International Journal of Educational Research Open 7 (2024) 100388

Contents lists available at ScienceDirect

International Journal of Educational Research Open

journal homepage: www.elsevier.com/locate/ijedro

Development and validation of a multiple-choice test for sustainability competence in primary school using the GreenComp framework

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ARTICLE INFO

Keywords:
GreenComp
Sustainability competence
Instrument validation
Primary education assessment
Validity
Reliability

ABSTRACT

There is no standardized definition or measurement tool for sustainability competence, which hinders comparative research. This study addresses this gap by developing a new test based on the European reference framework GreenComp. The proposed instrument, consisting of eleven multiple-choice items, was validated through expert review and exploratory and confirmatory factor analysis, showing strong construct validity and high internal consistency reliability. Applied to students aged 8 to 12, it revealed a prevalence of basic and anthropocentric perspectives on sustainability. This promising tool can assess sustainability competence in primary education and has the potential for use across European countries.

1. Introduction

Research on sustainability competencies has surged recently. This trend stems from two main factors. Firstly, international policy increasingly emphasizes sustainability, influenced by organizations like the United Nations (UNESCO, 2017). Secondly, there is a rising public movement advocating for development models that prioritize human well-being and environmental concerns (Asara et al., 2015; Kaul et al., 2022). This situation places significant responsibility on educational institutions and policymakers to equip individuals with the skills and knowledge necessary for a sustainable future (Chankseliani & McCowan, 2021; Pegalajar et al., 2022).

The United Nations Education Scientific and Cultural Organization (UNESCO) defines sustainability as "prioritizing the needs of all life forms and the planet by ensuring that human activity does not exceed planetary boundaries" (Bianchi et al., 2022, p. 12). According to this framework, sustainability competence involves integrating sustainability principles into education from an early stage. Individuals with this competence can think, plan, and act with sustainability in mind. The framework emphasizes lifelong learning across formal, informal, and non-formal education. It highlights the need to cultivate sustainability competence from early childhood and continuously nurture it throughout life. Researchers like Annelin and Boström (2023) stress the importance of developing these competencies in an integrated manner to achieve a holistic approach to sustainability problem-solving.

Despite numerous frameworks and assessment methods for measuring sustainability competencies (Annelin & Boström, 2023; Brundiers et al., 2021; Redman et al., 2021), a major challenge remains: the lack of standardization. Current assessments often define competencies so differently that comparisons are difficult (Montanari et al., 2023). Additionally, there is a lack of measurement instruments specifically designed for primary school students. This study addresses this gap by developing and assessing the psychometric properties of a new instrument based on the European GreenComp framework. It also provides baseline data on its use by gender and grade level. The GreenComp framework offers a robust foundation for measuring sustainability competence that can be generalized across European Union (EU) countries, as it is the reference framework for sustainability competence. Furthermore, this study is the first to apply the GreenComp framework within primary education, making it a timely and novel contribution that paves the way for standardized measurement in this crucial educational stage. The proposed instrument aims to serve as a reference tool for educators and researchers. It helps identify primary school students' sustainability competence, enabling targeted educational interventions to address specific areas where students lack proficiency.

1.1. The GreenComp framework

This article introduces a new instrument designed to align with the European GreenComp recommendations for assessing sustainability competence (Bianchi et al., 2022). The GreenComp framework uses interchangeably terms such as sustainable competence, green

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https://doi.org/10.1016/j.ijedro.2024.100388
Received 17 April 2024; Received in revised form 16 September 2024; Accepted 18 September 2024
Available online 25 September 2024

competence or green skills -which is common in the literature (Montanari et al., 2023), and defines this competences as the ability to engage thoughtfully, strategically, and empathetically with sustainability issues, driven by a sense of responsibility and concern for planetary well-being. To achieve this, the framework outlines four key areas: embodying sustainability values, embracing complexity, envisioning sustainable futures, and acting for sustainability. These areas encompass twelve specific competencies that map onto the eight key sustainability competencies. Table 1 presents the GreenComp framework, outlining these areas, competencies, and their associated descriptors.

Several sustainability competency frameworks preceded GreenComp (Bianchi et al., 2022). Notably, Wiek et al. (2011) identified six core competencies essential for sustainability-focused undergraduate and graduate programs. These include systems thinking, future-oriented (or anticipatory) thinking, value-based (or normative) thinking, strategic (or action-oriented) thinking, and collaboration (or interpersonal) skills. UNESCO (2017) adopted these competencies for its Education for Sustainable Development. UNESCO emphasized diverse problem-solving approaches. They also highlighted the need for integrating knowledge from various disciplines and perspectives to address complex sustainability challenges. Later on, Brundiers et al. (2021) proposed a refined framework similar to Wiek et al. (2011). Their goal was to guide program development, implementation, and evaluation to improve graduate employability. They expanded the UNESCO (2017) framework to include new competencies: interdisciplinary competence, critical thinking, self-awareness, and implementation skills.

Table 1
Areas, competencies, and descriptors addressed in the instrument.

Areas	Competences	Descriptors	Questionnaire
1. Embodying sustainability values	1.1 Valuing sustainability	Reflect on and evaluate personal values concerning sustainability.	Item 1
	1.2 Supporting fairness	Promote intergenerational equity and justice, learning from the past for a sustainable future.	Item 2
	1.3 Promoting Nature	Recognize human role in nature, respecting other species and ecosystems for their restoration and resilience.	Item 3
2. Embracing complexity in sustainability	2.1 Systems Thinking	Tackle sustainability issues holistically, considering various temporal, spatial, and contextual factors.	Item 4
	2.2 Critical Thinking	Critically analyze information and biases, understanding how backgrounds shape perspectives and decisions.	Item 5
	2.3 Problem framing	Define sustainability challenges by scope and complexity to devise proactive and adaptive strategies.	Item 6
3. Envisioning sustainable futures	3.1 Futures literacy	Imagine and plan for sustainable futures, outlining steps towards the desired outcome.	Item 7
	3.2 Adaptability	Navigate complex sustainability transitions, making future-oriented decisions amidst uncertainty.	Item 8
	3.3 Exploratory thinking	Embrace interdisciplinary thinking, fostering creativity and innovative approaches.	Item 9
4. Acting for sustainability	4.1 Political agency	Engage with the political realm for accountability and policy advocacy for sustainability.	–
	4.2 Collective action	Collaborate with others to drive sustainable change.	Item 10
	4.3 Individual initiative	Recognize and utilize personal abilities to enhance community and global sustainability.	Item 11

Note: Adapted from Bianchi et al. (2022; pp. 14–15). The wording of the items can be found in the Supplementary File.

GreenComp includes almost all these competencies (Bianchi et al., 2022). It covers all UNESCO competencies and also emphasizes values, fairness, and promoting the well-being of nature and other species. Wiek et al. (2011) and Brundiers et al. (2021) focus more on strategic and normative competencies and specifically training sustainable professionals. Yet, Greencomp also integrates ethical dimensions, focuses on fostering a general sustainability mindset, and is broadly applicable across various educational levels. In addition, it includes knowledge, skills, and attitudes (KSA) statements (Bianchi et al., 2022), making it easier to define operational indicators. Thus, GreenComp offers a comprehensive value-oriented approach for audiences beyond professionals, being more suitable for our target audience.

1.2. *Measuring sustainability competence*

Measuring sustainability competence is a relevant topic. Several reviews over the past two decades provide a comprehensive understanding of available frameworks and instruments (Brundiers et al., 2010; Grosseck et al., 2019; Wiek et al., 2011). More recently, Redman et al. (2021) identified 121 assessment tools categorized into eight types: scaled self-assessment, reflective writing, scenario/case tests, focus groups/interviews, performance observation, concept mapping, conventional tests, and regular coursework. Scaled self-assessment tools predominated and limited refinement of the instruments across studies was observed, except for a few scenario/case tests. In addition, they identified shortcomings in sustainability assessment practices, including inconsistent coherence across studies, especially regarding what outcome for sustainability is measured, overreliance on scales self-assessment instruments with limited validity and reliability evidence, and a dearth of novel assessment tools development. In the same vein, Annelin and Boström (2023) examined instruments for assessing sustainability competence among higher education students. The study revealed that most assessments relied on fieldwork and in-class assignments wherein educators evaluated students after lessons, assignments, or real-world experiences. Few studies used questionnaires, but these often measured general sustainability competence or were subject-specific competence. Finally, the authors highlight that existing tools need improvement and validation in different settings.

Vesterinen and Ratinen (2023) conducted a systematic literature review on sustainability competencies within the context of primary school education for sustainable development. Only 14 articles were identified that addressed this educational level. The review revealed that systems thinking competence and collaboration competence were the most frequently studied sustainability competencies, followed by action-oriented competence and values thinking competence, with futures thinking competence being less investigated. Also, the research papers employed both qualitative and quantitative methods, with the mixed methodology being the most common ($n = 8$). These included observations, surveys, tests, interviews, and children's drawings. Other research methods included surveys and questionnaires ($n = 3$), individual and focus-group interviews ($n = 2$), and document analyses, such as students' posts on Instagram ($n = 1$).

From the literature reviewed, including assessments of instruments and sustainability competence (Brundiers et al., 2010; Redman et al., 2021), no tools specifically designed for primary school students have been identified. Although two studies have developed tests for school children, neither used the GreenComp framework nor addressed all

competencies outlined in UNESCO's 2017 framework. Specifically, Levchyk et al. (2021) created a questionnaire with multiple-choice questions, yet such a questionnaire was not psychometrically validated. On the other hand, Clark et al. (2017) focused on general systems thinking, including perception of systems, connectedness with nature, and understanding consequences. Therefore, the evaluation of primary school students' sustainability competencies is at a nascent stage. A gap exists in the literature concerning the precise definition of constructs and the identification of dimensions related to sustainability competencies. Furthermore, there is an absence of comprehensive assessment tools that encompass all sustainability competencies and that were subjected to rigorous validity and reliability analyses. The existing body of work largely focuses on other educational levels, and while numerous instruments have been reviewed, gaps remain, particularly in the context of primary education.

2. Materials and methods

The development of the multiple-choice instrument rooted in the GreenComp framework adheres to the guidelines proposed by Redman et al. (2021), which involves establishing clear learning objectives aligned with the assessment context, a robust theoretical framework for item development, a psychometric model linking objectives to the tool, and pilot testing with the target group.

2.1. Sample size and justification

The sample for this study consisted of 158 primary school students drawn from three different schools in Spain. These schools were carefully chosen to represent different educational milieu and areas of Spain. One school was located in A Coruña (northern Spain), another in Almería (southern Spain), and the last in Badalona (eastern Spain). Of note, these regions represent some of the highest and lowest achievement scores in PISA in science and math (MECD, 2023). The majority of the participants were girls, making up 55.1 % of the sample. In terms of grade level, most students were in the higher grades of primary school (5th and 6th grade), accounting for 67.1 % of the participants. The remaining 32.9 % were in the middle grades (3rd and 4th grade). Students from various grade levels were included to account for diverse perspectives, and developmental differences, and ensure the instrument could be used across primary school years.

Determining the ideal sample size for factor analysis can be complicated. While there are general rules of thumb, like having at least 100 participants or specific ratios of participants to the number of variables (e.g., 10:1), these are increasingly discouraged. Research shows that these heuristics are not reliable and can lead to misleading results (Gaskin & Happell, 2014). Instead, the accuracy of the results from factor analysis depends on how well individual items relate to their underlying factors (communalities) and how strongly they load onto those factors. This study, therefore, draws upon the findings of simulation studies suggesting that even a sample size of 100 can yield reliable factor solutions, but under specific conditions (Mundfrom et al., 2005): (1) simple structure, with each item primarily loading onto one specific factor; (2) at least 8 items per factor; (3) high item communalities (0.40 to 0.80); and (4) mid to high factor loadings (0.40 to 0.60). Based on these conditions, this study's findings (detailed in the Results section) suggest that the sample size of 158 responses can be considered adequate for producing reliable and accurate factor solutions.

2.2. Development of the test items

The development of the items was based on the theoretical framework that the GreenComp establishes for each sustainability competency, i.e., both the general explanation of each competency area and the detailed description of each competency with its descriptor. The main premise for its elaboration was to develop a question for each competency, which was able to collect through its answers the necessary information to evaluate its development. For this purpose, the examples provided by GreenComp for each competency were also taken into account, where the knowledge, skills, and attitudes involved in each competency are described and an example related to real life is given, in some cases including references to online material related to the subject matter. Thus, a total of 12 multiple-choice items were formulated, one for each competency and their respective answers.

Specifically, the responses were formulated following the theory of conceptual profiles (El-Hani et al., 2015). Thus, three responses were formulated for each question, representing an anthropocentric perspective, a basic sustainability perspective, and an informed perspective of sustainability (for primary school children), respectively. We use the word "perspective" as a mindset or worldview that prioritizes or not sustainability principles. The anthropocentric perspective conceives human beings and their interests as the center of everything, thus subordinating the "other" (living beings, environment, etc.) to the needs and well-being of human beings. The basic sustainable perspective is very focused on the environment and people understand that human beings are part of the Earth's ecosystem and that we are responsible for it. A sophisticated perspective implies a better understanding of the eco-social systems in which sustainability takes place and an understanding of the complexities and uncertainties associated with decision-making in this area. This level of understanding depends on the level of training in the matter. In our case, the proposed answers represent an informed response at the primary school level according to the GreenComp framework - i.e., at a higher level of competence. To these three responses, a fourth response was added to represent no knowledge about the issue the question addresses.

Multiple-choice items were selected due to several advantages over Likert-scale self-assessments or qualitative methods. First, it minimizes bias by presenting realistic scenarios with no obvious correct answers. This may reduce the risk of socially desirable responses. Second, the multiple-choice format provides a standardized and objective measure of competence. Therefore, the potential bias of the evaluator is reduced. Third, it allows for straightforward administration and evaluation of competencies. Therefore, data collection would be efficient and data analysis would be highly reliable since it is an easy-to-score format. Finally, multiple-choice items offer a basis for comparison across different populations and educational settings.

A preliminary version of the items was administered to four children, aged 7–9 years old, to better adjust the items' wording for primary school children. Once the total set of 12 items with their respective four responses had been prepared, the instrument was submitted for validation by an expert in the field who was firstly introduced to the idiosyncrasy of the instrument and, secondly, was asked to review the content of the questions and their responses. This process was carried out in two rounds, that is, after the modifications made in response to the first review by the expert, the new version was presented again for final review, in which the questions and answers of the different categories were adjusted.

Finally, the instrument was subjected to a pilot test with 87 primary school students, aged 8–11 years old to determine possible comprehension difficulties. Through this process, some aspects of the wording were adjusted, and the item related to competency *4.1. Political Agency* was eliminated since it was detected that this competency represents too much difficulty for its comprehension by primary school students. Therefore, the final instrument was composed of 11 items (see Supplementary File for the Spanish and English-translated items).

2.3. Analytical strategy

The construct validity of the proposed instrument was assessed using robust exploratory factor analysis, following established guidelines (Ferrando et al., 2022; Gaskin & Happel, 2014). As the items were nominal, and two items exhibited moderate skewness (item 1 = −1.15,

item 5 = −1.59), Ordinary Least Square estimation on Polychoric correlations was used. For this same reason, parallel analysis with principal component analysis as the extraction method served as the criteria for determining the appropriate number of factors to retain (Gaskin, 2014). Subsequently, confirmatory factor analysis with Maximum Likelihood estimation was conducted to evaluate model fit against established indices, including CFI and TLI ≥ 0.95, RMSEA ≤ 0.06, and SRMR ≤ 0.08 (Hu & Bentler, 1999).

The internal consistency reliability of the items was assessed using McDonald's omega coefficient, as it is generally preferred over Cronbach's alpha for nominal data (Hayes & Coutts, 2020). Similar to the interpretation of Cronbach's alpha, an omega coefficient greater than 0.70 is considered satisfactory, and greater than 0.80 indicates high reliability.

Finally, to establish baseline data for the instrument, students' responses were analyzed using descriptive and inferential statistics. Specifically, the chi-square test of independence was used to analyze whether there are gender (girls and boys) and grade level (lower and upper level) differences across the four response categories (do not know, anthropocentric, basic, and sophisticated) for each item. Bonferroni correction was used to mitigate the risk of Type 1 errors (false positives) arising from multiple comparisons; by doing so, a more stringent significance level controlled for inflated error rates (Knapp, 2018). The practical significance of the differences was determined based on Cramer's V. Only effects classified as medium (0.17) or large (0.29) were deemed educationally relevant, excluding smaller, negligible effects (0.06); this ensures results hold meaningful implications for educators and researchers.

2.4. Data collection procedure

Teachers signed a consent form on behalf of the students who responded to the questionnaire informing them of (a) the objectives of the study, (b) the time commitment involved in completing the questionnaire, (c) the procedure followed to guarantee anonymity and confidentiality; (d) its voluntary nature; (d) the strictly academic use of the data collected; and (e) the right of the participants to access the results, being able to request access, cessation, and cancellation of their participation. It should be noted that the results of this study do not link participants directly; the data collected through the questionnaires were numbered with a code that only allowed the instrument to be traced for the computerization process. For the pseudonymization, a code consisting of letters of the first and last name was used. The personal information requested included gender (with the possibility of not reporting), age, school year they were in, and school they attended.

3. Results

3.1. Construct validity and reliability

The Kaiser-Meyer-Olkin measure of sampling adequacy indicated adequate suitability for factor analysis (KMO = 0.885). Additionally, Bartlett's test of sphericity confirmed significant inter-item correlations ($\chi^2 = 830.553$, $p < 0.001$), further supporting the factorability of the responses. Parallel analysis suggested a unidimensional structure, as depicted in Fig. 1, where only one factor exceeded the eigenvalues of the simulated data. An exploratory factor analysis confirmed this hypothesis, revealing a parsimonious unidimensional structure explaining 46.5 % of the variance in students' sustainability competence. All items demonstrated strong loadings on the single factor, ranging from 0.547 to 0.768 (Table 2).

The confirmatory factor analysis supported the hypothesized unidimensional structure of sustainability competence with excellent model fit indices. Specifically, the CFI was 0.981, the TLI was 0.977, the RMSEA was 0.043, and the SRMR was 0.037. Standardized factor loadings for all items were high, ranging from 0.56 to 0.74 (Fig. 2).

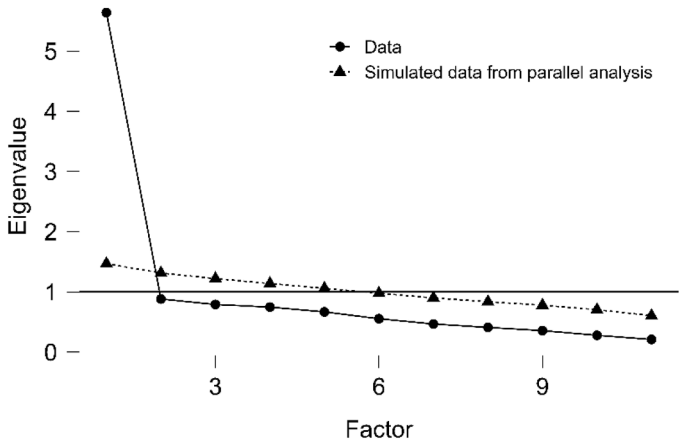

Fig. 1. Parallel analysis results.

Table 2
Factor loadings based on exploratory factor analysis.

Items	Factor loading	Communalities
Item 6	0.768	0.411
Item 10	0.762	0.419
Item 9	0.729	0.469
Item 11	0.708	0.499
Item 8	0.702	0.508
Item 3	0.672	0.548
Item 2	0.670	0.551
Item 5	0.665	0.557
Item 7	0.660	0.565
Item 4	0.588	0.654
Item 1	0.547	0.701

Further analysis revealed high internal consistency reliability, with a McDonald's omega coefficient of 0.898. Notably, further examination indicated that removing any item would not improve the omega coefficient. This finding suggests strong inter-item correlations within the instrument. Therefore, each item contributes meaningfully to the overall reliability.

3.2. Baseline data

Table 3 presents the distribution of students' understanding of sustainability across four categories: no answer, anthropocentric perspective, basic understanding, and sophisticated understanding. Overall, the results suggest that primary school students in this sample exhibited a predominantly basic to anthropocentric level of sustainability competence. Item 5, which assessed the *critical thinking* competencies of sustainability, elicited the most anthropocentric responses. This indicates that many students primarily viewed sustainability through the lens of subordinating the "other" living beings and environment to human beings' needs. Items 2 and 4, focusing on the *supporting fairness* and *systems thinking* competencies of sustainability, were associated with basic understanding. This suggests that students generally understand that human beings are responsible for the environment, yet they did not achieve an informed understanding of the eco-social systems that take place. Items 6 and 11, addressing *problem framing* and *collective action* competencies of sustainability, respectively, revealed a more sophisticated understanding. This implies that some students could understand the complexities and uncertainties associated with decision-making regarding improving the environment.

There were slightly more girls than boys with sophisticated competence levels in six items (1, 5, 7, 9, 10, 11), and opposite results for the remaining five items (2, 3, 4, 6, 8). The major difference is for item 5, with 34.5 % of girls displaying sophisticated understanding against only

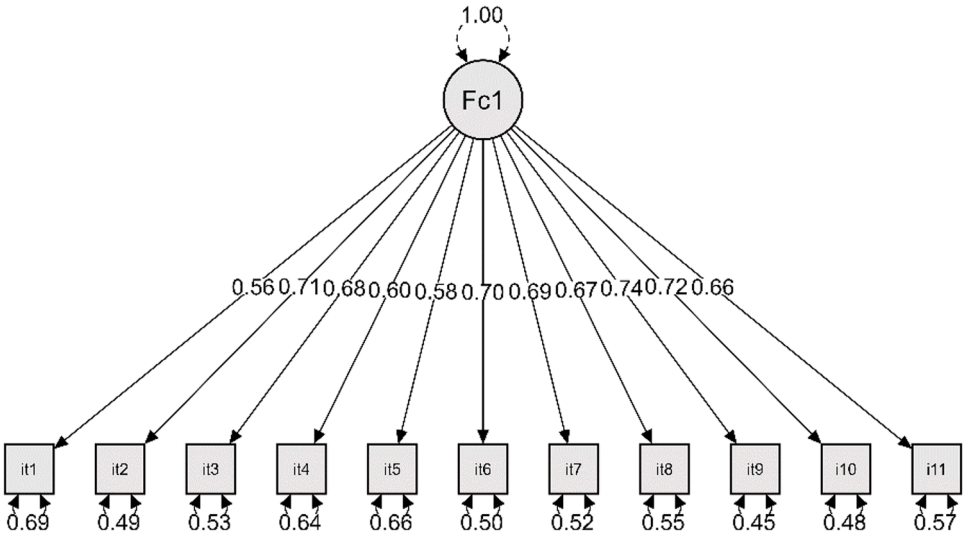

Fig. 2. Standardized estimates based on confirmatory factor analysis.

Table 3
Overall sustainability competence.

	Do not know	Anthropocentric	Basic	Sophisticated
Item 1	25.9	11.4	46.2	16.5
Item 2	17.7	3.8	66.5	12
Item 3	19.6	8.2	38.6	33.5
Item 4	20.3	13.9	55.7	10.1
Item 5	34.2	16.5	21.5	27.8
Item 6	22.2	5.1	13.3	59.5
Item 7	13.3	1.3	47.5	38
Item 8	19	4.4	52.5	24.1
Item 9	21.5	3.2	49.4	25.9
Item 10	20.3	3.8	22.8	53.2
Item 11	16.5	13.3	14.6	55.7

19.7 % of boys. However, chi-square tests of independence indicated that any of these gender differences were not statistically significant (p = 0.07 to 0.954). This suggests that both girls and boys have similar levels of sustainability competence (Table 4).

Regarding grade level, findings differed significantly (Table 5). Overall, students in upper grades (5th and 6th primary school graders) displayed a more sophisticated understanding of sustainability than those in lower grades (3rd and 4th grade). Chi-square tests of independence revealed that these differences were statistically significant in all items, favoring students in upper grades. Effect sizes were large for all comparisons, as indicated by Cramer's V ranging from 0.37 to 0.61.

Table 4
Sustainability competence by gender.

	Do not know		Anthropocentric		Basic		Sophisticated	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Item 1	25.3	26.8	12.6	9.9	44.8	47.9	17.2	15.5
Item 2	14.9	21.1	5.7	1.4	67.8	64.8	11.5	12.7
Item 3	20.7	18.3	9.2	7	39.1	38	31	36.6
Item 4	19.5	21.1	16.1	11.3	52.9	59.2	11.5	8.5
Item 5	33.3	35.2	17.2	15.5	14.9	29.6	34.5	19.7
Item 6	23	21.1	2.3	8.5	16.1	9.9	58.6	60.6
Item 7	11.5	15.5	2.3	0	46	49.3	40.2	35.2
Item 8	19.5	18.3	5.7	208	52.9	52.1	21.8	26.8
Item 9	17.2	26.8	2.3	4.2	50.6	47.9	29.9	21.1
Item 10	19.5	21.1	3.4	4.2	21.8	23.9	55.2	50.7
Item 11	14.9	18.3	8	19.7	16.1	12.7	60.9	49.3

4. Discussion and conclusions

Fostering environmental awareness that translates to sustainable practices requires the promotion of sustainability competence from the primary school level (Pegalajar et al., 2022; UNESCO, 2017). However, a critical gap exists. There is a notable lack of instruments easily accessible and usable by teachers and researchers (Vesterinen & Ratinen, 2023). In addition, literature reviews suggest that existing instruments are not based on a theoretical framework that could be generalized across educational systems (Redman et al., 2021). Likewise, few instruments focus on the measurement of sustainability competence at the primary education stage (Annelin & Boström, 2023). The few that exist lack evidence for validity and reliability (Clark et al., 2017; Levychyk et al., 2021). This lack becomes even more evident when considering the absence of instruments aligned with GreenComp, the European reference framework for sustainability competence (Bianchi et al., 2022). This lack hinders the evaluation of student progress in sustainability competence. The development of such an assessment tool is, therefore, essential. Having such an instrument that assesses students' progress in sustainability competence would pave the way toward a sustainability education that could be effective and measurable.

The current study introduces a new instrument designed following the GreenComp framework established by Bianchi et al. (2022). This instrument is composed of eleven multiple-choice items carefully developed to assess facets of sustainability competence, thus providing a comprehensive tool for measuring and promoting sustainable practices. Psychometric evaluation has shown that the instrument has a unidimensional factor structure, indicating that it measures a single construct or dimension (Ferrando et al., 2022). Its psychometric evaluation demonstrates its ability to measure sustainability competence in students aged 8–12 years old, hence filling the gap in the literature with a valid and reliable instrument. Specifically, all items contribute significantly to the measurement of the overall sustainability competence construct. Therefore, these results reinforce that the instrument possesses adequate construct validity (Gaskin & Happell, 2014). On the other hand, reliability assessment is another crucial aspect in the development of measurement instruments. In the case of the proposed instrument, the results far exceed the minimum values suggested in the specialized literature, which indicates a high consistency in the participants' responses and reinforces the credibility of the findings (Hayes & Coutts, 2020). Overall, it can be concluded that the proposed instrument represents a promising first step for the measurement of sustainability competence in line with the European reference framework.

On the other hand, the use of the proposed instrument has te

Table 5
Sustainability competence by grade level.

	Do not know		Anthropocentric		Basic		Sophisticated	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Item 1	55.8	11.3	5.8	14.2	25	56.6	13.5	17.9
Item 2	46.2	3.8	5.8	2.8	36.5	71.1	11.5	12.3
Item 3	51.9	3.8	9.6	7.5	17.3	49.1	21.2	39.6
Item 4	51.9	4.7	1.9	19.8	32.7	67	13.5	8.5
Item 5	27.7	22.6	25	12.3	7.7	28.3	9.6	36.8
Item 6	44.2	11.3	3.8	5.7	9.6	15.1	42.3	67.9
Item 7	34.6	2.8	1.9	0.9	40.4	50.9	23.1	45.3
Item 8	40.4	8.5	5.8	3.9	36.5	60.4	17.3	27.4
Item 9	55.9	4.7	5.8	1.9	19.2	64.2	19.2	29.2
Item 10	44.2	8.5	5.8	2.8	17.3	25.5	32.7	63.2
Item 11	40.4	4.7	13.5	13.2	5.8	18.9	40.4	62.2

*Statistically significant results with at least moderate effect size.

potnetial to be a valuable resource for researchers and educators committed to promoting sustainability. Thus, a detailed analysis of student responses shows that, in general, students have a basic understanding of sustainability. In addition, the individualized analysis of each item reflects those areas that need further strengthening. Specifically, the need to focus more on systems thinking, critical thinking, and individual initiative is identified. These components are essential to foster a less anthropocentric perspective, integrating environmental, social, and economic considerations in decision-making and daily action.

The present study is not without limitations. Although it presents a valid and reliable tool, the results face the limitation that the sample size in each of the three Spanish regions was small, which prevented an effective comparison between regions. To overcome these limitations, it is crucial to undertake future research with larger samples to allow a detailed analysis of the impact of the educational context on students' competence for sustainability. A larger and more representative study could provide valuable insights into how different educational environments influence the development of sustainability competence. Similarly, future studies could benefit from applying item-response theory (IRT) to further refine the assessment items; however, the current analysis was constrained by the sample size, which fell short of the requirements for robust IRT modeling as outlined by Jiang et al. (2016).

In addition, studies examining the psychometric properties of the proposed instrument in secondary school students are recommended. This would not only enhance the understanding of the validity and reliability of the instrument but also facilitate longitudinal research to understand the development of sustainable competencies, which are increasingly recognized as fundamental educational systems worldwide. Moreover, future studies translating the instrument into different languages are also warranted. This endeavor would allow comparisons to be made across EU countries. Finally, it should be noted that this instrument measures overall student sustainability competencies by using a single item for each competency from the GreenComp framework. While this approach may seem less detailed, it does not compromise the instrument's validity. Instead, it prioritizes efficiency by keeping the instrument short, which makes it easier for teachers and primary students to use and provides a general overview of sustainability competencies. Future research with secondary students will include a more detailed assessment of individual competencies with additional items per competency.

Acknowledgement

We thank Dr. Antonio Jesús Canepa Oneto (University of Burgos), expert in biology and sustainability, for his detailed and significant feedback in the conceptualization of the instrument items.

Data availability

The data that support the findings of this study are available upon request to the corresponding author.

Funding statement

This study was supported by the Spanish State Investigation Agency (Agencia Estatal de Investigación de España) under the research grant: PDC2021-121498-100.

Consent statement

Informed consent was obtained from the participants in this study.

CRediT authorship contribution statement

Radu Bogdan Toma: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Jairo Ortiz-Revilla:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Ileana M. Greca:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijedro.2024.100388.

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