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Dealing with Global Environmental Change: the design and validation of the GEC attitude scale

Mercedes Varela-Losada[1], Uxío Pérez-Rodríguez[1], María Lorenzo-Rial[1], Pedro Vega-Marcote[2] and Alan Reid[3]

[1] Faculty of Education and Sport Sciences, University of Vigo, A Xunqueira, 36005 Pontevedra, Spain

[2] Faculty of Education Sciences, University of A Coruña, Campus Elviña, 15071 A Coruña, Spain

[3]Faculty of Education, University of Monash, Clayton, Victoria, Australia

Abstract

Global Environmental Change (GEC) refers to alterations in the structure and functioning of Earth Systems arising from the detrimental effects of human activities in the biophysical and socioeconomic spheres. This study constructs and validates a scale to measure GEC-related attitudes (SGEC) for use with educators and the public. The results, which were validated by a wide sample (N = 962), show a factor structure of four well-defined interrelated factors (χ^2 = 268.75; p < .000; χ^2/gl = 1.84; AIC = 394.75; CFI = .934; RMSEA = .042 [.034 .050]), with reliability (α=.817, glb=.894, Ω=.855). The factors were: Social Responsibility (SR), Need to Cope (NC), Individual Responsibility (IR), Anthropogenic Origin (AO). These factors and findings suggest the SGEC can provide relevant information on: (i) awareness of the anthropogenic origins of GEC, (ii) perceptions of the need to deal with GEC, and attributions of (iii) social and (iv) individual responsibility in solving and mitigating GEC-related problems.

Keywords

Global Environmental Change, attitudes scale, validation, factor analysis, responsibility

Introduction

The current worldwide environmental and human crisis, caused by the increasing negative impact of human activities on the atmosphere, oceans and land masses, has created a 'double bind' for humanity (Gare, 2006), in that people are positioned at the centre of both the problems and solutions of Global Environmental Change (GEC).

This bind has emerged from the long-term effects of industrialisation, growing use of non-renewable fossil fuels and the transformation of societies globally into those characterised by mass consumption, a situation that has also given rise to the so-called Great Acceleration (Steffen et al., 2006). Illustrated by changes and alterations in a wide range of exponential global indicators since the 1950s—such as composition of the atmosphere and land use (see Figure 1)—the variety and complexity of these changes requires that they be recognised and addressed from different social, economic, political, ethical and, of course, educational angles (Öhman, 2016). The current Agenda 2030 for Sustainable Development (UN, 2015), for example, places special emphasis on the need for local to joint global action at all levels across a range of goals, a key component of which is Quality Education (SDG4), to address GEC.

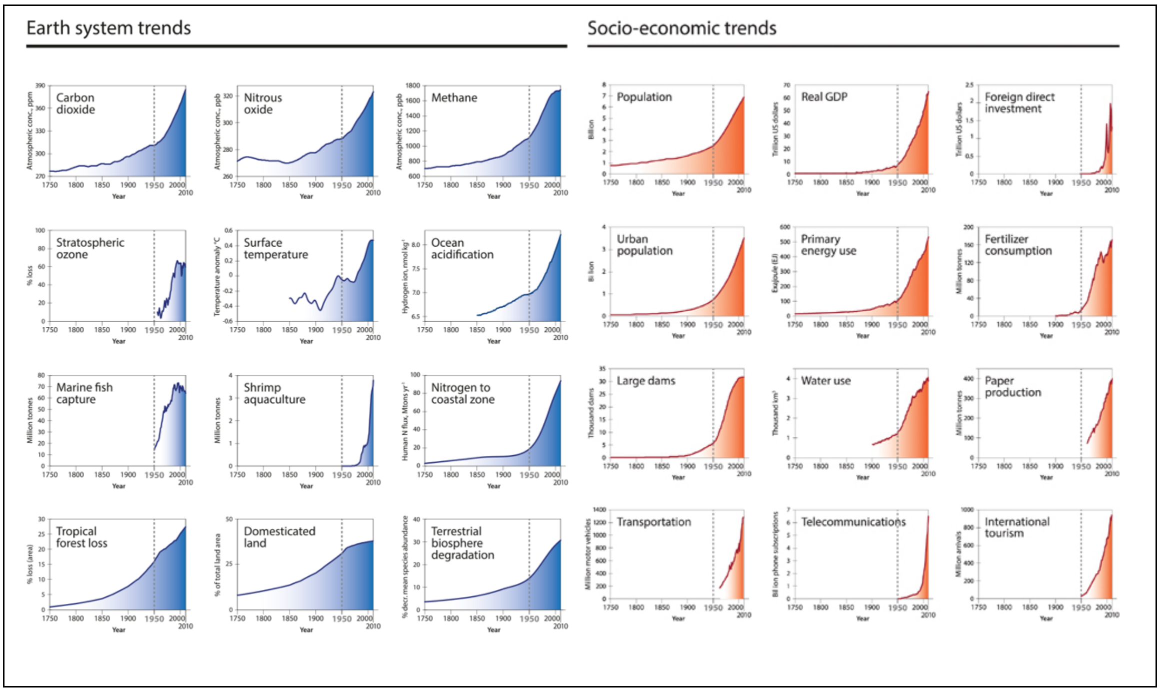

Figure 1. Global indicators of change related to the Earth system and the socioeconomic field (Source: Steffen et al., 2006)

Such calls for action on GEC are based on increasingly sophisticated data sets available to experts and the public (Figure 1). Analysis of data related to GEC indicators and the identification of human beings as their main change agents has also given rise to both the scientific hypothesis and cultural metaphor that we are embarking on a new epoch called the 'Anthropocene', a term chosen to reflect how humanity as a species has been transformed into a global and geologically-significant force. The term is stark: it requires us to recognise humanity's ability to radically disrupt planetary processes, whilst also warning of possibly unpredictable and dangerous consequences for people and the environment as 'planetary boundaries' are passed (Crutzen & Stoermer, 2000; Lövbrand *et al.*, 2015).

The associated biophysical and socioeconomic changes that are altering the structure and functioning of the Earth System are the very ones that invite us to consider processes and understandings of Global Environmental Change in educational settings and amongst the lay public. GEC is indexed to disturbances caused by human actions with regard to a wide range of planetary phenomena: climate change, the destruction of the ozone layer, the acidification of the oceans, the loss of biodiversity, the alteration of nitrogen and phosphorous flows, land-use change, the global use of fresh water, aerosol loads on the atmosphere and chemical pollution, and so on (Vitousek, 1994; Oldfield & Steffen, 2004). On the one hand, the threat is magnified if we take into account the interactions and links between the different phenomena and their largely non-linear nature, which could cause abrupt and even irreversible changes; on the other, the risk of disengagement and denial greater still, if the scale and complexity of GEC leads to cognitive and emotional overload.

Climate change is a paradigmatic example of the challenges for science, education and the public. Recent reports (World Meteorological Organization, 2019; IPCC, 2019) warn of the increase in the average global temperature, which for the period, 2015-2019, is on the way to becoming the warmest of any other equivalent period of human civilisation recorded. This period has been accompanied by phenomena such as lethal and generalised heatwaves, unprecedented wildfires, devastating cyclones and hurricanes or the continuous shrinking of sea ice, with their subsequent effects on people and communities. Thus, the 2015 Paris Agreement under the United Nations Framework Convention on Climate Change argues that it is necessary to “strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty”. But in spite of warnings by relevant international bodies, CO_2 emissions continue to increase, in fact by 2% in the year 2018 (World Meteorological Organization, 2019), taking us ever closer to a point of no return (IPCC, 2014). The socioeconomic system appears to remain largely oblivious to the environmental disasters that human action causes on a global level (Álvarez-Lires, Arias-Correa, Lorenzo-Rial & Serrallé-Marzoa, 2017), and thus our cultural responses, including via education and climate change education, are found wanting (Reid, 2019).

Accordingly, GEC is a problem of not just massive environmental, social, economic, political proportions but also of socio-cultural recognition and fairness too. Both aspects pose a huge challenge to humanity as a whole (Steffen & Stafford, 2013), to the extent that we are regularly implored to reflect on the need to change the current model of development (Rockström, 2011) and respond to a series of scientists’ warnings about

GEC (e.g. Ripple et al., 2020). Facing this crisis and evolving towards sustainable and fair development (UN, 1987; UNESCO, 2014) involves changes from within the political sphere, the business sector and people's ways of life, especially insofar as consumption is concerned (Bauman, 2013; Bengtsson, 2018). Such ways of life, it is argued, must be redirected towards more conscious and austere positions, including in terms of what we buy and produce, by incorporating principles and processes of social and environmental justice, and moving away from excess, to better take account of the limits involved in living on a planet with finite resources. Thus, in recent years, new models have emerged that defend degrowth, or prosperity without growth, where welfare and happiness do not automatically implicate economic growth (Latouche, 2011; Jackson, 2009). Also of interest are the approaches fostering a *circular* (as opposed to *linear*) economy, and learning about and practicing resource use in more sustainable ways from both an economic and environmental point of view (Kirchherr et al. 2017; Rodríguez-Chueca et al., 2020).

Finally, within the UN system, steps are being taken to focus development, and learning about development, on a sustainability orientation and framework. The 17 Sustainable Development Goals of the current 2030 Agenda explicitly set out to contribute towards achieving a better future for all, by eliminating poverty, combating climate change, promoting the conservation of protection of seas and oceans, attaining equality for women, improving our cities, and favouring the defence of the environment (UN, 2015). As noted above, the SDGs identify quality education as an independent aim (SDG4) with education for sustainable development as a subgoal, seeking, in this way, to give both education in general and tailored education a role in enabling change in many different areas (Vladimirova & Le Blanc, 2015).

The role of education in an uncertain future

Socio-environmental challenges mean that we must start to adopt measures to mitigate harmful environmental impacts as well as take action to adapt to change, which should be both scientific and social. Alongside structural changes, technological solutions alone will not resolve complex global questions such as Climate Change, so they should be tackled by engaging people's everyday habits (Uzzell, 2010). Education is an essential element with which to respond to GEC at an individual and cultural level, such as within an obligation to prepare current students for change and facilitate their resilience skills (Worldwatch institute, 2017). As Lotz-Sisitka et al. (2015) have argued, critical analysis of Sustainable Development (and, by extension, of the SDGs) must educate students to address the acceleration of change, increased complexity, conflicting informative accounts, and inevitable uncertainty about pathways forward. While as Delors (1996:7) put it, “faced with the future’s numerous challenges, education is an indispensable asset and essential instrument in humanity’s attempt to attain the ideals of peace, freedom and social justice.”

However, educational institutions have often reinforced rather than challenged the notion that their graduates are to be, first and foremost, employees and consumers (Worldwatch Institute, 2017). This reality exacerbates our current problems and encourages consumerism as the dominating cultural context in which the majority of students grow up today. Some studies give clues about capitalist influences in schools, such as the analysis by Morales and Cassany (2020) that shows how schoolbooks can promote cultural stereotypes of a neoliberal nature, or the research of Golin and Campbell (2017) that warn about the expanding foothold that corporations have in schools around the world, like oil giant Chevron sponsoring American science education. Schools, colleges and universities are still very much influenced by a prevailing neoliberal political-educational rhetoric, to the extent that few sustainability models are investigated (Huckle & Wals, 2015), and pre-existing established ways of life are continuously replicated with little fundamental change to address GEC (Alvarez & Vega, 2009). However, in this context, we do note educational initiatives are emerging that seek to graduate informed and responsible people with more sustainable consumption habits (Hadjichambis et al., 2015; Frank & Stanszus, 2019; Brocos & Aleixandre, 2020).

Thus, an important challenge continues to be how to encourage responsible behaviour educationally which guides us towards sustainable lifestyles (Heimlich & Ardoin, 2008). In recent years, authorities in the environmental and sustainability education field have proposed educational approaches that encourage action competence (Mogensen & Mayer, 2005) based on the acquisition of critical knowledge (Piasentin & Roberts, 2017) and the development of values, attitudes, skills and ways of acting in social interaction, collaboration and dialogue (Tilbury, 2011). They may also favour ways of seeing the world far from the chimera of techno-scientific control of the world (Morín, 2011) and neoliberal (Klein, 2015) and consumerist stances (Bauman, 2013), relying on the involvement of teachers to achieve these ends.

Teachers' attitudes

In this context, it is essential to investigate, conceptualise and address people's responses to the impacts and adaptations involved in GEC. On the one hand, these depend on and reflect social cognitions, emotions, norms, decision-making processes and coping strategies (Wise *et al*., 2014). On the other, dealing with GEC in education should start from an awareness not only of the attitudes of people in general (Gifford, 2014), but, above all, of educators, as their profession is a fundamental component to most educational processes.

In their recent review, Marcinkowski and Reid (2019) define attitudes as a person's evaluative dispositions and judgments about an 'object' (e.g. a being, thing, event, idea, issue, or action) that are derived, at least in part, from their experience or situation. They are usually considered from a multi-dimensional approach, where assessments are influenced by cognition as well as by beliefs and affections (van der Pligt, Zeelenberg, van Dijk, de Vries & Richard, 1997). The study of environmental attitudes is crucial because it helps us to understand behavioural intention, even though its influence depends on internal variables and external ones such as surroundings and circumstances (Heberlein, 2012), where socialisation processes and experiences with other people are especially relevant (Bohner & Wanke, 2002).

In environmental education research, it is common to draw on a variety of attitude scales (Varela *et al.,* 2016) to investigate this topic (Ardoin *et al.,* 2018). The New Ecological Paradigm (NEP) scale is probably the most recognised, being used in studies around the world and with different types of samples (Dunlap, 2008). The Two Major Environmental Values (2-MEV) scale (Schneller et al., 2015) or the Motivation Toward the Environment (MTE) scale (Pelletier et al., 1998) are also noted. Recently, other scales have emerged with more current approaches, such as that of Biasutti and Frate (2016), which considers the three dimensions of sustainable development, or that of Olsson et al. (2020) which focuses on action competence. Also in this more innovative line, it is interesting to consider the scales designed specifically for university students and early career teachers, such as that of Tuncer Teksoz et al. (2014), on the identity or value formation aspects (Prati *et al.,* 2017), or on the longitudinal aspects (Shephard *et al.,* 2015).

Such attitude-behaviour scales are also used in a significant number of studies of the attitudes of teachers with regard to the environment (Marcinkowski & Reid, 2019). We can also identify different examples of present-day studies aimed at evaluating teachers' awareness of specific environmental problems. Their results generally show that teachers may have high levels of positive attitudes towards the environment, such as those obtained by Aznar *et al*. (2019) and Palmberg *et al*. (2018) in relation to biodiversity; Moggias (2015), focusing on oceanic problems, or Boon (2016) on Climate Change. However, these studies also show important weaknesses insofar as teachers' positions are concerned:

(i) they do not always consider which attitudes are problematic or absent for GEC, as shown by Alkaher and Carmi (2019), who warn that teachers without specific training do not consider the exponential growth of the population a problem;

(ii) sometimes teachers underestimate the wider aspects of GEC when dealing with GEC-related problems in class, as shown in the research by Palmberg *et al*. (2018) with regard to biodiversity, or

(iii) GEC problems are not dealt with properly, as pointed out in the study by Herman, Feldman and Vernaza (2015) regarding the lack of a global approach from social, political and economic angles when dealing with Climate Change.

Finally, in reviewing the literature base, it is also notable that few studies tackle attitudes related to the GEC phenomenon as a whole, as this has only been detected, represented and contextualised as such recently. Therefore, in this context, the main aim of this study was to construct and validate an attitude scale on the subject of GEC (the "SGEC"), to include aspects related to awareness of its origin, the need for it to be addressed, and the attribution of responsibilities in solving and mitigating it, which could contribute towards improving the education of both teachers and the public.

Materials and methods

Design of the initial questionnaire

We began the design process by carrying out a literature review of related instruments assessing the subject matter. In order to draw up the initial questionnaire, meetings were held with experts (specialists in the areas of environmental education, psychology and sustainability) to assess the scales and what was drafted as an initial proposal of items for the SGEC.

In the first selection, a Likert-type pilot scale was compiled, drawn from 81 ordinal-type items with five levels of response. This was administered to a small sample of Pre-service Primary Teacher Education degree students (N=11). The categories the items addressed mapped onto the dimensions involved in the concept of Sustainability (Society-Economy-Education-Environment) (UNESCO, 2005) and are shown in Table 1. The pilot group students were asked to indicate if any item was problematic in terms of phrasing and response, and the reason(s) why.

Table 1. Themes addressed by the items in the initial questionnaire.

Society and Environment	Causes of GEC, Perception of the gravity of GEC, Necessary changes (adaptation and mitigation), Individual and social responsibility, Sustainable lifestyles
Economy and Environment	Development model, Environmental and social consequences, Fairness of said consequences, Progress/Growth vs. Wellbeing/Quality of Life, Resource exploitation and use, Production and consumption model
Education and Environment	Educational aims, Priority of treatment of socio-environmental problems in the classroom, Development of sustainable skill sets (reflection, critical thinking, participation, decision-making), School-Community relationship

Feedback from this exploratory phase led to some items being redrafted. Furthermore, an introductory note that explained the meaning of the term GEC was added. The SGEC instrument after piloting then, was an 80-item scale in which the respondent was required to show their level of agreement or disagreement (Blanco, Sanz & Vallejo, 2003) by choosing one from among five response options.

Sample and administration procedure

The sample used to validate the SGEC comprised 962 Pre-School and Primary School Teacher Education students from three faculties in the Spanish university system (78.8% female and 21.2% male). 65.5% were under 22 years of age, 32.1% between 22 and 30 and 2.4% were over 30. With respect to the degree course being studied, 54.3% were studying Primary Education, and 45.7%, Pre-school Education. By year, 20.9% were first year students, 39.7% second year, 34.0% third year and 5.1% fourth year. The school focus was Humanities and Social Sciences in 66.6% of cases, Science and Technology in 29.4% of cases, and Arts in 1.9%.

The questionnaires were administered in paper form, amongst students in all years of the two degree courses being studied at both universities in the 2018/2019 academic year, using non-probability convenience sampling. Students in class answered anonymously and voluntarily, and in the presence of members of the research team or collaborating lecturers. Student participation was very high; almost all responded to the questionnaire when administered.

In order to draw up the scale in paper form, the optical mark recognition software SDAPS version 1.1.7 for Linux was used. The software was also used for the recognition of responses and automatic processing carried out was checked for accuracy.

Prior data analysis

Data examination is a necessary initial step in multivariate analysis (Hair, Black, Babin & Anderson, 2010). We used SPSS 20 for Windows, the same program with which the rest of the statistical analyses in this study were conducted, except where otherwise stated.

The missing data analysis showed that it was limited to a very small amount. Only in 4 of the 80 variables did its percentage exceed 2%, without ever reaching 4%. Therefore, no item variable was removed for having too many missing values. However, the missing data were spread out among the responses of 38.4% of participants. This is a disadvantage, as various relevant statistical procedures are not applicable if there is any missing value in any item. As Cheema (2014) points out, the missing data problem is common in educational research studies based on questionnaires, and there are general guidelines to address large gaps. However, with ordinal data, there are few procedures available to address absence (Quintero & LeBoulluec, 2018). Chen (2018) indicates that suboptimal strategies are often the only ones available. Here, we chose an imputation procedure, estimating the missing values on the basis of the valid ones. Little’s test was significant ($p=0.027$), and as such the strong assumption that data are missing completely at random (MCAR) was not fulfilled. Under these conditions, using maximum likelihood has the advantage of being applicable under weaker assumptions (Agresti, 2010), and therefore an expectation-maximisation algorithm was used for imputation, an interactive procedure that produces maximum likelihood estimates (Graham, 2009).

A search for atypical cases was also made, but none were found (the anomaly index did not exceed the cut-off value of 2), and therefore no case was removed based on this criterion.

Validation and calibration of the questionnaire

The original sample (N = 962) was divided into two random subsamples made up of 481 individuals (subsamples N_1 and N_2). An exploratory analysis was carried out with the former in order to draw up a model of the main dimensions involved, and the latter was used to carry out a confirmatory factor analysis.

For the exploratory factor analysis of internal consistency, we used the program Factor 10.10.01, developed at Rovira i Virgili University (Spain), as it includes many useful features, not all of which are available in SPSS. In particular, it allows the use of additional techniques to study the number of factors to be extracted, and was also utilized to calculate the glb (*greater lowest bound*, Woodhouse & Jackson, 1977) and Ω coefficients. The confirmatory factor analysis was performed with AMOS 21.

Subsequently, the definitive questionnaire was drawn up, of which proof of reliability and validity are shown below, and the underlying factor structure is analysed.

We tested several forms of validity:

- *Content validity* is understood as the degree to which the items chosen represent a suitable sample and representation of the content studied.
- *Convergent validity* is understood as the extent to which various different approaches to construct measurements yield similar results. There are several methods that can be used for this purpose. We: 1) investigated the factor loadings, which should be higher than 0.5 (Anderson & Gerbing, 1988) and, 2) used the values of the NFI (Normed Fit Index) and the NNFI (Non-Normed Fit Index) (Ahire, Golhar, & Waller, 1996), which should be higher than .9.
- *Discriminant validity* is understood as the degree to which two conceptually similar concepts are distinct. The absence of crossed saturations in the factor structure is taken to be evidence of discriminant validity (Hair *et al*., 2010), as this implies that all of the individual items form a part of a single factor. As Das (2017) points out, if correlations between constructs are less than .9, it is unlikely that a group of loading items in one construct will also load in another. We also used an approach based on the multitrait-multimethod matrix to assess discriminant validity: the Heterotrait-monotrait (HTMT) ratio of correlations

(Henseler, Ringle, & Sarstedt, 2015). Henseler et al. (2015) propose the superior performance of this method by means of a Monte Carlo simulation study and found that HTMT is able to achieve higher specificity and sensitivity compared to the cross-loadings criterion and Fornell-Lacker (Hamid, Sami, & Sidek, 2017). The exact threshold level of the HTMT is debatable; Clark and Watson (1995) and Kline (2011) suggest a maximum acceptable threshold of .85, while Gold, Malhotra & Segars (2001) as well as Teo, Srivastava and Jiang (2008) propose .90.

Before construct validity can be assessed, we also needed to establish a measure of reliability and internal consistency of the measured variables representing each latent construct, the Construct Reliability.

The steps are summarised in Figure 2.

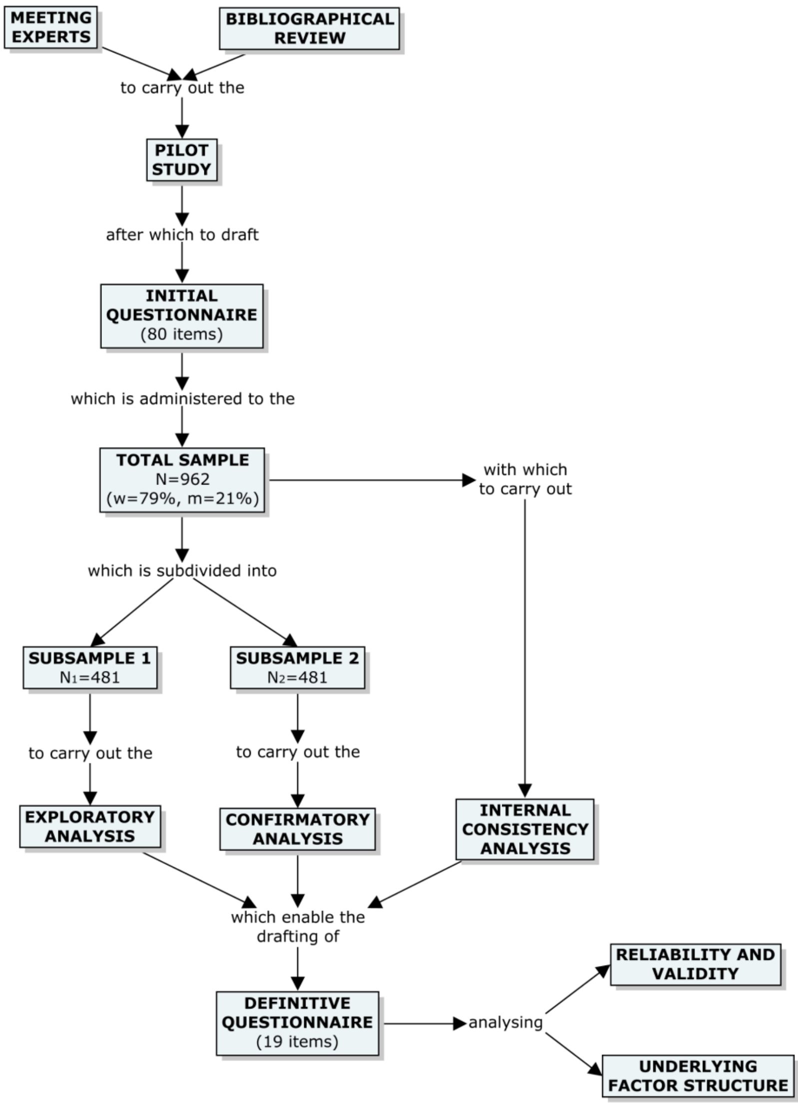

Figure 2. Steps followed in the study

Results

Reliability analysis

Having used the instrument with the entire sample and evaluated the reliability and possible factorial solutions, 19 items were chosen for the definitive version of the instrument (Table 2).

The following points were taken into account in the selection of these items:

- Removing items with high skewness is recommended, with different criteria available on which to base the decision. An absolute skew value larger than 2 may be used as a reference value for determining substantial non-normality (George & Mallery, 2010), and consequently the variables in which this value is exceeded were removed.
- Items whose presence significantly reduced the reliability of the instrument were eliminated (Table 2, column α_w).
- Items that were not included in well-defined factors were removed.
- Items whose association with others did not generate clear or relevant interpretation factors were deleted.

The items selected for the final scale meet these criteria. However, it is important to note that the process of selecting items is not reached solely by a defined algorithm, but involves making different trials of removing and adding factors. When the initial exploratory analysis was carried out, numerous items appeared that were not sufficiently related to others or that diminished the reliability of the scale. However, the elimination or addition of an item affects all the points indicated in the previous criteria (except the items with high skewness), and an item that is a candidate for elimination, may become relevant at a later time. Therefore, we followed the recommendation that the item selection process is carried out by experts familiar with techniques for looking for the appearance of differentiated and relevant factors, making tests of suppression and addition of variables based on their knowledge.

Table 2. Descriptive statistics and internal consistency analysis

ITEM	ITEM CONTENT	M	SD	r	α_w
i1	The solution to environmental problems lies in educating communities to find more conscious and austere lifestyles.	3.83	.96	.36	.810

i2	Integrating education on Climate Change in schools must be a priority.	4.49	.77	.55	.802
i3	Changing fossil fuels for renewable energy sources can halt the global environmental crisis.	4.01	.89	.37	.809
i4	Addressing climate challenges requires training specialist scientists in the search for technological solutions to Global Environmental Change.	4.03	.90	.45	.805
i5	Protecting the environment must be a priority criterion when voting for a particular political party.	3.95	.96	.50	.802
i6	I think that including environmental education in the school curriculum can contribute towards changing the entire community's behaviour.	4.51	.72	.60	.800
i7	Climate variations will force us to change our way of life in just a few years.	4.37	.77	.46	.806
i8	Pre-school and primary education must prepare pupils for the challenges posed by Global Environmental Change.	4.44	.77	.42	.808
i9	It is important to deal with the changes that occur in the chemistry of the oceans.	4.55	.71	.51	.804
i10*	It is possible to reduce social inequalities without changing our current socioeconomic model.	3.96	1.09	.24	.818
i11	The long-term decisions we make should take into account the future effects of Global Environmental Change.	4.42	.72	.53	.803
i12	I will not buy products from companies that pollute the environment.	3.52	1.00	.36	.810
i13	I have made the decision to mobilise against Climate Change.	3.32	1.05	.32	.813
i14	I am prepared to make sacrifices in order to fight against Global Environmental Change.	4.14	.83	.48	.804
i15*	I prefer a cheaper product even though I might know that it has been manufactured irresponsibly.	4.00	1.06	.37	.810
i16*	It seems to me that people, at individual level, contribute	3.42	1.26	.27	.819

	insignificantly to the increase in greenhouse gases.				
i17*	Climate Change is a natural phenomenon.	3.82	1.18	.30	.816
i18*	Human beings do not have an important effect on the variability of the planet's conditions.	4.19	1.15	.35	.811
i19	Climate Change is directly related to human activity.	4.32	.81	.41	.808

Notes: M = mean; SD = standard deviation; r = correction item-total correlation; α_w = Cronbach's alpha coefficient if the item were removed. The level of agreement with the items shown ranges from 1 (minimum agreement) to 5 (maximum agreement). The asterisks indicate that the responses to the item have been re-coded by inverting their order, in such a way that, for example, a score of 1 for a response to a specific question is recoded with a 5.

The internal consistency of the scale was adequate (α = .817). Other coefficients were also used to assess reliability (Ω and glb) because the use of α as the only reliability indicator has been criticised (Peters, 2014; Revelle & Zinbarg, 2009). The Ω coefficient, unlike the alpha coefficient, works with factor loadings (Gerbing & Anderson, 1998), which are the weighted sum of the standardised variables. This is a transformation that makes the calculations more stable (Timmerman, 2006) and it does not depend on the number of items, as occurs with the alpha coefficient (McDonald, 1999). For its part, the glb represents the minimum reliability possible given the observed covariance matrix (Ten Berge, Snijders & Zegers, 1981). These coefficients must only be used with large samples, as is the case here, due to a positive sampling bias (Ten Berge & Socan, 2004). For the SGEC, it was calculated that glb = .894, which would indicate that its true reliability has a value in the interval [.894; 1] (Sijtsma, 2009). On the other hand, it is computed that Ω = .855, a value that is greater than α, which is generally the case (McDonald, 1978). Overall, these results show that internal consistency is good.

Exploratory analysis

The original sample (N = 962) was divided up into two random subsamples (N_1=481, N_2=481). With regard to the former, an exploratory analysis was performed in order to draw up a model of the main dimensions involved and the latter was used to carry out a confirmatory factor analysis.

Previous contrasts were used to evaluate the appropriateness of factorising the variables. The KMO sampling adequacy measure was .863 and Bartlett's sphericity has a significance level of .000, both results indicating that the methods to be used are appropriate. Therefore a principal components analysis with Promax rotation was performed with a Kappa value=4, as recommended by its creators, Handrickson and White (1964). An oblique rotation was used since the resulting factors are expected to be correlated with each other. This was checked later to ensure that the choice of rotation type was appropriate.

Numerous statistics and criteria exist in literature to decide upon the number of factors to extract, none of them having been shown to behave unequivocally in any situation. We chose to use the Kaiser–Guttman criterion (eigenvalues > 1), and on the basis of the aforementioned exploratory analysis 4 factors that explain 46.7% of the total variance were proposed. Their eigenvalues and the common variance that they explain are shown in Table 3. The Factor program was also used to carry out the Parallel Analysis based on factor analysis using the minimum sample size (Timmerman & Lorenzo-Seva, 2011) for estimating the correlation matrix and the Hull method for selecting the number of common factors (Lorenzo-Seva, Timmerman, & Kiers, 2011). We used this software in this situation because these analyses are not available in SPSS. The Parallel Analysis and the Hull method indicated in both cases that only one factor should be retained. This circumstance were taken into account when carrying out the confirmatory analysis, in order to evaluate whether the option chosen (4 factors) is preferable to the single-factor option.

Table 3. Extracted dimensions

DIMENSION	CODE	NUMBER OF ITEMS	EIGENVALUES	% EXPLAINED VARIANCE
Social Responsibility	SR	6	4.9	25.9
Need to Cope	NC	5	1.6	8.3
Individual Responsibility	IR	4	1.2	6.5
Anthropogenic Origin	AO	4	1.1	6.0

Since it is desirable that the factors represent differentiated attitudes, whether the factor loadings ensure practical significance should also be checked. Following Hair et al. (2010) with N>350, a factor loading of .30 or higher is considered significant ($p < .05$) to obtain a power level of 80 percent, so it would be minimally acceptable. However, values greater than ±.50 are generally considered necessary for practical significance, so we try to bring them close to this value, if possible. That said, it may be premature to discard an item because such a value is not reached. As Hair et al. (2010) point out, statistical tests of significance for factor loadings are generally conservative and should be considered only as starting points needed for including a variable for further consideration. On the other hand, it is important to avoid cross-loadings, that is, a variable with several significant loadings, so a variable with cross-loadings should be a candidate for deletion. Considering all of the above, the items of each factor satisfy the following criteria:

- Saturation of the item in the principal factor > .430.
- Saturation of the item in the other factors < .330.
- Saturation difference between the principal factor and the rest > .150.

Table 4 shows the configuration matrix.

Table 4. Configuration matrix after performing the principal components analysis and promax rotation

ITEM	**ITEM CONTENT**	**FACTOR SATURATION OF THE ITEM**			
		SR	**NC**	**IR**	**AO**
i1	The solution to environmental problems lies in educating communities to find more conscious and austere lifestyles.	**.865**	-,247	-,065	,012
i2	Integrating education on Climate Change in schools must be a priority.	**.589**	,217	,070	-,049
i3	Changing fossil fuels for renewable energy sources can halt the global environmental crisis.	**.584**	-,126	-,103	,321
i4	Addressing climate challenges requires training specialist scientists in the search for technological solutions to Global Environmental Change.	**.576**	,102	-,048	-,007

i5	Protecting the environment must be a priority criterion when voting for a particular political party.	**.558**	,029	,213	-,072
i6	I think that including environmental education in the school curriculum can contribute towards changing the entire community's behaviour.	**.454**	,293	,136	-,037
i7	Climate variations will force us to change our way of life in just a few years.	-,156	**.808**	,076	-,058
i8	Pre-school and primary education must prepare pupils for the challenges posed by Global Environmental Change.	,178	**.621**	-,013	-,192
i9	It is important to deal with the changes that occur in the chemistry of the oceans.	-,021	**.621**	-,008	,176
i10*	It is possible to reduce social inequalities without changing our current socioeconomic model.	-,105	**.620**	-,261	,085
i11	The long-term decisions we make should take into account the future effects of Global Environmental Change.	,124	**.585**	,021	,088
i12	I will not buy products from companies that pollute the environment.	,047	-,115	**.817**	-,075
i13	I have made the decision to mobilise against Climate Change.	-,038	-,140	**.803**	,026
i14	I am prepared to make sacrifices in order to fight against Global Environmental Change.	,157	,087	**.501**	,099
i15*	I prefer a cheaper product even though I might know that it has been manufactured irresponsibly.	-,114	,242	**.431**	,123
i16*	It seems to me that people, at individual level, contribute insignificantly to the increase in greenhouse gases.	-,201	-,060	,260	**.679**
i17*	Climate Change is a natural phenomenon.	,161	-,064	-,095	**.670**
i18*	Human beings do not have an important effect on the variability of the planet's conditions.	,000	,111	-,055	**.648**
i19	Climate Change is directly related to human activity.	,102	,130	,001	**.461**

Note: Sphericity test = .000; KMO = .863. The asterisks indicate that the responses to the item have been recoded by inverting their order.

Therefore, the results of the exploratory analysis show a factor structure with four well-defined factors. These were correlated with each other, and all the correlations between the pairs of factors were statistically significant ($p < .01$). Their sizes were between .27 and .52, which is, therefore, low or moderate in size. These findings confirms the appropriateness of the choice of an oblique rotation, rather than an orthogonal one.

Confirmatory analysis

The second sub-sample (N_2=481) was used to perform the confirmatory factor analysis. This analysis was carried out with AMOS 21 software using the method of maximum likelihood estimation. To determine the number of factors to retain, three models were considered:

- M1: a single factor, as the results of the Parallel Analysis and the Hull Method indicated (calculated with the Factor program).
- M2: four unrelated factors (following the Kaiser-Guttman criterion).
- M3: four interrelated factors (following the Kaiser-Guttman criterion).

Several fit indices were calculated in order to assess which model was the most suitable. Using several of such indices to evaluate the models is recommended (Markland, 2007; Hooper, Coughlan & Mullen, 2008). Thus, a combination of absolute and relative fit indices was used here (Table 5), the analysis of which will enable us to choose between the models available.

Table 5. Fit indices of the models

Model		Fit indices							
		χ^2	p	χ^2/gl	AIC	CFI	RMSEA 90% CI		
M1	Single factor	476.28	.000	3.11	588.28	.827	.066	[.060	.073]
M2	Four unrelated factors	713.19	.000	4.69	827.19	.700	.088	[.081	.094]
M3	Four interrelated factors	268.75	.000	1.84	394.75	.934	.042	[.034	.050]

Note: Sub-sample 2 (N_C = 481)

In the three models the χ^2 test was significant, which would suggest that the theoretical models are not an adequate fit to the data. However, the result of this test will be affected by different factors, including the sample size, making it very difficult to obtain a non-significant result when the sample size is big (Jöreskog & Sörbom, 1993).

The value of χ^2 divided by degrees of freedom was used to reduce χ^2's sensitivity to the sample size. Different acceptable maximum values have been proposed for this statistic (it is perfect if its value is 1). Tabachnick and Fidell (2007) consider values lower than 2 to be correct values, and Hu and Bentler (1999) those lower than 5. Using this heuristic method, M3 would have the best fit (χ^2/df_{M3} = 1.84). M1 and M2 would not exceed the strictest criterion, the value of the former being a better fit (χ^2/df_{M1} = 3.11; χ^2/df_{M2} = 4.69).

The Akaike Information Criterion (AIC) was used to estimate the relative quality of a model with respect to others, based on the relative quantity of information that is lost when using a given model (Akaike, 1974). The smallest values indicate a better fit and a more parsimonious model, but it cannot be used to evaluate the quality of a model in an absolute sense, rather it serves to compare models. In the case of those studied, the AIC is lower in M3, which suggests that it is the model with the best goodness of fit of the three. The second best model in this sense would be M1, followed by M2.

Bentler (1990) developed the CFI (Comparative Fit Index) on the basis of a previous index (BFI) which he corrected so that its values would range between 0 and 1, indicating a better fit the higher its value. It compares the χ^2 of the model proposed with an independent model which maintains that there is no relationship between the different variables, correcting the calculation with the degrees of freedom. Bentler (1990) indicates that a value higher than .90 is acceptable, and Hu and Bentler (1999) recommend a value higher than .95 in order to guarantee a higher fit. The value of the CFI calculated for M3 was acceptable (CFI_{M3} = .934), whereas it was not for the models M1 (CFI_{M1} = .827) and M2 (CFI_{M2} = .700).

The RMSEA index reflects the fit of the model, with unknown parameters but estimated optimally, to the population covariance matrix (Byrne, 1998). It favours parsimonious models taking into account the proportion of variance unexplained by the model per degree of freedom. Hu and Bentler (1999) indicate that values lower than .05 are good and lower than .10, acceptable. Using this criterion, the RMSEA value is acceptable in M1 ($RMSEA_{M1}$ = .066) and M2 ($RMSEA_{M1}$ = .088), and good in M3 $RMSEA_{M3}$ = .042).

All of the above indicates that of all those put forward, the 4 interrelated factors model is the best, which is why we decided to retain it (Figure 3).

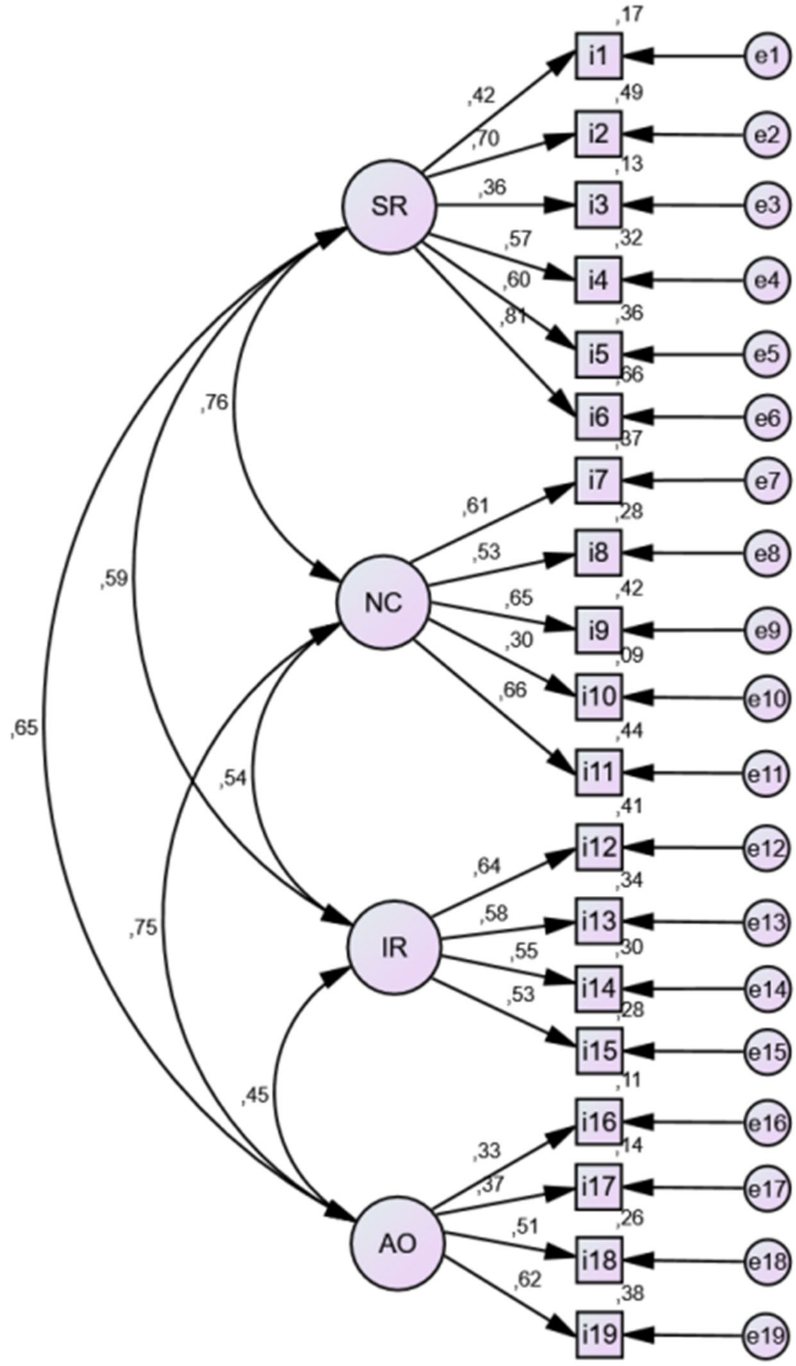

Figure 3. Confirmatory factor analysis

Note: (N_2 = 481). χ^2 = 268.75; p < .000; χ^2/gl = 1.84; AIC = 394.75; CFI = .934; RMSEA = .042 [.034 .050].

Validity evidence

As can be seen in Table 6, good values are found for Construct Reliability in SR and acceptable ones in NC and IR, while in AO the value is somewhat lower than would be desired, in accordance with the criteria shown by Hair et al. (2010). However, it should be taken into account that the AO factor consists of few items, and the CR value will be affected to a large extent by this circumstance (Valentini & Figueiredo, 2016).

Content validity

Content validity must be judged both qualitatively and quantitatively. With regard to the first point, the representativeness and technical correctness of the items, as well as the specific definition of the domain, were supported in the bibliographical review and by the judgement of experts. The questionnaire was constructed via meetings with experts who proposed candidate items related to the topics of interest. The item selection process carried out during the exploratory analysis was also conducted by the same groups of experts, in order to assess the theoretical appropriateness of the various factorial solutions. Empirical analysis is also needed to assess aspects such as unidimensionality and convergent validity (Hair *et al.*, 2010). We provide relevant evidence in this sense (unidimensionality of constructs, convergent validity...) as follows:

Convergent validity

Four items had higher than .700 factor loadings, and only three items did not reach a value of .500, while all of them exceeded .400. Therefore, the factor loading exceeded the recommended cut-off point, except in three cases. We also performed an analysis of convergent validity of each individual construct with two goodness-of-fit indices, the NFI and the NNFI (Das, 2017). Table 6 shows that the NFI ranges from .959 to .972 and the NNFI from .896 to .966, which suggests a satisfactory convergent validity of the constructs.

Discriminant validity

The inexistence of crossed saturations in the factor structure proposed is evidence of discriminant validity (Hair *et al*., 2010), as this implies that all of the individual items form a part of a single factor. Furthermore, none of the correlations between factors comes close to .9 (the highest is .52), which also supports the existence of this type of validity (Kline, 2011). The last method we used was HTMT analysis, calculated using the formula provided by Henseler, Ringle and Sarstedt (2015). Table 7 shows that the HTMT values were adequate, which supports the existence of discriminant validity.

Table 6. Assessment of reliability and convergent validity of the constructs

Construct	Number of items	Construct Reliability	NFI	NNFI
Social Responsibility (SR)	6	.756	.963	.961
Need to Cope (NC)	5	.691	.962	.949
Individual Responsibility (IR)	4	.664	.959	.896
Anthropogenic Origin (AO)	4	.519	.972	.966

Table 7. HTMT results

Construct	Social Responsibility (SR)	Need to Cope (NC)	Individual Responsibility (IR)	Anthropogenic Origin (AO)
Social Responsibility (SR)	-	-	-	-
Need to Cope (NC)	.86	-	-	-
Individual Responsibility (IR)	.72	.59	-	-
Anthropogenic Origin (AO)	.84	.74	.49	-

Discussion and conclusions

The results of the analysis of the SGEC scale show that it is an instrument with good internal consistency (α = .817, glb .894 and Ω = .855). Furthermore, the exploratory and confirmatory analyses reveal a factor structure with four well-defined interrelated factors.

The SR factor was related to social responsibility in the mitigation and adaptation of GEC, which requires the involvement of citizens/communities, the political sphere, the scientific and technological field, and the educational environment. People, and of course, educators, must be aware of the need to create and promote an environmental citizenship which shares a social responsibility, removed from the individualisation encouraged by neo-liberal societies (Aarnio-Linnanvuori, 2019). Therefore, this factor provides information on people's attitudes towards social solutions, such as the development of more conscious (Ferreira, 2013) and austere communities (Jackson, 2009) or the search for political leaders (Vanderheiden, 2008) with environmental values (Ratzell, 2009) and techno-scientific solutions, such as changes in energy production and the training of experts (Stern, 2007). Both are clearly linked to educating citizens, which must encourage responsibility, critical thinking and participation (Varela-Losada *et al.*, 2015), enabling them to look for means of social and technological mitigation and adaptation within a framework of Sustainability (Ernst *et al.,* 2017).

The NC factor refers to awareness of the need for change in order to tackle GEC. It provides data on awareness of present-day and future consequences of our development model for the natural environment (the atmosphere, oceans) and for the social environment (way of life, inequalities), which international bodies guarantee (IPCC, 2014; UNDP, 2018). It also provides information on people's attitudes when it comes to dealing with GEC (through education, consequential decision-making and changes to the socio-economic model). In this way, this factor is important because it helps us to know whether respondents are aware of the importance of education in facing the environmental challenge, which has to make society more resilient to the changes the future will bring (Worldwatch Institute, 2017), and where consequential decision-making is fundamental (Mogensen & Mayer, 2005). Räthzel and Uzzell (2009) argues that change must be guided by decisions with a view to the future, and be critical towards current policies, which are based on the moment and typically represent the opposite of what radical sustainability pathways require (see also Huckle & Wals, 2015). Furthermore, this factor gives us clues as to whether or not people are aware of the need to change the current socioeconomic model, which is the main cause of socio-environmental problems, and the lifestyle it promotes (Stiglitz, 2015).

The IR factor includes elements relating to individual responsibility, as change must come from within society but encouraged by individuals by empowering them (Sauvé, 2017). It is essential to encourage awareness of the importance of specific relevant actions in individuals' daily lives (Kuthe *et al.*, 2019). However, some studies show how businesses, administrations and politicians are usually made responsible for environmental problems (Manolas & Tampakis, 2010) when searching for reasons behind a lack of individual mobilisation. Literature also shows the reluctance and low motivation of students to act on the solution of socio-environmental problems Skamp, Boyes, & Stanisstreet, 2013), which can be combated in schools (Lehnert et al., 2020). To this end, this factor can provide information on respondents' tendencies towards activism (Arnold, Cohen & Warner, 2009), their stance in the face of the need to make more conscious and austere lifestyle changes (Chavez, 2017) and a way of making decisions that leads to responsible actions (Stevenson & Stirling, 2010).

The AO factor, whose items provide information relating to awareness of the anthropogenic origin of GEC, also include items with regard to Climate Change. Transnational studies reveal considerable levels of scepticism as to the origin and scope of socio-environmental problems such as Climate Change (Tranter & Booth, 2015), relating it to factors such as gender, political orientation or environmental awareness (McCright *et al.*, 2016). This lack of confidence could be linked to the mobilisation of certain sectors of society to defend the industrial capitalist order in the face of warnings from environmentalists and scientists (McCright *et al.,* 2013). The amount of false information and fake news that can be found on the Internet with regard to environmental problems such as Climate Change that influences readers, students and educators has also been well documented (Bentley *et al.*, 2019).

In light of the above, the SGEC scale, focused on a recently-conceptualised phenomenon, is a novel instrument that can encourage new lines of research to tackle understandings about mitigation of and adaptation towards the GEC, bearing in mind the social, economic and educational dimensions that are involved in the search for Sustainability (UNESCO, 2005). The GEC cannot be dealt with as if it were solely a techno-scientific problem, but rather it requires a social and participatory approach. In addition, as opposed to other scales with more classical approaches, this one starts from a paradigm which is critical of the current development model and reflects the complexity required by the treatment of socio-environmental problems, so that the items included attempt to surface conflicts in attitude to avoid socially desirable responses (Crowne & Marlow, 1960).

From this perspective, the SGEC scale provides us with relevant information on three key elements: *Are we aware of human responsibility for the planet's deterioration? Are we aware of the need to tackle this serious problem? Are we aware of the necessary social and individual measures required to mitigate the problem and adapt to change?* Therefore, this tool can be useful for advancing the role of education in tackling GEC, providing clues for the design of initiatives that address a more conscious search of the worldview on the part of students (Gough, 2016), the promotion of responsibility and empowerment of individuals (Aarnio-Linnanvuori, 2019), and the development of the skills needed for social transformation (UNESCO, 2015). SGEC can also help us determine and improve people's positions with regard to their ways of acting, without ignoring the fact that environmental action is a complex and multifactorial process (Wals, Brody, Dillon & Stevenson, 2014), which, as we accept, requires a complex approach.

Therefore, we recommend undertaking further qualitative and quantitative studies, and with different types of samples, that would help examine the significance of the instrument testing results in more depth. It is also necessary to take into account that in this type of study, technical limitations always appear, and in our case, while it can be said that the model proposed accounts for a significant percentage of common variance (46.7%), it would have been desirable for it to be even higher. Furthermore, two of the factors consist of four items, when at least five would be a more suitable number to increase the construct reliability values, in particular that of the AO factor. Nevertheless, the factors found emerged clearly against various tests of significance, which is why we have chosen to maintain the proposed model. It remains though, that the common practice (Liddell & Kruschke, 2018) of treating scale data as metrics, when in fact they are of ordinal type, has been followed. This is not necessarily problematic when you have five or more levels of response, as in this study. However, one option to consider would be to use ordinal data analysis techniques, which in certain circumstances may be more robust (Rhemtulla et al., 2018). Finally, sampling was non-probability-based, even though the sample was large.

Finally, we recognise that the SGEC was developed with a cohort drawn from the next generation of teachers in Spain, but could be tested further with other institutions and cohorts. It remains though, that the use of the SGEC by the pre-service teachers, their educators and the institutions in which they work can raise wider discussions about GEC and Sustainability, and their roles as providers of citizenship-focused education. Thus it is not simply a technical exercise to create and validate the SGEC, but can be used as part of ongoing conversations and initiatives aligning education with community action that fosters capacity building to deal with current and future socio-environmental challenges.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Mercedes Varela-Losada is assistant professor at the Faculty of Educational Sciences and Sport at the University of Vigo (Spain). Her research interests focus on Environmental Education and Sustainable Development, Climate Change, Science Teaching and innovative teaching methodologies.

Uxío Pérez-Rodríguez serves as associate dean of the Faculty of Education and Sport Sciences of the University of Vigo (Spain). He is a Professor of Experimental Science Education. His current research interests include problem-based teaching methodologies, Astronomy teaching and Environmental Education.

María A. Lorenzo-Rial is interim lecturer at the Faculty of Education and Sports Sciences, University of Vigo, in the area of Didactics of Experimental Sciences. Her current research interests include Education for Sustainability and, in particular, Ocean Sustainability, Science Teaching, the use of ICTs and problem-based teaching methodologies.

Pedro Vega-Marcote is professor at the Faculty of Educational Sciences at the University of Coruña (Spain). Currently his research interests focus on: Teacher training in Environmental Education and Sustainable Development, the Ecological Footprint and reduction of emissions of Greenhouse Gases, the implementation of

Agenda 21 at the University and Municipalities (A21L), and Experimental Science Teaching.

Alan Reid edits the international research journal, Environmental Education Research, and publishes regularly on environmental and sustainability education (ESE) and their research. Alan's interests in research and service focus on growing traditions, capacities and the impact of ESE research. A key vehicle for this is his work with the Global Environmental Education Partnership, and via NAAEE's eePRO Research and Evaluation. Find out more via social media, pages or tags for eerjournal.

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