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Insight

Teaching the ecosystem service concept: experience from academia

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ABSTRACT. Although ecosystem service (ES) is a well-established concept among the scientific community, it has not reached the mainstream of public awareness because it lacks wide recognition among citizens and educators. Teaching of ES may contribute to the mainstreaming of the ES concept and its framework in society in a critical and meaningful way, toward sustainable development. In fact, the ES concept is a key tool for communicating our social dependence on natural ecosystems, and therefore it has high didactic potential. However, this didactic potential is under-explored, because there is a lack of scholarship related to teaching the ES concept. There is little evidence, for example, on whether scientists who research ES also teach the concept and thus contribute to raising the level of ES awareness in society, and if so, how such teaching processes could be improved, to broaden the impact to citizen awareness. To close this knowledge gap, we delved deeper into how the ES concept is taught and which teaching strategies are currently being used by ES research academics. We aimed to establish connections between those teaching practices and best educational practices described in educational literature. This analysis will help to provide insights into academics' teaching approaches, as well as how these practices could be improved. A key finding of our research is that teachers with little experience in ES teaching are less likely to use active teaching methods or to evaluate their teaching (both related to best educational practices), whereas lecturers with more years of experience in teaching the ES concept are more in line with best educational practices. Therefore, collaboration and networking among teachers with different levels of experience could help improve the quality of ES concept teaching. We suggest the establishment of a platform to facilitate regular exchange among teachers and educators from different teaching contexts and educational levels. Finally, we propose several future research directions in this emerging research area in order to continue revealing the existing research gap in the teaching of the ES concept.

Key Words: *active learning; ecosystem services; evaluation; interdisciplinarity; networking; teaching*

INTRODUCTION

Ecosystem services (ES) are the ecological characteristics, functions, and processes that directly or indirectly contribute to sustainable human well-being (Costanza 2020). As previously stated in the Millennium Ecosystems Assessment (MEA 2005), the ES concept could support the acquisition of general knowledge regarding how nature around us functions and how important it is for human beings. The ES concept has the potential to support, in a straightforward way, ecological wisdom (Xiang 2014), ecological literacy (Pitman et al. 2018), ecological sensitivity, and even ecological ethics (Naveh 1995). Furthermore, the ES concept has the advantage of addressing all parts of society, and can be used as a door-opener to raise people's awareness of the significance nature represents for well-being (Costanza et al. 2017, García-Llorente et al. 2018); to highlight the need for mainstream ES approaches; and to emphasize that substantial contributions of ES to the sustainable well-being of humans and the rest of nature should be at the core of the fundamental social change needed to achieve a societal transformation to a sustainable future. Much progress has been made at different scales, both in science and at the policy and planning levels, to delve deeper into the theoretical and practical aspects related to the ES concept. However, the ES concept is still in its infancy with respect to greater public awareness, because it still lacks wider recognition among citizens and educators (Barracosa et al. 2019). Therefore, teaching the ES concept assumes a relevant role concerning improvement of this situation. In fact, increasing education levels can contribute to increasing awareness of the importance of different ES (Xun et al. 2017). Moreover, teaching can contribute to a better understanding of the ES concept, which can support the general public to better understand the need for effective biodiversity management (Buijs et al. 2008).

The ES concept is a key tool for communicating our social dependence on natural ecosystems (Torkar and Kraûovec 2019), and therefore it has high didactic potential (Rodríguez-Loinaz et al. 2017). The basic idea behind the ES concept is simple, related to the fact that people perceive benefits obtained from nature and may link them directly to their well-being. In connection with nature conservation and sustainability issues, the ES concept could help explain such benefits and links to society through teaching. Nevertheless, research on teaching and learning the ES concept, although it is recently starting to emerge, is relatively sparse (Taylor and Bennett 2016, Alonso and Gutiérrez 2017, Ruppert and Duncan 2017, Löw Beer 2018, Schneider and Lüderitz 2018, Barracosa et al. 2019, Schneider and Popovici 2019, Rodríguez-Loinaz and Palacios-Agundez 2022). Moreover, the concept is recognized as relatively new by the community of teachers (Rodríguez-Loinaz et al. 2017). Current research experiences related to what is being taught about the ES concept are limited, and concern, for example, what types of ES are being taught and how specific ES types are perceived by students (Alonso & Gutiérrez 2017). Because the ES concept is highly interdisciplinary, the specific ES teaching content depends on the

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addressed knowledge area(s), e.g., biology, geology, and economics, in each specific course, as well as on the teaching audience and teaching context. However, there are many basic ideas on the importance of nature for human well-being that every ES teaching should cover. In this sense, Kurt and Ulrich (2015) defend a basic argument for teaching the ES concept, linked to biodiversity: it helps students to understand that life on earth, in its abundant variety, is of existential value to human beings. Moreover, interdisciplinary conceptual thinking is an important element of the teaching process of the ES concept, and allows showing this concept in a wider perspective related to the implementation of Sustainable Development Goals (SDGs; Schneider and Lüderitz 2018). Therefore, analyzing the methods applied in ES teaching and establishing connections between those teaching practices and the best educational practices described in the educational literature would give insight on how to improve ES teaching experiences. This may be beneficial for ES teaching as a whole, regardless of the knowledge area(s), e.g., natural sciences, or social sciences, involved in each specific course or teaching context, which may help to increase the social understanding of the ES concept.

Currently, little is known about the extent to which students develop knowledge and understanding related to the ES concept (Torkar and Kraûovec 2019). What we do know is that paying attention to the applied teaching approaches and methodologies is of great importance for improvement of learning outcomes (Drew and Hess 2003, Prince 2004, Freeman et al. 2014), as well as for achievement of transformative education toward sustainability (UNESCO 2017, Leicht et al. 2018). In this sense, teaching ES through active teaching methodologies has proven to be useful and necessary to help students understand and be able to defend the importance of nature conservation (Rodríguez-Loinaz and Palacios-Agundez 2022). Moreover, recent studies suggest that teaching ES through the use of active teaching methodologies, such as inquiry-based learning, provides an ideal opportunity to help students make connections between ecological, geological, and social systems (Taylor and Bennett 2016). Analyzing how the ES concept is taught and how these teaching practices are evaluated provides a common discussion space regarding ES teaching among academics from different disciplines working on ES and, more importantly, provides the opportunity to improve such teaching experience.

There is little evidence on whether scientists who research the ES also teach the concept and, therefore, contribute to raising the level of ES awareness in society, and if so, how such teaching processes could be improved to broaden the impact on citizen awareness of ES. ES is a concept generated by academia that still lacks wider recognition among citizens and educators. Therefore, it is important to analyze the teaching practices that take place at the academic level, and then to see how they could continue to play a role in society. In our study, we have compared teaching practices used by ES academics with best educational practices described in educational literature. First, we aimed to analyze how academics taught the ES concept at universities and research centers, and to establish connections between those teaching practices and best educational practices described in educational literature. This analysis aims to help provide insights into academics' teaching approaches and into how ES teaching experiences are being evaluated, as well as into how these practices could be improved. Second, we aimed to discuss further steps and research directions to support teaching the ES concept, as a key step toward making it more relevant for society. To implement our aims, we conducted an international survey that focused on academics' current experiences in teaching the ES concept, involving 99 scientists who research ES and teach the ES concept.

MATERIALS AND METHODS

This research is based on an ad hoc web-based survey (Jamsen and Corley 2007) aimed at academics from universities and research centers around the world who teach the ES concept.

Questionnaire design and validation

The ad hoc questionnaire was designed by the authors of this study. It included both open-ended (17) and closed questions (six) distributed in five main parts: (1) respondent's personal information; (2) teaching experience; (3) teaching methods; (4) effectiveness of the teaching processes; and (5) interest in participating in a working group on ES teaching (Table 1). Parts two, three, and four asked about their experience in ES teaching. Respondents with no experience in teaching the ES concept did not have to answer questions concerning teaching methods and effectiveness of their teaching. They were redirected to the last part of the questionnaire in order to detect whether there was interest in teaching the ES concept among people who have never done it.

Table 1: Questionnaire design

Questionnaire's main parts	Questions concerning
1. Respondent's information	Representing institution Membership to different communities
2. Teaching experience in ES	Target audience Type of courses Years of teaching
3. Teaching methods	Active vs. lectures Use of inductive teaching methods Outside classroom activities (outdoor activities) Online exercises Teaching ES in relation to SDGs
4. Effectiveness of the teaching processes	Evaluation techniques used Perception of most effective evaluation techniques
5. Interest in participating in a working group on ES teaching	Kind of Interest

In the third part of the questionnaire, the teaching methods were organized into two main categories: (1) traditional lectures, where students passively receive information from the teacher; and (2) active and collaborative learning methods that engage students in the learning process and where students work together in small groups toward a common goal. Based on the classification used by Prince and Felder (2006), inside the active teaching methods,

eight categories were considered: inquiry learning, problem-based learning, project-based learning, case-based learning, discovery learning, just in time teaching, peer instruction, and educative gamification (Appendix 1).

Before distributing the questionnaire, it was validated by 10 external experts in the field of teaching and ES (Appendix 2) in order to confirm that the questions captured the anticipated data and would not be interpreted differently by researchers and participants (Ball 2019). The validation process focused mainly on content validation, because such validity is essential to making inferences and generalizations from the results obtained with a questionnaire (Escofet et al. 2016). To do so, the authors used the Delphi method (Linstone and Turoff 1975, Loo 2002). This method has been widely applied as a questionnaire-validation instrument in numerous studies and fields of knowledge (Hung et al. 2008). In this method, the questionnaire is sent to several experts and is modified and improved, if necessary, according to various recommendations made by the experts obtained in successive rounds. After each round, the experts' opinions were collected and analyzed. Suggested modifications were made to improve the instructions and the understanding of some questions, and several questions considered irrelevant were also deleted. The authors repeated this procedure in three rounds until arriving at the final version of the questionnaire.

Sampling method

In order to reach as many people as possible, the questionnaire was distributed online by different methods to reach both sampled and self-selected respondents (Jamsen and Corley 2007). The sampled participants were contacted proactively and invited to answer the questionnaire. To do so, the authors used the snowball sampling method (Goodman 1961), which identifies the individuals who have the desired characteristics and uses these individuals' social networks to recruit similar subjects (Sadler et al. 2010, Kowald and Axhausen 2012). Using this approach, the authors sent the questionnaire link by email to all the participants of the scientific session "Effective teaching strategies for making the ecosystem services concept relevant to society" of the Ecosystem Services Partnership conference held in Hanover, Germany, in October 2019, asking them to fill in the questionnaire and to forward the message to their contacts who might teach the ES concept. After the conference, the authors carried out a more thorough sampling campaign by identifying researchers who could be teaching ES and contacting them directly. Following the snowball sampling method, the contacted researchers were asked to fill out the questionnaire and to forward the message to their contacts who might teach the ES concept. Using this snowball approach, over 700 individuals were directly emailed.

To reach potential self-selected respondents, the survey was published several times on different websites relevant for the ES community, such as the Ecosystem Service Partnership and Young ES Specialists (YESS), and in their newsletters. ESP and YESS members were also invited to take part in the survey via social media (Twitter and Facebook). The questionnaire was also published on websites relevant for ecology researchers, such as International Association of Landscape Ecology (IALE), Global Land Program (GLP), and researchers in general, such as ResearchGate. The sampling took place between 11 October 2019 and 6 January 2020.

Ethical considerations

All participants who completed this voluntary survey were adults aware of the purpose of the research. Participants provided consent after reading the specific notice on data protection that the survey included (Appendix 3).

RESULTS

Respondents' general profile

A total of 136 responses were received. About 2.2% of the questionnaires were incomplete and, therefore, were eliminated from further analysis. In the end, the total number of completed responses was 133. The responses came from 43 countries all over the world (Table 2), mainly concentrated in Europe (79.6%). Data showed that 50.4% of the respondents were members of different professional scientific communities, whereas 49.6% were not members of any professional scientific community.

The target group in this research was academics from universities and research centers lecturing on ES. The authors excluded responses from further analyses given by (1) respondents with other profiles (secondary and informal educators, government workers, and NGO/consultancy professionals; 10% of the total sample); and (2) respondents who had never taught the ES concept (18% of the 133 respondents). Therefore, the results shown below correspond to the answers given by the 99 responders who were academics from universities and research centers who had ever taught the ES concept (Table 2), except for the case of the analysis of the interest in participating in a working group on ES teaching, where all 133 responders were considered.

Experience in teaching the ES concept

The level of expertise in teaching the ES concept among the 99 respondents included in the final analysis was quite diverse. One-third of the respondents had more than five years experience teaching the ES concept, whereas 27% of the sample had less than one year of experience or had taught the ES concept occasionally. Regarding the type of course taught, the results showed that 74% of the sample had taught a course, module, or workshop with a specific focus on the ES concept, whereas 82% of the respondents had taught about ES in other courses not specifically focused on ES. The number of hours devoted to teaching ES courses differed substantially depending on the type of course, from two to 110 hours. Regarding the target audience, although the great majority of respondents (98%) taught at the university level (bachelor, master's, and PhD), half of them had also given courses to public administration workers, and 37% of them to the general public; interestingly, 23% of the academics who answered the survey had given courses focused on including the concept of ES in compulsory primary and secondary education (Fig. 1).

Teaching methods

According to the classification of teaching methods described in the methodology section, 34% of the respondents used only active teaching methodologies, 21% taught the ES concept only through traditional lectures (where students passively receive information from a teacher), and the remaining 45% combined traditional lectures with active teaching methodologies. The most often-used active methodologies were project-based learning (49% of the studied sample), case-based teaching (46%), problem-based learning (39%), and inquiry-based learning (36%; Fig. 2).

Table 2. Place of origin of respondents (only the countries with two or more answers are specified, which means that the number of respondents of "others" equals the total of other different countries). Note that the percentages have been included in the total number of respondents (133), and in the total 99 respondents finally included in the analysis (those respondents from universities or research centers who teach ecosystem services).

Continent	Country	N° respondents	% of respondents	% of respondents finally included
Africa	TOTAL	6	4.5	2
	Kenya	2		
	Other countries	4		
Asia	Total countries	8	6.0	5
	Israel	2		
	Other countries	6		
Europe	TOTAL	106	79.6	85
	Spain	20		
	Germany	19		
	Poland	14		
	Romania	7		
	Netherlands	7		
	Czech Republic	5		
	Portugal	5		
	Switzerland	5		
	Italy	4		
	Sweden	4		
	United Kingdom	3		
	Turkey	2		
	Other countries	11		
North America	TOTAL	3	2.2	2
South America	TOTAL	10	7.5	6
	Brazil	3		
	Argentina	2		
	Colombia	3		
	Other countries	2		

Fig. 1. Percentage of respondents who selected each target audience category in the closed question on the target audience of the ES teaching (multiple choices allowed). Those who answered "others" were asked to specify their answer in an open-ended format. Received answers on "others" category in the open-ended answer include NGO, policy makers, and industry.

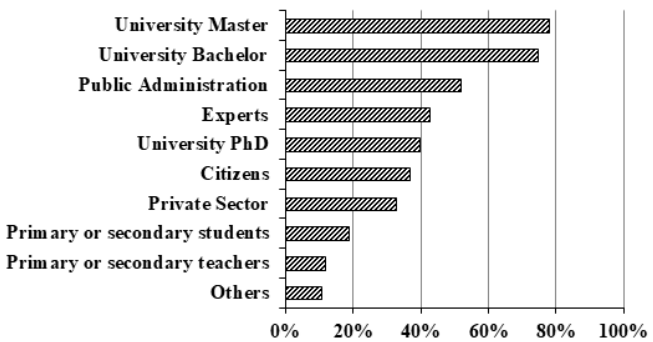
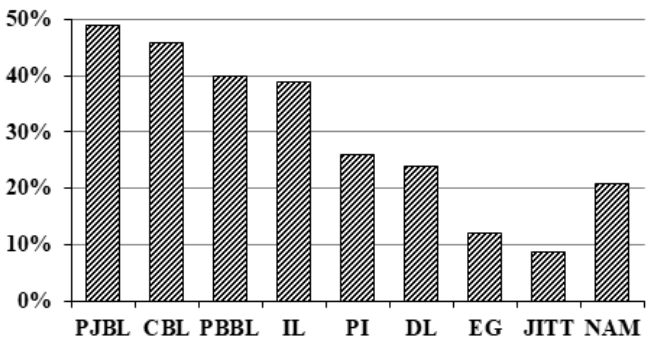


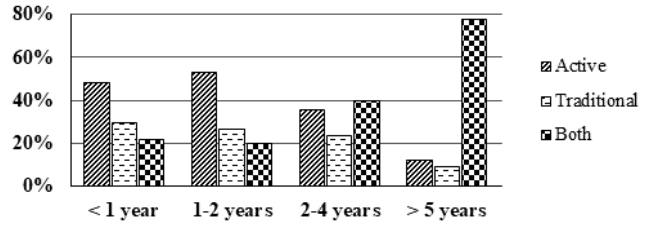
Fig. 2. Percentage of respondents that use each method to teach the ecosystem services concept (multiple choice allowed). PJBL: Project-based learning; CBL: Case-based teaching; PBBL: Problem based learning; IL: Inquiry learning; PI: Peer Instruction; DL: Discovery learning; EG: Educative Gamification; JITT: Just-in-time teaching; NAM: Non-active methods.



In addition, 59% of the respondents developed outdoor classroom practical teaching activities, and 17% included online exercises in their ES teaching strategies. Finally, 57% of the respondents included in their teaching strategies the relationship of the ES concept to the SDGs.

The analysis of the applied teaching methodologies according to academics' expertise on teaching the ES concept shows that the use of active teaching methods, alone or combined with traditional lectures, increases with teaching experience (Fig. 3).

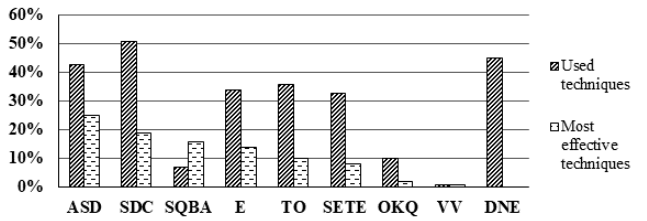
Fig. 3. Percentage of active and passive teaching methods by respondents' teaching experience.



Evaluation of the teaching and learning processes

In their questionnaires, 55% of the respondents stated that they evaluated the effectiveness of their teaching (Fig. 4). Their evaluations were conducted using the following techniques: students' direct comments (51%); analysis of the students' deliverables (46%); teachers' observations on students' learning process (36%); an exam that measures student performance or learning (34%); and students' evaluation of teaching effectiveness (33%).

Fig. 4. Percentage of respondents by each evaluation technique: used techniques by respondents (multiple choices allowed) and most effective evaluation techniques perceived by respondents (single-answer question). Name codes: ASD: Analysis of the students' deliverables; SDC: Students' direct comments; SQBA: Specific questionnaire to student on Ecosystem Services before and after the class/course/module; E: Exam; TO: Teacher's observations on students learning process; SETE: Students' Evaluation of Teaching Effectiveness; OKQ: Other kind of quiz; VV: Video or voice recording of the lessons; DNE: Do not evaluate.



When respondents were asked about their opinion on what was the most effective technique to make such an evaluation, the first two positions in the ranking of preferences matched with the most commonly used evaluation techniques (i.e., analysis of the students' deliverables and students' direct comments; Fig. 4). However, the third position, "specific questionnaire to students on ES before and after the class, course, or module," did not match with the most used evaluation techniques. Moreover, it was almost the least used technique (Fig. 4). The results indicate that scholars who used active teaching methods to teach the ES concept were more likely to evaluate the effectiveness of their ES teaching and learning processes (62% of them do so) than those who only used traditional lectures (Fig. 5), and that scholars with little experience in teaching the ES concept were less likely to evaluate the effectiveness of their teaching (Fig. 6).

Fig. 5. Percentage of respondents who evaluated (or did not evaluate) the effectiveness of their ecosystem services teaching and learning processes using active teaching methods, in contrast to those who only used traditional lectures.

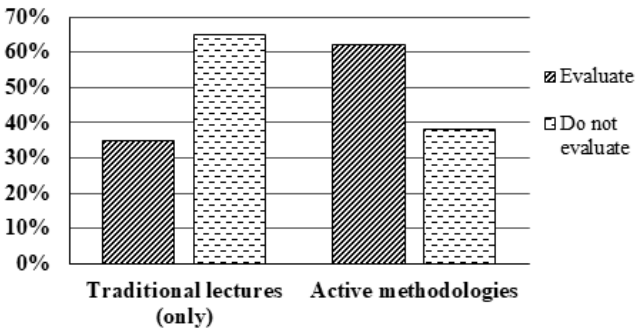
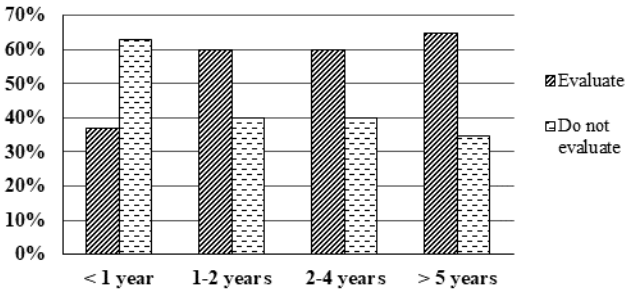


Fig. 6. Percentage of respondents who evaluated (or did not evaluate) the effectiveness of their ecosystem services teaching processes by teaching experience.



Interest in participating in a working group on teaching the ES concept

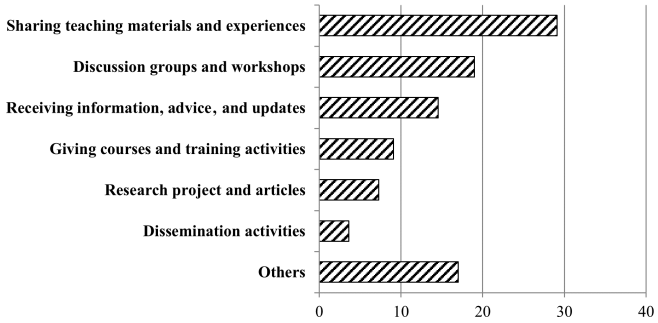
As explained above, the 133 respondents, regardless of whether or not they had experience in ES teaching, or whether they were academics or not, were also asked about their interest in being part of a thematic working group on teaching the ES concept. The overall aim of such group would be to provide an interdisciplinary exchange platform about ES concept teaching.

Interest was expressed by 78% of the total 133 respondents. Interestingly, 78% of the respondents who have never taught the

ES concept were inside this group. In addition, 90% of non-academics who teach the ES concept also showed interest in participating in a working group on teaching the ES concept.

Among the 68 respondents who specified the type of collaboration they were interested in, 29% stated they were willing to share teaching materials and experience, followed by 19% who were interested in participating in discussion groups and workshops (Fig. 7). There was also an important fraction (15%) of respondents who were not willing to actively participate but were interested in receiving information, advice, and updates.

Fig. 7. Percentage of the 68 respondents that specified the type of collaboration they are interested in by type of collaboration (open-ended answer).



DISCUSSION

Our results show that academics are teaching the ES concept both through teaching specific courses on ES and through teaching the ES concept in courses with a more general focus (e.g., biology, environmental economics, landscape planning, sustainability). This is in agreement with other recent studies that show the ES concept is indirectly involved in educational courses that address broader issues such as life on earth and its impacts on human existence (Kurt and Ulrich 2015), or climate change impacts (Fortmann et al. 2020). Interestingly, the results of our study show that academics from universities and research centers do not only teach the ES concept at the university level where they do research and teach, but they also teach it in many different contexts to very diverse audiences such as professional workers of the administration or private consultancy, and NGOs. This finding is promising, because these stakeholders are often involved in planning and policy-making processes related to biodiversity and ES (Spyra et al. 2019). Planners' understanding of the ES concept supports the general public to acknowledge human-nature relations that are crucial for the sustainable future of our planet (Musacchio 2018). Therefore, current ES teaching experiences from academia seem to be contributing to raising social awareness.

Regarding teaching expertise in ES, our results show a wide variety of expertise levels among academics, from those with brief teaching expertise, to others with over 10 years of experience in teaching the ES concept. One-third of our respondents have been teaching the ES concept for only a short time (i.e., less than a year). This could indicate that the ES concept has entered the university arena on a larger scale only recently. In contrast, another third of the sample had over five years of experience in teaching the ES concept. This means that there is a wide range of educational experience in ES that can be shared within the ES community.

Are these teaching experiences in ES in line with best educational practices?

The authors have shown that academics use a wide variety of teaching methods. Importantly, a high percentage (79%) of academics who participated in the survey use active teaching strategies and methods to teach ES (e.g., project-based learning, problem-based learning, and inquiry-based learning), either alone or combined with passive methods. Through the use of such active teaching methods as problem-based learning, students will retain information longer and may develop critical thinking and problem-solving skills (Prince 2004). This is a very positive outcome, because stimulating critical thinking among students and problem-solving skills can be a good basis for more effective implementation of the ES concept in research and practical work. This method of teaching the ES concept could be specifically valuable for a more intuitive and effective understanding of this concept, because it allows a direct application of ES concept into open-ended, complex, and authentic (real-world) problems. Our results also indicate that lecturers teaching ES combine, in their active and inductive teaching methods, in-class activities with outdoor classroom activities. This is also a positive outcome because outdoor classroom activities have been acknowledged to increase well-being and boost subsequent classroom engagement (Kuo et al. 2018, Largo-Wight et al. 2018). Besides, this finding is in line with the International Union for Conservation of Nature's claims regarding the need to increase education in nature or in naturalized school environments (https://www.hawaiiconservation.org/our-work/iucn-hawaii-commitments/). Moreover, studies on inquiry-based science learning also identify outdoor learning as a best practice in teaching concepts related to ES, such as biodiversity and climate change (Regan et al. 2014). Therefore, the ES teaching experiences of academics are often in line with current best educational practices concerning related subjects such as science education (Freeman et al. 2014) or Education for Sustainable Development (Lozano et al. 2017, Leicht et al. 2018).

Measuring teaching effectiveness is of great importance because the evidence produced is used to improve the quality of teaching (Berk 2005), and therefore to improve students' learning and social understanding of the ES concept. Our results show that teachers involved in implementing active teaching methods for ES are more likely to conduct the evaluation of the teaching and learning processes they have implemented. This could indicate that, aligned with educational science knowledge (e.g., Prince 2004, Berk 2005), there are scholars who are aware of the importance of both the use of active teaching methods and the evaluation of such teaching experience for successful ES learning processes. A key finding of our research is that teachers with little experience in ES teaching are less likely to use active teaching methods and to evaluate their teaching experience. This may be because of the fact that successful teaching evaluation practices require gradual implementation of lessons learned from evaluation results, and time to allow for such change (Peterson 2000). In contrast, lecturers with more than five years of experience in teaching the ES concept are more in line with best educational practices, applying active teaching methods and

evaluating the effectiveness of their teaching processes. Therefore, creating a platform for collaboration and networking among teachers with different levels of experience could help to improve ES teaching among various groups of teachers.

Why teaching the ES concept is relevant to society and how to improve its social understanding

A large part of the problem of ecosystems degradation lies in the population's lack of awareness of the link between nature and human well-being (Rodríguez-Loinaz and Palacios-Agundez 2022). This is largely because of the way nature is treated in compulsory education, where, generally, humans are presented as a separate unit from the environment (Ruppert and Duncan 2017), and the conservation of nature and biodiversity is decontextualized from the social sphere (García and Martínez 2010). The ES concept, making explicit the close relationship between humans and ecosystems, can contribute to solving some of the limitations of the educational models currently used in Environmental Science Education (Ruppert and Duncan 2017). Increasing awareness and understanding of the ES concept through teaching processes could, for example, contribute to improve landscape planning and governance (Flint et al. 2013, Spyra et al. 2020), and may contribute to reducing unsustainable ES trade-offs (Richards et al. 2017). On the contrary, a poor understanding of the ES concept can risk increasing environmentally or socially harmful activities (Ainscough et al. 2019). For this reason, when raising awareness of the ES concept, critiques need to be considered (e.g., Bekessy et al. 2018). Therefore, it is crucial to teach the ES concept effectively and link it to the concepts of biodiversity and sustainability. Active teaching methodologies, which stimulate problem-solving skills (Wieman 2014) and critical thinking among students (Duron et al. 2006), offer the possibility of engaging students in fruitful dialogues that stimulate critical thinking, helping students understand and appreciate ES provided by overlooked and under-protected ecosystems (Leigh et al. 2019). Moreover, such methodologies encourage students to look for win-win planning and governance solutions leading toward SDGs implementation. Recent studies have shown that teaching ES can contribute to the achievement of SDGs by helping students understand the close relationship between the protection of nature and human well-being and by providing them with strong arguments to defend the need for sustainable development (Rodríguez-Loinaz and Palacios-Agundez 2022). In short, we argue that by improving and mainstreaming the ES concept teaching practices, social awareness and understanding of the importance of ecosystems and nature to our well-being will increase, contributing to the necessary cognitive paradigm shift away from the dominant and flawed neoliberal/neoclassical economic view and toward a more holistic and regenerative worldview, based on the life cycle and social well-being.

Collaboration and networking among academics who teach ES would provide a helpful basis for improving current ES teaching practices. Moreover, this kind of collaboration would help to establish a foundation for how to teach the ES concept that would improve current teaching practices, ultimately enabling one to increase both the scope and depth of understanding related to this subject at different educational levels. Our results show that there is demand for further collaboration concerning how to teach the ES concept, not only by teachers who already teach it, but also by those who do not. The primary interest lies in experience exchanges, i.e., either personal classroom experience or shared teaching materials (e.g., Ban et al. 2015, Cox 2015). Exchanging experience and materials could encourage interested teachers who do not yet teach the ES concept to start doing so. Besides, fostering collaborative activities in teaching the ES concept is also important to enable academics already teaching ES to continuously improve their teaching. In these exchange networks, many academics who already apply different active teaching methods and evaluate their teaching practices can be mentors for others by providing best practice examples. Furthermore, an interest in covering the existing research gap inherent in the teaching of ES has also been detected among respondents. In fact, 19% expressed interest in participating in discussion groups and workshops, whereas 7% directly stated that they were interested in collaborating on research projects on the subject. The results of our research support the need for establishing a network based, interdisciplinary working group on ES education, which would further facilitate regular exchanges concerning teaching the ES concept. This could lead to joint work related to a collaborative approach to share experience, to systematize the evaluation of teaching practices on the ES concept, and to increase knowledge regarding effective teaching approaches.

In order to increase social awareness and understanding of the importance of ecosystems and nature to our well-being, further steps need to be taken, not only at the university level, but also at other educational levels, such as primary and secondary education. Non-university levels of education would also benefit from sharing, with academics, experience, materials, and evaluation methods for teaching the ES concept. Interestingly, our results also show that non-academics who teach ES are interested in networking with academics to collaborate in a working group regarding teaching the ES concept and its framework in a critical and meaningful way toward sustainable development. The joint collaboration between ES academics and primary and secondary school teachers may have a significant educational impact. That collaboration is beginning to take place (Spyra 2014, Palacios-Agundez et al. 2017, Perdices and Ruiz-Alonso 2019); however, mechanisms need to be developed to incorporate the lessons learned from these experiences, so that these collaborative practices can be generalized. In the end, well-conducted science-practice interaction processes can help increase awareness and communication of the ES concept (Dick et al. 2018).

Strengths, limitations and future research directions

We draw attention to the lack of research around teaching the ES concept and provides valuable insights, based on experience from academia, on how to improve teaching experiences in ES, as well as on the importance of sharing and mainstreaming such experience. The novel nature of the study implied that the target group for the research, meaning the total population of academics teaching the ES concept, is unknown. In such cases, the sample size and selection process are subject to different interpretations, sampling strategies, and approaches. In this study, we used the snowball sampling method following several recommendations by Kirchherr and Charles (2018) to enhance sample diversity (e.g., we used diverse sample seeds, reasonable persistence and different waves of sampling). This sampling method is often used when a sampling frame cannot be constructed (Kirchherr and Charles 2018). Furthermore, it allows one to gather a wide diversity of

perspectives within a subject or knowledge area, beyond organizations or institutions. Although distribution of the questionnaire started within scientific communities and their social network, the snowball sampling method was also used to reach academics who were not members of these communities. In this sense, the sampling method used in this study was successful, as almost half of the respondents were not members of a scientific community. However, the sampling method was not as successful, in terms of the geographical coverage of the respondents, because the responses showed a bias toward Europe. Further research, apart from uncovering how the ES concept is taught by academics from universities and research centers, is needed to provide a broader picture of ES teaching. For example, because the ES concept and its framework present an interdisciplinary approach that can be taught within different disciplines (e.g., ecology, economy, political studies) involving many different topics (e.g., mapping, economic valuation, landscape planning, cultural values), further research directions could focus on what exactly is being taught when teaching ES. This could mean exposure of various aspects related to which disciplines teach ES concepts and which aspects of the ES framework are being considered. Another relevant future research direction involves a study of current experience by non-academic teachers and, more importantly, investigation of how to promote a collaborative network between respective university lecturers and school teachers, because the inclusion of the ES concept in compulsory education is crucial for mainstreaming the ES concept in society. In this respect, inclusion of the ES concept in the Next Generation Science Standards, a multi-state effort in the United States to create, with teachers and researchers, new education standards for improving science education, was an important ES milestone (National Academies of Sciences, Engineering, and Medicine 2013). However, little is known about what and how the ES concept is taught at compulsory schools, and very little collaborative experience between school teachers and respective ES research academics has been reported. Future research directions in this emerging research area point to the need to help establish solid mechanisms to generalized collaborative practices between formal education and ES research academics.

CONCLUSIONS

Our research addresses a novel research area related to the teaching of the ES concept by analyzing current ES teaching experiences from academia and exploring their potential to help improve and mainstream such educational experiences. Teaching the ES concept in a comprehensive, practical, and meaningful way could support ecological wisdom and literacy, and thus help ensure the proper dissemination and implementation of the ES concept, which may help achieve the SDG. When comparing teaching practices used by ES academics with current best educational practices described in educational literature, we have seen that many of the interviewed academics teach the ES concept in line with current best educational practices, and that the use of the best practices is influenced by the academics' experience in ES teaching. These results show that there is enough quality experience in the field of ES teaching to disseminate this knowledge and, therefore, to help improve and mainstream ES teaching practices. Thus, collaboration and networking among teachers with different levels of experience could help improve the quality of ES concept teaching and, therefore, public awareness and understanding of the importance that ecosystems and nature have on our well-being would increase. Finally, we suggest that sharing good practices in the teaching of the ES concept at different educational levels could play an important role that requires further attention.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/13286

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Data Availability:

The raw data that support the findings of this study are available on request from the corresponding author. The raw data are not publicly available because they contain information that could compromise the privacy of research participants.

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Appendix 1. Classification and description of the active teaching methods used in the study (based on Prince and Felder 2006).

Type of active teaching method	Description
Inquiry learning	Students are presented with questions to be answered, problems to be solved, or a set of observations to be explained.
Problem-based learning	Students are confronted with an open-ended, complex, authentic (real-world) problem and work in teams to identify learning needs and to develop a viable solution.
Project-based learning	Begins with an assignment to carry out one or more tasks that lead to the production of a final product.
Case-based teaching	Is designed to engage students in a discussion of specific case studies that resemble or are real examples; it uses a guided inquiry method and provides more structure than PBL during small-group sessions.
Discovery learning	Students are given a question to answer, a problem to solve, or a set of observations to explain, and then work in a largely self-directed manner to complete their assigned tasks and draw appropriate inferences from the outcomes.
Just-in-time teaching	Combines Web-based technology with active learning methods in the classroom. This method is commonly used in the flipped classroom approach, where students study material before an interactive session.
Peer instruction	This method enables students to generate knowledge through discussion with their peers and is often used in the interactive session of the flipped classroom.
Educative gamification	Using video game design and game elements in learning environments.

Appendix 2. Description of the area of expertise and professional profile of the 10 experts who took part in the questionnaire validation process.

Area of expertise	Number	Professional profile of the experts
Teaching	3	2 Lecturers from the Mathematic and Experimental Science Didactic Department at the University of the Basque Country (Spain)
		1 Lecturer at Education Faculty and Coordinator of the Educational Advisory Service of the University of the Basque Country (Spain), responsible for the training of university teachers (e.g. in teaching and evaluating methodologies) and management of Educational Innovation Projects.
ES	2	1 PhD from the Center for Development Research (ZEF) of the University of Bonn and researcher at the Territorial Planning Laboratory of the Catholic University of Temuco (Chile) with years of experience in ES research.
		1 Researcher at the Department of Sustainable Landscape Development, Martin Luther University Halle-Wittenberg, (Germany) with over 5 years' experience in ES research and manager of projects focused on ES.
Teaching and ES	5	2 Lecturers from the Ecology Department of the University of the Basque Country (Spain) and main researchers of projects focused on ES.
		1 Environmental Education specialist from the Environmental Training Centre for Teachers of Villaviciosa (Spain) that teaches school teachers regarding ES together with the Spanish National Assessment Researchers team.
		1 Senior researcher from Ruhr University Bochum (Germany) and expert in ES with over 5 years' experience teaching ES.
		1 Research and Teaching Fellow from the Chair of Ecosystem Services at the Technische Universität Dresden (Germany) with experience in teaching ES devoted courses.

Appendix 3. Notice of Data Protection included in the questionnaire.

We (Igone Palacios-Agundez, Gloria Rodríguez-Loinaz, Nina Hagemann, Marta Sylla, and Marcin Spyra) are researchers that are conducting this survey with the aim of sharing and discussing experience regarding the teaching of the ES concept and starting a research study on evaluation methods of the teaching success related to the ES concept.

We are aware of the data protection laws and that this is a voluntary survey. We do not request any personal information other than gender, type of institution and place of residence. Thus, the identity of the respondents remains anonymous. This enables the respondents to express their opinion freely. Additionally, we give respondents the option of providing us with their email address so that they can keep updated on the research results and on the options for collaborating with us. The data are only used for the above-mentioned study project. The data collected is to be processed personally by us (Igone Palacios-Agundez, Gloria Rodríguez-Loinaz, Nina Hagemann, Marta Sylla, and Marcin Spyra) without access to anybody else. Only compiled results will be shared with our project partners. Upon completion of the project, all collected information will be deleted. The compiled results will remain in the form of a report.

Thank you for taking the time to fill out our survey!