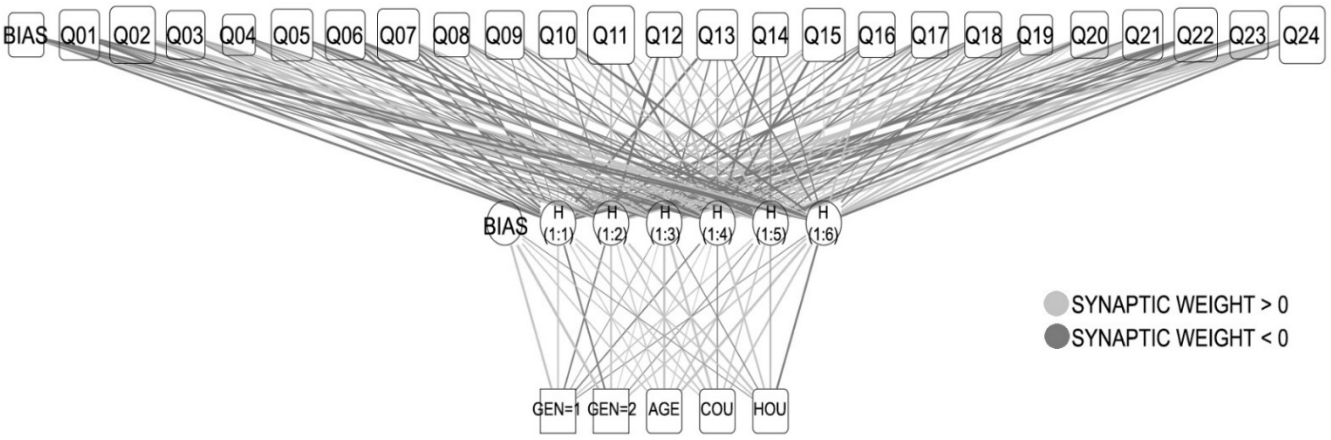

Figure 2. Graphic representation of the ANN.

Table 3. Model summary.

Training (N = 238; 72.56%)	Sum of Squares Error		330.589
	Average Overall Relative Error		0.802
	Percent Incorrect Predictions for Categorical Dependents	GEN	31.51%
	Relative Error for Scale Dependents	AGE	0.741
		COU	0.716
		HOU	0.939
	Stopping Rule Used		1 consecutive step with no decrease in error (based on the testing sample)
	Training Time		0:00:00.24
Testing (N = 90; 27.44%)	Sum of Squares Error		124.805
	Average Overall Relative Error		0.902
	Percent Incorrect Predictions for Categorical Dependents	GEN	25.55%
	Relative Error for Scale Dependents	AGE	0.954
		COU	0.763
		HOU	0.997

The goodness of fit of the ANN is shown in Table 4, both in its entirety and detailed by the different items of the student profile. The MAPE is the percentage difference between the real values and those estimated by the network, which on average are around 21%. The coefficient of determination (R^2) refers to the percentage of the variability of the variance that is explained by the ANN. In this case, the GEN stands out with an almost perfect fit (Table 4). On average, the network is explaining 55% of the variability of the sample variance.

Table 4. Adjustment of the ANN obtained.

	GEN	AGE	COU	HOU	Overall
MAPE	24.85%	22.10%	19.79%	17.33%	21.02%
R^2	90.44%	65.88%	34.85%	29.26%	55.11%

The ANN also allows for the quantifying of the relevance that each of the input values contributes to itself (Figure 3). In this case, the awareness that sustainable development should be a priority for the rulers (Q11), the willingness to collaborate in the process of sustainable development from the school (Q24), or the vision of sustainable development as a contributor to cultural diversity (Q02) appear as the most influential in the development of the network. On the other hand, factors such as the purchase of local products (Q19) or the maintenance of biodiversity (Q04) appear as the least relevant for it.

Finally, the ANN developed allows for the quantifying of the degree of increase (Table 5) or decrease (Table 6) that each of the questions contributes to each of the different items of the student profile. To determine these values, each of the questions takes its minimum value and its maximum value, while the rest of the input values remain at their mean values. During this process, all the output values that the network provides are collected. Once these values are obtained, all the differences between the set of questions with maximum and minimum values are calculated, which are presented as a percentage. The 10 questions that represent a greater increase or decrease in the output values are highlighted in Tables 5 and 6, respectively. Gender (GEN) is excluded from them since the increases/decreases reflected are not relevant enough to suppose a change in the student's profile.

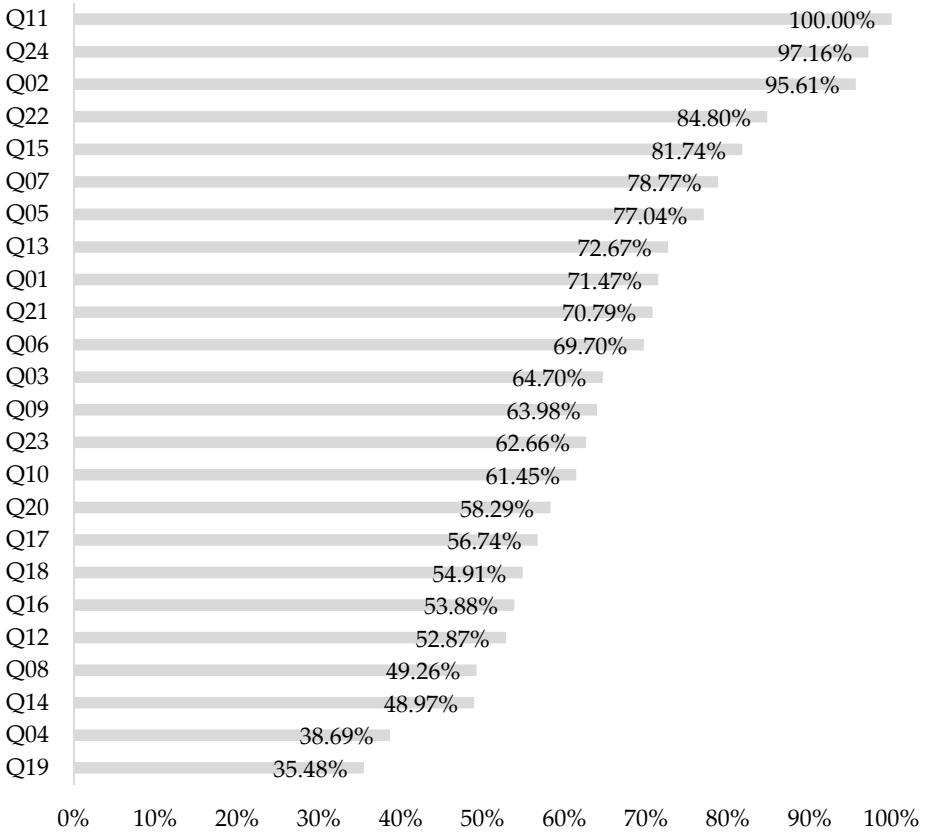

Figure 3. Normalised importance of exogenous variables in the ANN model.

Table 5. Questions with the most direct influence on profiles' items.

	Question	Item	Var.
Q11	Governments and communities should adopt sustainable development as a national priority	COU	28.51%
Q15	Society should further promote equal opportunities for men and women	COU	25.74%
Q02	Education for sustainable development supports cultural diversity	COU	16.34%
Q09	Men and women must have equal access to all types of education and employment	COU	14.93%
Q24	I am willing to participate in the sustainable development process of my school	HOU	14.58%
Q17	I use eco-friendly light bulbs at home	COU	13.68%
Q03	Inappropriate human actions are contributing to changes in our atmosphere and climate systems (e.g., not recycling, throwing garbage on the street, etc.)	COU	13.05%
Q20	I reduce water consumption	HOU	11.92%
Q11	Governments and communities should adopt sustainable development as a national priority	AGE	11.55%
Q02	Education for sustainable development supports cultural diversity	AGE	11.00%

Table 6. Questions with the most inverse influence on profiles' items.

	Question	Item	Var.
Q07	Improving people's opportunities for a long and healthy life contributes to sustainable development	COU	−26.90%
Q22	I recycle some of the things I use	COU	−23.22%
Q13	The protection of the environment and the quality of life of people are directly related	COU	−20.23%
Q23	I contribute to reducing pollution	COU	−17.48%
Q01	Sustainable development requires companies to behave responsibly towards their employees, customers and suppliers	COU	−16.52%
Q02	Education for sustainable development supports cultural diversity	HOU	−15.75%
Q22	I recycle some of the things I use	AGE	−12.88%
Q13	The protection of the environment and the quality of life of people are directly related	AGE	−12.64%
Q05	Sustainable development requires access to good quality education for all	COU	−12.01%
Q05	Sustainable development requires access to good quality education for all	AGE	−10.79%

Thus, Table 5 shows how there is a growing awareness of governments and communities to bet on sustainable development as a national priority (Q11), and that education in it supports cultural diversity (Q02) as the students are in higher years of study (COU) and are older (AGE). On the other hand, a greater willingness to collaborate in the sustainable development of the school (Q24), and to reduce water consumption (Q20), is related to living with a greater number of members in the home. In addition to this, according to the student which is in higher grade years (COU), he/she finds greater awareness of equal opportunities for both genders (Q15) and, issues related to the above (Q09), as well as other issues related to the use of eco-friendly light bulbs (Q17) or awareness about climate change (Q03).

Conversely, Table 6 reflects how, as the course is higher, awareness is lost regarding the matter that improving people's opportunities (Q07) or their quality of life (Q13) contributes to sustainable development and the environment, in addition to other factors such as recycling used goods—shared by the younger profiles—(Q22), reducing pollution (Q23), business awareness (Q01), or quality of education (Q05)—also shared as the age of the student decreases. The latter also relates to a greater perception that caring for the environment is related to people's quality of life (Q13).

5. Discussion

The instrument used in the present study has shown an adequate structure that allows measuring knowledge, attitudes, behaviour, and intention to participate in activities related to sustainable development. The techniques used to obtain the results of the study show that the students of this research have positive perceptions towards the knowledge, attitudes, behaviours, and intentions of participating in sustainable development. These positive perceptions can increase the development of sustainable behaviours [24,31,38,44].

The students' perceptions towards sustainable development show that they know that these are aspects related to the sustainable behaviour of companies, cultural diversity, education, inappropriate human actions, biodiversity, and the fair distribution or improvement of opportunities for the population. This knowledge favours students to have greater behaviours towards sustainable development [59]. These perceptions also show that they have favourable attitudes towards an education based on values, equal access to education and employment, actions to reduce poverty, sustainability as a national priority for the country, and the protection of natural resources. These results have followed the trends observed in other studies [7,17,44]. Thus, the positive attitudes of students can determine their intentions and behaviours towards sustainable development [22–33].

The results also show that students use eco-friendly light bulbs at home, buy local products, reduce water and electricity consumption, recycle, and contribute to reducing pollution. Kagawa [36] pointed out that, when attitudes are positive, students are more likely to engage in more sustainable behaviours, such as recycling, saving energy and water, using public transportation, and buying organic and healthy products. In addition, students are interested in participating in more actions towards sustainable development. In this way, students who demonstrate favourable behaviours towards sustainable development will increase their desire to participate in actions and activities related to sustainable development [59].

The results in this work have shown that students have knowledge, attitudes, behaviours, and intentions to participate in sustainable development actions; however, sustainable development has not yet been evidenced as a training practice in schools in the Dominican Republic. Therefore, the questionnaire provided for this study, as well as the results, can help improve sustainable initiatives in Dominican schools. Thus, the government must implement educational actions to increase knowledge, attitudes, and favourable behaviours towards sustainable development, as can be seen in the results of Figure 3 and Table 5, since there is a perception that sustainable development should be a priority for the rulers. For this reason, education must contribute to expanding information and learning opportunities in this field, in both formal and informal contexts [44].

6. Conclusions

The theoretical implications of this research show how the item of the student's profile most influenced by questions of sustainable development is the course in which he/she is, followed by age, closely related to the former and, to a lesser extent, the household members. Gender is not sufficiently decisive in the composition of the profile regarding the questions asked.

In this way, it is necessary to expose at earlier ages and course content the role of communities and governments in the commitment to sustainable development, decisively train in cultural diversity and equal opportunities for any type of gender, and to a lesser extent, raise awareness about climate change and the use of eco-friendly light bulbs. Conversely, it is interesting to raise awareness in more advanced ages and courses in order for quality education to promote sustainable development, as well as to use it as an instrument to improve the quality of life, corporate responsibility in this matter, and above all, to specially instruct on how to reduce pollution and recycle used objects.

Awareness to collaborate with sustainable development in schools and to reduce water consumption should have a greater impact on those students from homes with fewer members, that are perhaps more affluent, and who perceive distantly the problem. Broadly, there should be an impact on issues such as biodiversity or raising awareness about the convenience of consuming local products, issues that were not very relevant in estimating the profile of the students.

The main practical application of this work resides in the utility of the ANN itself, which allows for the obtaining of a determined collection of answers—easily customisable by the researcher—to questions about sustainable development, the estimation of a specific profile, or a "composite picture" of a student from a developing country. This can be useful to educational communities interested in optimising economic resources through sustainable development, so that they know which issues they should focus more (or less) according to the profile of the student they are targeting.

Like all research, this study contemplates some limitations: it should be noted that the study is based on the perspective of the student, making it difficult to obtain data from other relevant stakeholders, such as government technicians, teachers, directors, and other institutions linked to educational centres. As a future line of research, it would be interesting to introduce new variables that help to understand the explained variance of sustainable knowledge, attitudes, behaviours, and intentions to participate in actions in favour of sustainable development.

Author Contributions: Conceptualisation, investigation, and methodology, C.M.D.-V.; software, validation, and formal analysis, M.Á.S.-S.; writing—review and editing, visualisation, and supervision, A.L.-T. and M.A.-R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was carried out in line with the ethical recommendations proposed in previous research in the same field and observing the principles and recommendations of the Declaration of Helsinki.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Priyadarshini, P.; Abhilash, P. From piecemeal to holistic: Introducing sustainability science in Indian Universities to attain UN-Sustainable Development Goals. *J. Clean. Prod.* **2020**, *247*, 119133. [CrossRef]
2. Padda, I.U.H.; Hameed, A. Estimating multidimensional poverty levels in rural Pakistan: A contribution to sustainable development policies. *J. Clean. Prod.* **2018**, *197*, 435–442. [CrossRef]
3. Brundtland, G.H. *Our Common Future: From One Earth to One World*; Oxford University Press: Oxford, UK, 1987.
4. Faham, E.; Rezvanfar, A.; Mohammadi, S.H.M.; Nohooji, M.R. Using system dynamics to develop education for sustainable development in higher education with the emphasis on the sustainability competencies of students. *Technol. Forecast. Soc. Chang.* **2017**, *123*, 307–326. [CrossRef]
5. Muralikrishna, I.V.; Manickam, V. *Environmental Management: Science and Engineering for Industry*; Elsevier-Butterworth-Heinemann: Oxford, UK, 2017.
6. De Leeuw, A.; Valois, P.; Seixas, R. Understanding high school students' attitude, social norm, perceived control and beliefs to develop educational interventions on sustainable development. *Procedia-Soc. Behav. Sci.* **2014**, *143*, 1200–1209. [CrossRef]
7. Al-Naqbi, A.K.; Alshannag, Q. The status of education for sustainable development and sustainability knowledge, attitudes, and behaviors of UAE University students. *Int. J. Sustain. High. Educ.* **2018**, *19*, 566–588. [CrossRef]
8. Dunlap, R.E.; Van Liere, K.D. The "new environmental paradigm". *J. Environ. Educ.* **2008**, *40*, 19–28. [CrossRef]
9. Leeming, F.C.; Dwyer, W.O.; Bracken, B.A. Children's environmental attitude and knowledge scale: Construction and validation. *J. Environ. Educ.* **1995**, *26*, 22–31. [CrossRef]
10. Bogner, F.X.; Wiseman, M. Adolescents' attitudes towards nature and environment: Quantifying the 2-MEV model. *Environmentalist* **2006**, *26*, 247–254. [CrossRef]
11. Milfont, T.L.; Duckitt, J. The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *J. Environ. Psychol.* **2010**, *30*, 80–94. [CrossRef]
12. Bergman, B.G. Assessing impacts of locally designed environmental education projects on students' environmental attitudes, awareness, and intention to act. *Environ. Educ. Res.* **2016**, *22*, 480–503. [CrossRef]
13. Biasutti, M. An intensive programme on education for sustainable development: The participants' experience. *Environ. Educ. Res.* **2015**, *21*, 734–752. [CrossRef]
14. Michalos, A.C.; Creech, H.; McDonald, C.; Kahlke, P.M.H. Knowledge, attitudes and behaviours. Concerning education for sustainable development: Two exploratory studies. *Soc. Indic. Res.* **2011**, *100*, 391–413. [CrossRef]
15. Michalos, A.C.; Creech, H.; Swayze, N.; Kahlke, P.M.H.; Buckler, C.; Rempel, K. Measuring knowledge, attitudes and behaviours concerning sustainable development among tenth grade students in Manitoba. *Soc. Indic. Res.* **2012**, *106*, 213–238. [CrossRef]
16. Schneller, A.J.; Johnson, B.; Bogner, F.X. Measuring children's environmental attitudes and values in northwest Mexico: Validating a modified version of measures to test the Model of Ecological Values (2-MEV). *Environ. Educ. Res.* **2015**, *21*, 61–75. [CrossRef]
17. Biasutti, M.; Frate, S. A validity and reliability study of the attitudes toward sustainable development scale. *Environ. Educ. Res.* **2017**, *23*, 214–230. [CrossRef]
18. Kilinc, A.; Aydin, A. Turkish student science teachers' conceptions of sustainable development: A phenomenography. *Int. J. Sci. Educ.* **2013**, *35*, 731–752. [CrossRef]
19. Zsóka, Á.; Szerényi, Z.M.; Széchy, A.; Kocsis, T. Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *J. Clean. Production* **2013**, *48*, 126–138. [CrossRef]
20. Van Riper, C.J.; Kyle, G.T. Understanding the internal processes of behavioral engagement in a national park: A latent variable path analysis of the value-belief-norm theory. *J. Environ. Psychol.* **2014**, *38*, 288–297. [CrossRef]
21. Nadlifatin, R.; Razif, M.; Lin, S.-C.; Persada, S.F.; Belgiawan, P.F. An assessment model of Indonesian citizens' intention to participate on environmental impact assessment (EIA): A behavioral perspective. *Procedia Environ. Sci.* **2015**, *28*, 3–10. [CrossRef]
22. Anderson, C. *The Theory of Planned Behavior Used to Better Understand Health Eductaion and Health Promotion Students' Engagement in Environmentally Sustainable Behaviors and Activities*; University of Wisconsin-La Crosse: La Crosse, WI, USA, 2017.
23. Savelyeva, T.; Douglas, W. Global consciousness and pillars of sustainable development: A study on self-perceptions of the first-year university students. *Int. J. Sustain. High. Educ.* **2017**, *18*, 218–241. [CrossRef]

24. Yu, T.-Y.; Yu, T.-K. The moderating effects of students' personality traits on pro-environmental behavioral intentions in response to climate change. *Int. J. Environ. Res. Public Health* **2017**, *14*, 1472. [CrossRef]
25. Jegstad, K.M.; Sinnes, A.T. Chemistry teaching for the future: A model for secondary chemistry education for sustainable development. *Int. J. Sci. Educ.* **2015**, *37*, 655–683. [CrossRef]
26. Moral-Cuadra, S.; Solano-Sánchez, M.Á.; López-Guzmán, T.; Menor-Campos, A. Peer-to-Peer Tourism: Tourists' Profile Estimation through Artificial Neural Networks. *J. Theor. Appl. Electron. Commer. Res.* **2021**, *16*, 1120–1135. [CrossRef]
27. García-García, L.; Solano-Sanchez, M.Á.; Muñoz-Fernández, G.A.; Moral-Cuadra, S. Flamenco experience in Córdoba, Spain: Estimating tourist profiles by multilayer perceptron's artificial neural networks. *J. Cult. Herit. Manag. Sustain. Dev.* **2021**. [CrossRef]
28. Moral-Cuadra, S.; Solano-Sánchez, M.Á.; Menor-Campos, A.; López-Guzmán, T. Discovering gastronomic tourists' profiles through artificial neural networks: Analysis, opinions and attitudes. *Tour. Recreat. Res.* **2021**. [CrossRef]
29. Kruglanski, A.W. *Lay Epistemics and Human Knowledge: Cognitive and Motivational Bases*; Springer: New York, NY, USA, 1989.
30. Pooley, J.A.; O'Connor, M. Environmental education and attitudes: Emotions and beliefs are what is needed. *Environ. Behav.* **2000**, *32*, 711–723. [CrossRef]
31. Braßler, M.; Sprenger, S. Fostering Sustainability Knowledge, Attitudes, and Behaviours through a Tutor-Supported Interdisciplinary Course in Education for Sustainable Development. *Sustainability* **2021**, *13*, 3494. [CrossRef]
32. Sherburn, M.; Devlin, A.S. Academic major, environmental concern, and arboretum use. *J. Environ. Educ.* **2004**, *35*, 23–36. [CrossRef]
33. Çimer, A.; Aydin, Ö. Development of a Scale to Assess High Schoolers' Attitudes toward Sustainable Development. *Int. Educ. Stud.* **2018**, *11*, 116–124. [CrossRef]
34. Trail, G.T.; McCullough, B.P. A longitudinal study of sustainability attitudes, intentions, and behaviors. *Sustain. Sci.* **2021**, *16*, 1503–1518. [CrossRef]
35. Mancha, R.M.; Yoder, C.Y. Cultural antecedents of green behavioral intent: An environmental theory of planned behavior. *J. Environ. Psychol.* **2015**, *43*, 145–154. [CrossRef]
36. Kagawa, F. Dissonance in students' perceptions of sustainable development and sustainability: Implications for curriculum change. *Int. J. Sustain. High. Educ.* **2007**, *8*, 317–338. [CrossRef]
37. Arbuthnott, K.D. Education for sustainable development beyond attitude change. *Int. J. Sustain. High. Educ.* **2009**, *10*, 152–163. [CrossRef]
38. Kendall, C.J.; Leeds, A.; Tinka, J.; Lukas, K.E.; Folta, E. Teacher training as a means to sustained and multiplicative behavior change: An example using fuel-efficient stoves. *Am. J. Primatol.* **2021**, *83*, e23193. [CrossRef]
39. Sahin, E.; Ertepinar, H.; Teksoz, G. University Students' Behaviors Pertaining to Sustainability: A Structural Equation Model with Sustainability-Related Attributes. *Int. J. Environ. Sci. Educ.* **2012**, *7*, 459–478.
40. Ajzen, I. The theory of planned behaviour: Reactions and reflections. *Psychol. Health* **2011**, *26*, 1113–1127. [CrossRef] [PubMed]
41. Steg, L.; Bolderdijk, J.W.; Keizer, K.; Perlaviciute, G. An integrated framework for encouraging pro-environmental behaviour: The role of values, situational factors and goals. *J. Environ. Psychol.* **2014**, *38*, 104–115. [CrossRef]
42. Liobikienė, G.; Juknys, R. The role of values, environmental risk perception, awareness of consequences, and willingness to assume responsibility for environmentally-friendly behaviour: The Lithuanian case. *J. Clean. Prod.* **2016**, *112*, 3413–3422. [CrossRef]
43. Montano, D.E.; Kasprzyk, D. The theory of reasoned action and the theory of planned behavior. In *Health Behavior and Health Education: Theory, Research and Practice*; Glanz, K., Rimer, B.K., Viswanath, K., Eds.; Jossey-Bass: San Franciso, CA, USA, 2008; pp. 67–96.
44. Borges, F. Knowledge, Attitudes and Behaviours Concerning Sustainable Development: A Study among Prospective Elementary Teachers. *High. Educ. Stud.* **2019**, *9*, 22–32. [CrossRef]
45. Mahat, H.; Idrus, S. Education for sustainable development in Malaysia: A study of teacher and student awareness. *Geogr. Malays. J. Soc. Space* **2017**, *12*, 77–88.
46. Nousheen, A.; Zai, S.A.Y.; Waseem, M.; Khan, S.A. Education for sustainable development (ESD): Effects of sustainability education on pre-service teachers' attitude towards sustainable development (SD). *J. Clean. Prod.* **2020**, *250*, 119537. [CrossRef]
47. Aminrad, Z.; Zakariya, S.Z.B.S.; Hadi, A.S.; Sakari, M. Relationship between awareness, knowledge and attitudes towards environmental education among secondary school students in Malaysia. *World Appl. Sci. J.* **2013**, *22*, 1326–1333. [CrossRef]
48. Hungerford, H.R.; Volk, T.L. Changing learner behavior through environmental education. *J. Environ. Educ.* **1990**, *21*, 8–21. [CrossRef]
49. Kaiser, F.G.; Wölfing, S.; Fuhrer, U. Environmental attitude and ecological behaviour. *J. Environ. Psychol.* **1999**, *19*, 1–19. [CrossRef]
50. Brody, S.D.; Ryu, H.-C. Measuring the educational impacts of a graduate course on sustainable development. *Environ. Educ. Res.* **2006**, *12*, 179–199. [CrossRef]
51. Boyes, E.; Kilinc, A.; Stanisstreet, M. Turkish Students' Ideas about Global Warming. *Int. J. Environ. Sci. Educ.* **2008**, *3*, 89–98.
52. Esa, N. Environmental knowledge, attitude and practices of student teachers. *Int. Res. Geogr. Environ. Educ.* **2010**, *19*, 39–50. [CrossRef]
53. Best, H.; Mayerl, J. Values, beliefs, attitudes: An empirical study on the structure of environmental concern and recycling participation. *Soc. Sci. Q.* **2013**, *94*, 691–714. [CrossRef]

54. Asan, I.; Mile, S.; Ibraim, J. Attitudes of Macedonian High School Students towards the Environment. *Procedia-Soc. Behav. Sci.* **2014**, *159*, 636–642. [CrossRef]
55. Dagiliūtė, R.; Liobikienė, G.; Minelgaitė, A. Sustainability at universities: Students' perceptions from green and non-green universities. *J. Clean. Prod.* **2018**, *181*, 473–482. [CrossRef]
56. Podsakoff, P.M.; MacKenzie, S.B.; Lee, J.-Y.; Podsakoff, N.P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Appl. Psychol.* **2003**, *88*, 879–909. [CrossRef] [PubMed]
57. Sarabia Sánchez, F.J. *Metodología Para la Investigación en Marketing y Dirección de Empresas*; Piramide: Madrid, Spain, 1999.
58. Rumelhart, D.E.; McClelland, J. *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*; MIT: Cambridge, MA, USA, 1986.
59. Too, L.; Bajracharya, B. Sustainable campus: Engaging the community in sustainability. *Int. J. Sustain. High. Educ.* **2015**, *16*, 16–33. [CrossRef]