Education for sustainable development through e-learning in higher education: experiences from Portugal

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ABSTRACT

E-learning in higher education can be of great relevance in effective life-long learning education for sustainable development in a population of students who are simultaneously full time employees. The aim of this research was to assess the Education of Sustainable Development effectiveness through e-learning in higher education in a case study. The expectations and experience of students who enrolled in more than one programme in environmental and/or sustainability science (bachelor, master, and doctorate), offered by Universidade Aberta, the Portuguese Distance Learning University, were analysed. The six dimensions analysed were: general expectations; learning quality; teaching resources, pedagogical tools and evaluation; acquired competences in education for sustainable development; satisfaction and interactions; and reasons to pursue enrolment in a new programme at Universidade Aberta. Data was collected using semi-structured qualitative interviews. The results showed that the surveyed students felt that they attained a high level of motivation and satisfaction, and had reached an effective learning outcome of knowledge, competences, values, attitudes and behaviour in environment and/or sustainability sciences. For these reasons they were motivated to return to Universidade Aberta and enrol for further training in the sustainability area. These results are built upon previous work developed by the authors, and allow us to conclude that formal e-learning programmes can provide an effective alternative to face-to-face training, allowing students to pursue their studies, in a flexible, collaborative and interactive way, whilst holding down full time jobs. In this way, Education for Sustainable Development in an e-learning regime can contribute to, and have a role in, the transition to sustainable societal patterns.

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1. Introduction

Education for Sustainable Development (ESD) seeks to promote and improve the quality of life-long education which is directed to the acquirement of knowledge, skills and values for sustainability, and reorienting the academic curricula (rethinking, integrating, reforming, and greening education towards sustainability), thereby raising public awareness through a better understanding of the concept of Sustainable Development (SD) (Lozano, 2006; Læssøe et al., 2009; Wals, 2009). Sustainability science (although a distinctive research field (Kajikawa, 2008) with capacities, scientific and technical skills, methodologies and competences of its own), links knowledge to action for sustainability, embracing the principles of ESD, which is an emerging field within educational science with strong ties to sustainability science (Disterheft et al., 2013).

The raising of public awareness about environmental problems, and the simultaneous increase of educational courses on offer in this area at university level, together with novel information and communication technologies, demands new competences, flexibility, and competition between institutions. In view of these demands, life-long learning has created an educational *niche* opportunity for e-learning (Eneroth, 2000). E-learning is a teaching and learning process, according to an appropriate distance learning

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<table>
<tr><td colspan="2">List of acronyms</td></tr>
<tr><td>CU</td><td>Curricular unit</td></tr>
<tr><td>DESD, 2005–2014</td><td>the United Nation Decade of Education for Sustainable Development</td></tr>
<tr><td>ECTS</td><td>European Credit Transfer and Accumulation System</td></tr>
<tr><td>ESD</td><td>Education for Sustainable Development</td></tr>
<tr><td>HE</td><td>Higher education</td></tr>
<tr><td>ICT</td><td>Information and communication technologies</td></tr>
<tr><td>SD</td><td>Sustainable Development</td></tr>
<tr><td>UAb</td><td>the Portuguese Distance Learning University</td></tr>
<tr><td>VLE</td><td>Virtual learning environments</td></tr>
</table>

pedagogical model, that allows flexible learner-centred education since it is based on information and communication technologies (ICT). The ITC allow e-learning to take place in virtual learning environments (VLE) (also known as learning platforms) where multidirectional communication is possible (teacher-student and student–student) (Pereira et al., 2008, Garrison, 2000). An e-learning system, which is independent of time and place (Lee and Lee, 2008; Garrison, 2000), a self-regulated learning process (Narciss et al., 2007), and an inter-disciplinary approach to teaching and learning, constitute key factors in education for sustainable development (ESD) (Lozano et al., 2013a).

Online education provides students with an educational alternative to face-to-face courses, permitting students to proceed, at their own pace, and to identify their own personal course timeline (Shanley et al., 2004), while having at the same time full-time jobs (working students). Flexibility, interaction, teaching presence, collaborative learning and a great sense of community are very important categories in online students' discourses (Hansen, 2008; Moura et al., 2010). Arbaugh (2005) and Moura et al. (2010) stated this sense of online community as a significant predictor of online learning outcomes. Online learning pedagogy allows students to have a more accurate perception of the effectiveness of their own learning (Shohreh and Keesling, 2000), increasing student-to-teacher interaction, as well as critical thinking (Hay et al., 2004). Interaction among peers, and with teachers, is privileged by online students (Moura et al., 2010) promoting the existence of a learning community (Concannon et al., 2005; Peltier et al., 2007; Moura et al., 2010). Moura et al. (2010) and Paechter et al. (2010) also emphasized the teacher's expertise and role as a counsellor and facilitator in learning. Students experience the teacher's support and expertise as being particularly important for the acquisition of knowledge, skills, and competences, as well as for course satisfaction (Moura et al., 2010; Paechter et al., 2010).

Online programmes seem to produce the same level of student performance as face-to-face courses (Johnson et al., 2000; Weber and Lennon, 2007; Lapsley et al., 2008), with comparable learning outcomes (Sitzmann et al., 2006), and important levels of satisfaction (Chang and Tung, 2008; Shee and Wang, 2008), namely, in the environmental and sustainability science fields (Bacelar et al., 2009, 2012; Pretorius, 2004).

The aim of this work was to assess the ESD effectiveness through e-learning in higher education (HE), including students expectations and experiences and the will to pursuit their studies, according to a long term assessment. A case study was then analysed in this work: the students that enrolled in more than one e-learning programme in environmental/sustainability sciences offered by UAb, the Portuguese Distance Learning University. The following dimensions were analysed in the UAb students: general expectations, learning organisation and interactions in students' discourses, teaching resources, pedagogical tools, together with the evaluation of how, and if, concepts of sustainability are been acquired and put into practice by the students over time. These analyses were performed with students who have completed one programme at UAb and are in transition from Bachelor degree to Master, or from Master to PhD.

The UAb was chosen as a case study, since it is a public university in a southern Europe country dedicated exclusively to distance learning, using the most advanced technologies and methods of Distance Learning. The UAb became a reference European institution in the area of advanced e-learning and online learning through the recognition of its Virtual Teaching Model, unprecedented in Portugal and developed by this institution. The UAb was recently awarded internationally by Prize of European Foundation for Quality in E-learning and certification of The UNIQUE Quality Label for the use of ICT in HE, awarded with the 1st Level of Excellency of the European Foundation for Quality Management, and also awarded by the European Commission with the Diploma Supplement Label. UAb was also considered recently by an European Commission report as a key actor in the higher education system in Portugal and Europe (European Commission/EACEA/Eurydice, 2014).

2. Education for sustainability in higher education and E-learning: motivation, competences, and attitudes

Historically, universities have played many roles in transforming societies, by educating decision-makers, leaders, entrepreneurs and academics. However, education and research on sustainability in universities is at an early stage in many institutions. In addition, we need to consider that organizations such universities tend to change at relatively slow pace (Lozano et al., 2013a).

The evolvement of ESD in HE could be seen in several dimensions: 1) Sustainability in Policy, Planning, and Administration, 2) education (Courses and Curricula), 3) Research, 4) University's campus Operation, 5) Outreach and Services; 6) assessment and reporting (Saadatian et al., 2012; Lozano et al., 2013b). The emphasis of higher education institutions should be to promote interdisciplinary thinking and analysis, which is the basis of SD, by teaching the more complex interrelations between economic, social and environmental concepts. This is being done in several countries at the tertiary, or university, level in terms of the concept of SD (the development of course curricula within particular academic disciplines), but also in terms of the institutions' day-to-day operations (as in the whole school approach) (Zervakis and Wahlers, 2007). Also, the community aspects of a sustainable campus should be addressed, such as involvement and cohesion, diversity among student culture and gender, university/campus services and educational programmes about SD (Saadatian et al., 2013). Curricular development should also be complemented with research on pedagogical approaches and their efficacy for delivering sustainability education, and 'educating the educators' programmes (Lozano and Young, 2013).

Many universities are already actively motivated to integrate ESD into their educational activities. These initiatives are focused on: i) appropriate student learning outcomes; ii) course curricula and assessment methods; iii) displacing barriers; iv) changing teaching paradigms; v) developing social competencies; vi) communication skills, and community relations, and viii) deepening their involvement in local and regional (several examples of those initiatives can be found in Karatzoglou, 2013). One of the reasons behind the current efforts is the UN Decade of Education for Sustainable Development (DESD, 2005–2014), handled by UNESCO, which has the goal of integrating the principles, values and practices of sustainability (Segalàs et al., 2009). Universities must be part of a global structure offering ESD, with the aim of

inculcating people with the knowledge and ability to reflect on the effects of their behaviour on the globe (Barth et al., 2007). A set of competences required to enable active, reflective and co-operative participation toward sustainable development are described by several authors (e.g. de Haan, 2006; Segalàs et al., 2009; Fadeeva and Mochizuki, 2010). The integration of competences for SD in higher education programmes can be seen as an important step in achieving sustainability in higher education (Lambrechts et al., 2013). For higher education to address the issue of sustainability it requires a focus on the development of the following: (i) a learning process to attain the relevant, but yet key, competences; (ii) learning for sustainable development that requires social learning; and (iii) individual learning within a social context. These items will require a change in the teaching processes from teacher-centred to learner-centred (Barth et al., 2007). Experiential learning, by reconnecting to real-life situations and focussing on real and practical life issues and actual experiences as learning situations, and holistic thinking are also determinant in achieving sustainability through ESD.

Competences in sustainability are therefore related to acquired knowledge, skills, and attitudes that enable successful task performance and problem solving with respect to real-world sustainability problems, challenges, and opportunities (cf. Dale and Newman, 2005; Rowe, 2007; Barth et al., 2007). Consequently, ESD needs to translate these competences into an educational perspective in order that they may fully contribute to sustainable development and sustainability. There is an ongoing discussion about competences, inter- and trans-disciplinarity (e.g. Barth et al., 2007; Mochizuki and Fadeeva, 2010; Parker, 2010; Wals, 2010). However, most of the competences are related to critical thinking, systemic thinking and inter- and trans-disciplinarity. Mulder (2006) states that Sustainable Development is not just a matter of acquiring some extra knowledge. Attitude is also important. Moreover, it is often necessary to change social structures. In the words of Palmer et al. (2010) and Wals (2010), transformative social learning underlies the evolving concept of ESD directed to empowerment. As key competences for ESD, de Haan (2006), and Lambrechts et al. (2013) identify (i) competences in foresighted thinking; (ii) competence in interdisciplinary work; (iii) competence in cosmopolitan perception; cross-cultural understanding and cooperation; (iv) participatory skills; (v) competence in planning and implementation; (vi) capacity for empathy, compassion and solidarity; (vii) competence in self-motivation and in motivating others; and (viii) competence in distanced reflection on individual and cultural models. For a more detailed literature review of competences for sustainability and their framework see Wiek et al. (2011) and Rieckmann (2012). The challenge is how best to translate the objectives and competences of ESD into practice (Zilahy and Huisingh, 2009; Barth and Rieckmann, 2012).

In addition, according to Zsóka et al. (2013) there is a strong correlation in the University between the intensity of environmental education and the acquired environmental knowledge of students. Thus, providing adequate environmental and sustainability resources and (rigorous?) habits in everyday academic life turns out to be a very significant aspect for fostering (long term?) pro-environmental behaviour and sustainability. The role of ESD is indeed to support changes in behaviour, values, management, and policies towards more sustainable production and consumption patterns (Eneroth, 2000).

First degree HE programmes have tended to focus on conveying basic science and general principles. At the postgraduate level the application of those principles can be explored against the maturity and realism of a student's outlook, often based on the students own experiences and the constraints and complexities represented by

the wider issues related to sustainability (Fisk and Ahearn, 2006; Cruickshank and Fenner, 2012). After completing PhD level, graduates should be able to participate, apply and interlink their skills towards the competent delivery of sustainable development in their future careers.

The recognized importance of integrating sustainability issues into education, together with the reflection on different pedagogical approaches to exploring key sustainable themes, should be replicated in e-learning and the way we teach, and thus how the student learns. In this way a university's (open learning?) sustainability programme can produce sustainability leaders and change drivers for effectively educating students of 'all ages' and to help make the transition to 'sustainable societal patterns' (Lozano et al., 2013b). E-learning brings new dimensions to traditional education, when it comes to adult learning, and increases the motivation of students to learn about environmental issues. Moreover, it may increase their readiness to learn if the students are allowed to move into new social roles through the programme (Eneroth, 2000). Wilson et al. (2011) defend that by creating new ways of exploring and solving environmental problems in an interactive way online, that can add new dimensions to increase the motivation to learn sustainable issues.

Hansen (2008) highlighted that successful online students should have greater inclination to transfer knowledge to a new domain, greater sense of community and communication, and greater ownership of knowledge and independence, which leads to successful learning and transfer (Arbaugh, 2000a, b; Schramm et al., 2001). Moura et al. (2010) and Paechter et al. (2010) also stated that the flexibility in the choice of learning strategies and the exchange of knowledge with peer students are positively related to learning achievements. Students who use opportunities in self-regulated and collaborative learning also experience higher learning achievements, all important issues within ESD.

E-learning has been used for ESD, in particular in the context of life-long learning and adult education, and some studies have been conducted to assess the outcomes of e-learning of SD in HE. For example, in 2014 a book has been published about e-learning and sustainability, mainly in the context of HE, discussing in 18 chapters issues like: principles, concepts and competences, ICT tools and e-materials, and with several examples of good practice and learning experiments worldwide (Azeiteiro et al., 2014). Some of these chapters highlight the importance, in the context of ESD, of lived experience, trans-boundary competences, use of simulation and educational games, and collaborative learning through social networking. All of them appropriate for e-learning, considering its characteristics already listed above. Other authors have also evaluated the effectiveness of sustainability courses by way of e-learning, through student questionnaires, and to provide a resource for other educators and researchers in sustainability education and professional practitioners, aimed at the development and effective use of on-line technology for sustainability knowledge, assessment practices, and community generation (e.g. Pretorius, 2004; Holden and McIlhenney, 2010).

Nevertheless, there is still limited research on the effectiveness of e-learning, in terms of knowledge gained (environmental literacy) through online delivery methods, or if the course contents, organisation and learning regime help students acquire competences related to sustainability, and change their attitudes and behaviours during the life-long learning, educational, and professional process. The assessment of long term and interlinked ESD training throughout undergraduate, master and doctoral degrees is also an important innovative issue. As Lozano and Huisingh (2011) highlighted, the time dimension plays a key role in real, long-term changes towards sustainability.

3. Methods

Case study and grounded theory were used in this study according to a mixed method choice (see Denzin and Lincoln, 1994; Saunders et al., 2007).

This section explains the case study (Universidade Aberta) and the data analyses method used to evaluate the long term training interlinked ESD at UAb, in terms of learning and pedagogic quality, student satisfaction, motivation and attitudes towards SD.

3.1. Case study: the Universidade Aberta (the Portuguese open distance university)

Established in 1988, Universidade Aberta (UAb) is the only Distance Learning public higher education institution in Portugal. All pedagogical offers at UAb are integrated into the Bologna European Process and are taught via e-learning since 2008. UAb is a reference HE European institution in the area of on-line and advanced e-learning and learning, using the most advanced information and communication technologies, and a recognised Virtual Pedagogical Model (Pereira et al., 2008). UAb has more than 12,000 students and offers more than 40° and several life-long study programmes.

The formal educational offer of UAb in environmental/sustainability sciences - is organised according to the European Credit Transfer and Accumulation System (ECTS), and has its own virtual pedagogical model (Pereira et al., 2008). This on-line model is based on four major principles: student-centred learning, flexibility, interaction and digital inclusion. The core is a curricular unit or a Learning contract (for undergraduate or graduate programmes, respectively), developed by the teacher of each curricular unit (CU). Each of these documents is structured into topics, outcomes, competences to be acquired or developed, learning methodology, list of e-activities, timetable for developing learning activities, and list of support learning materials. The semester is defined as a period of twenty weeks, where the five final weeks are dedicated to final assessment. The continuous assessment component (obtained through the e-activities) is weighted 40% or a minimum of 60% (for undergraduate or graduate programmes, respectively) of the final mark (face-to-face final exams occur only in undergraduate programmes). Different learning strategies are developed depending on the study cycles: from mainly individual work (undergraduate) to more collaborative and cooperative learning where peer interaction becomes very important (MSc and PhD). The open source Moodle (http://elearning.uab.pt/) is the course management systems used in all the programmes. A two weeks online introductory module is available to students before the beginning of the 1st semester, which is intended to familiarise the students with the virtual environment and the e-learning tools, as well as promoting the acquisition of online communication and online social skills. All the courses have virtual class sites, a coordination site for student matters, a coordination site for the teacher's team, an online secretariat, and a virtual "café".

In line with the global requirement for an education for sustainable development, the UAb has developed a three cycle degree system, according to the reform of the "Bologna process", which aims to actively promote education for sustainable development, along with an increase in transdisciplinarity across subjects, and student cooperation:

- first cycle — Bachelor degree in Environmental Sciences (180 ECTS);
- second cycle — Master degree in Participation and Environmental Citizenship (100 ECTS); and

- third cycle — PhD degree in Social Sustainability and Development (180 ECTS).

The Bachelor degree in Environmental Sciences is a b-learning programme, directed to an adult public (over 21 years old), who are mostly working-students (they have to see that schooling is effective, even though they are also working full time) seeking professional development, which began in the academic year 2007. The general purpose of the course is to promote and develop a set of professional skills and competences within the Environmental Sciences. These include Natural Heritage, Environmental Health, and Environmental Management and Sustainability as three optional minors. The first two years are composed of mandatory curricular units of Science and Environmental Technology, Biological Sciences, Earth Science, Mathematics, Chemistry, Physics and Legal Sciences, for a total of 20 compulsory curricular units. With the exception of two curricular units (Fieldwork I and II that have each a face-to-face week), the undergraduate course follows the Universidade Aberta pedagogical model in its virtual class regime.

The Master degree in Participation and Environmental Citizenship was initially offered in 2005 as a b-learning programme (all modules are offered in e-learning, except for one which includes a one day face-to-face session). The main purpose of this programme is to develop competences in the area of Sustainable Development, covering both environmental and social aspects.

Lastly, the PhD degree in Social Sustainability and Development was developed as a natural sequence, due to the increasing demand for an advanced specialisation and research in sustainable development science, both from the professionals connected to the tertiary sector and public sector, as well as educators, managers in business and international organisations, whose area of activity is socio-environmental sustainability. This PhD aims to contribute to forming a generation of leading individuals capable of understanding the different meanings and implications of changes in global, social, and human systems and who choose the path of sustainability in implementing policies on the basis of this understanding. Thus, although the three cycle degree system is not fully specialized in SD, it transversally integrates SD into the courses of each programme and increases focus on SD, primarily at the Master and PhD levels covering all aspects of SD.[1]

In UAb the evaluation of sustainability programmes started with Caeiro et al. (2001, 2004) and Caeiro and Azeiteiro (2004, 2007) with the distance learning experience of the Curricular Units; Ecology, Environmental Education, and Environmental Sciences. The transition from the open and distance education to the e-learning, and namely the e-learning for the environment, was described in terms of new challenges for e-learning in environmental sciences by Martinho et al. (2010), Bacelar-Nicolau et al. (2007, 2009), Amador et al. (2008) and Caeiro et al. (2008). In summary the studies from Bacelar-Nicolau et al. (2007, 2009, 2012), Martinho et al. (2010) and Moura et al. (2010) showed: (i) a very high level of student motivation and satisfaction with the online programmes (changing their attitudes about environmental domains and contributing to others' changing attitudes and behaviours), and (ii) that online students are equally satisfied with their courses, revealing the same confirmed general expectations and acquired competences (online education is as effective at training students as face-to-face education). Also Martinho et al. (2014) indicate that the 1st cycle e-learning programme in Environmental Sciences of UAb, is globally adjusted to employability requirements, through the acquisition and/or development of

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[1] More information about the curricular plans are available at http://www2.uab.pt/guiainformativo/indexEN.php.

competences and skills as shown by its current graduates. Based on the results of a questionnaire survey applied to the master's students for 3 academic years, starting in 2007, Martinho et al. (2010) established a link between the knowledge acquired and changing attitudes and behaviours towards sustainability. However the works of Moura et al. (2010) and Oliveira et al. (2012) reinforce the need for more laboratory and practical classes (b-learning). The new virtual technologies are important but not sufficient, because they do not encourage the development of key learning skills, attitudes and values towards environmental conservation and sustainability development to the same level as face-to-face fieldwork (Oliveira et al., 2012).

3.2. Data analysis

A student's survey with semi structured interviews (Fontana and Frey, 1994) was used. The UAb's students who had completed more than one environmental/sustainability programme at Universidade Aberta, *i.e.* the 1st cycle/Bachelor (environmental sciences or other bachelor degree), 2nd cycle (Master on Environmental Citizenship and Participation), or had the frequency of the 3rd cycle (PhD on Social Sustainability and Development) were interviewed, corresponding to 9 students at the time the data was collected, during December of 2012 and January of 2013.

The semi-structured interview included a quantitative approach (using the Likert scale from "very good" to "poor", or from "total agreement" to "total disagreement"), and a qualitative approach (open questions) to analyse 6 dimensions of student discourse: general expectations; learning quality; teaching resources, pedagogical tools and evaluation; ESD acquired competences; satisfaction and interactions; and reasons to pursue a new enrolment at UAb (Fig. 1).

Sections B and C were evaluated by students using a Likert scale (categories: not applicable; poor; fair; good; very good), and open questions, while sections D and E used the Likert scale (categories: total agreement; partial agreement; no opinion; partial disagreement; total disagreement), with two open questions in section D. Sections A and F includes open questions only. The interview guide (questionnaire) was pre-tested, and improvements were made in the final version, which was validated. The interviews were conducted in face-to-face or using Skype software with an average duration of 45 min, and transcribed by direct note taking.

Descriptive statistics of the Likert based questions were conducted. Frequency distributions were converted to percentages to provide a standardised way of comparing the categories. For the open-ended questions a content analysis was conducted according to Bardin (1977) and discussed according to the theory and state of the art presented in Section 2, allowing to develop from the data collected: i) classification of the answers in categories, serving the survey questions as starting categories; and ii) integrating categories and their meaning, or modifying the categories to provide new interpretations based on theory. The limitations associated with interviewing, e.g. validity, reliability and generalizability, such as those associated with participant and observer error and bias (Saunders et al., 2007) were taken into account in the discussion of results, and when drawing conclusions.

4. Results and findings

All the students that met the established criteria participated in this research. The age profile of participants ranged from 34 to 53 years, the majority being in their early thirties. They represented career interests in different areas and several science backgrounds, from Natural Sciences and Engineering to Social and Economic Sciences. Six students had completed the 1st cycle Environmental Sciences at UAb and 4 had completed the 2nd cycle at UAb. Six students were currently enrolled in the 2nd cycle programme and 3 were PhD students. About half of them had previously enrolled in e-learning courses twice and the other half had experienced e-learning courses three times (one of the students experienced e-learning more than three times), which included short duration e-learning modules in sustainability issues.

Almost all students had known about the programmes by visiting the university web page and by internet searches; one student knew from a former university student colleague.

When asked about their **motivation** to study sustainability subjects and enrol in environmental/sustainability courses at UAb, students expressed two main reasons: the will to pursue knowledge and competences in sustainability; and professional advancement:

> *"To specialize in an area that I really like (Environment) and where I had many gaps of knowledge. The ability to contribute in a more scientific way to social and environmental interventions and to*
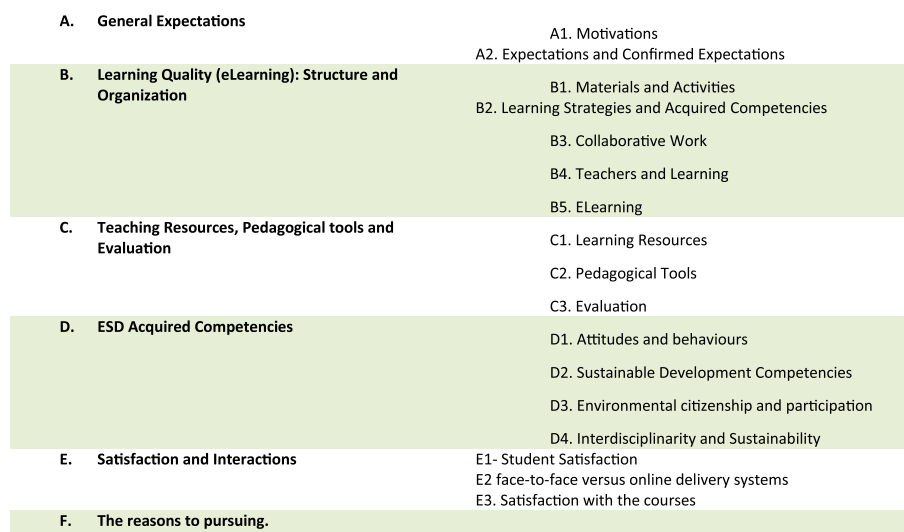
A.	General Expectations	A1. Motivations
		A2. Expectations and Confirmed Expectations
B.	Learning Quality (eLearning): Structure and Organization	B1. Materials and Activities
		B2. Learning Strategies and Acquired Competencies
		B3. Collaborative Work
		B4. Teachers and Learning
		B5. ELearning
C.	Teaching Resources, Pedagogical tools and Evaluation	C1. Learning Resources
		C2. Pedagogical Tools
		C3. Evaluation
D.	ESD Acquired Competencies	D1. Attitudes and behaviours
		D2. Sustainable Development Competencies
		D3. Environmental citizenship and participation
		D4. Interdisciplinarity and Sustainability
E.	Satisfaction and Interactions	E1- Student Satisfaction
		E2 face-to-face versus online delivery systems
		E3. Satisfaction with the courses
F.	The reasons to pursuing.	

Fig. 1. Dimensions analysed in students' discourses in the semi structured interviews.

have a greater awareness of the consequences of my actions, following greener alternatives and avoiding certain behaviours, harmful to living things in particular (including humans) and to the planet in general. Finally, be able to reconcile academic studies with work and family life, which Universidade Aberta can provide.” (Student #1)[2]

“To get back to study and work in the environmental education / sustainability areas as well as the desire to change professionally from what I was previously doing. (…) The search and 1st motivation was the thematic area, but when I saw it was in e-learning regime, that put together the useful with the pleasurable.” (Student #7)

One other important motivation is related to e-learning flexibility (already referred to in the previous discourses), together with the demand for new competences:

“While working full time, the choice for the 1st cycle at Universidade Aberta had to do with: 1) the spatial and temporal flexibility allowed by asynchronous teaching, and 2) the pedagogical offer which corresponded to my interests. My enrolment in the 2nd cycle, beyond the aforementioned flexibility, had to do with: 1) the scientific area of the Master degree in Citizenship and Environmental Participation, which corresponded to my research interests, and 2) the very good experience during the 1st cycle (…).” (Student #5).

Student **expectations** are related to the acquisition of knowledge, research skills, competences development, and professional improvement/preferment, and validation:

“My goals are linked to the continuous enhancement of personal skills that allow me to continue to learn and to research in the area of environment, in order to improve personally and to contribute to environmental citizenship (….). The expectations relate to the validation of the objectives, and to the achievement of a scientific study that allows contributing to environmental citizenship. At the professional level, due to the difference in scientific areas, I do not expect valuing my situation, but I will not refuse interesting proposals related to the environment as a complement or a replacement activity.” (Student #1)

The students, globally, confirmed their initial good expectations at the completion of their programmes, and for possible application in their work, or future jobs:

“Yes. (…) I had been working with rural communities for development but I needed to bring forth some more tools to continue this activity in the best possible way. Through the course I managed to achieve this. Professionally, it was good for me. Good expectations. On one hand it responds − professionally - to what are the demands of my work as a consultant, including Environmental Impact Assessment in the company I work for. On the other hand, it can contribute to a better environment in Mozambique through the tools acquired in the 2nd cycle programme.” (Student #3)

“Yes, they have been reached. The objectives were to expand knowledge in the field of sustainability and to gain new professional perspectives. (…).Thus it opened up a new professional perspective to later work: in the university context in research and teaching, or even connected to the implementation of sustainability

in higher education: or to work at community level in NGOs or other institutions in the area of ESD. I want to gain more theoretical background and experience in researching.” (Student #7)

On the topic of perceived **quality of the learning process** (e-learning): structure and organisation (materials and e-activities, learning strategies and acquired competences, collaborative work, teachers and learning, e-learning) most students (70–90%) evaluated the items as Good and Very Good (Fig. 2).

In general, students seemed interested and engaged in the course's contents. Results also revealed that most in-class activities were well received by students. One student asserted that e-learning provided him with competences that the face-to-face courses could not provide:

“I am not referring to scientific expertise, which I think would be identical to the face to face programmes of excellence, I would add that I gained more skills in the courses of Universidade Aberta than would obtain in other Universities' face-to-face courses. I refer specifically to: i) written communication competence, ii) relational competence written iii) competence in ICT.”(Student #6)

The results of the assessment of **teaching resources, pedagogical tools and evaluation** by the students are shown in Fig. 3. The bibliographic resources, Teacher's support texts and Moodle lessons were well rated. The slideshows, internet sites and videos were less well rated in pedagogical terms by the students, who included the evaluation "poor" and "fair", mainly for the videos; this was explained by one student by the fact that there should have been more videos available in the different courses. The scientific evaluation of slideshows and internet sites included an evaluation of "poor" by 2 students. Online exams (inside Moodle) were also rated as "poor" or "fair" by 5 students.

All Students agreed that the pedagogical and science quality parameters between 1st cycle/Bachelor, 2nd cycle/Master and 3rd cycle/PhD courses were consistent, and at a high level. Two of the Master's students mentioned that the interaction among peers, and with teachers, was advantageous in 2nd cycle/Master programmes:

“In general those aspects were maintained. However, the aspect of collaborative learning improved considerably; learning was quite solitary during the 1st cycle studies.” (Student #5)

Regarding **ESD Acquisition of Competences** (Attitudes and Behaviours, Sustainable Development Competences, Environmental citizenship and participation, Interdisciplinarity and Sustainability), students agreed that they had gained sustainability competences throughout their programmes. The change in attitudes and behaviours achieved good results (100% of "Total" and "Partial agreement"), with all the other parameters achieving "Total agreement" from the students (Fig. 4).

In the ESD Acquired Competences dimension, student discourses reinforced the quantitative data and their positive results:

“Without a doubt! (…).Also by the scientific area being the environment, the training I had allowed a very positive development in terms of skills for Education for Sustainability. Beyond technical courses, disciplines such as Environmental Education and Ethics, and Environmental Citizenship provided important tools for reflection, implementation and evaluation of environmental education actions that allow changing attitudes and behaviours.” (Student #1)

“If I drew a graph of learning over the time that I undertook the programme, I would place a rising line in terms of self-evaluation.

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[2] The transcriptions of students open answers were translated from Portuguese to English for this manuscript.
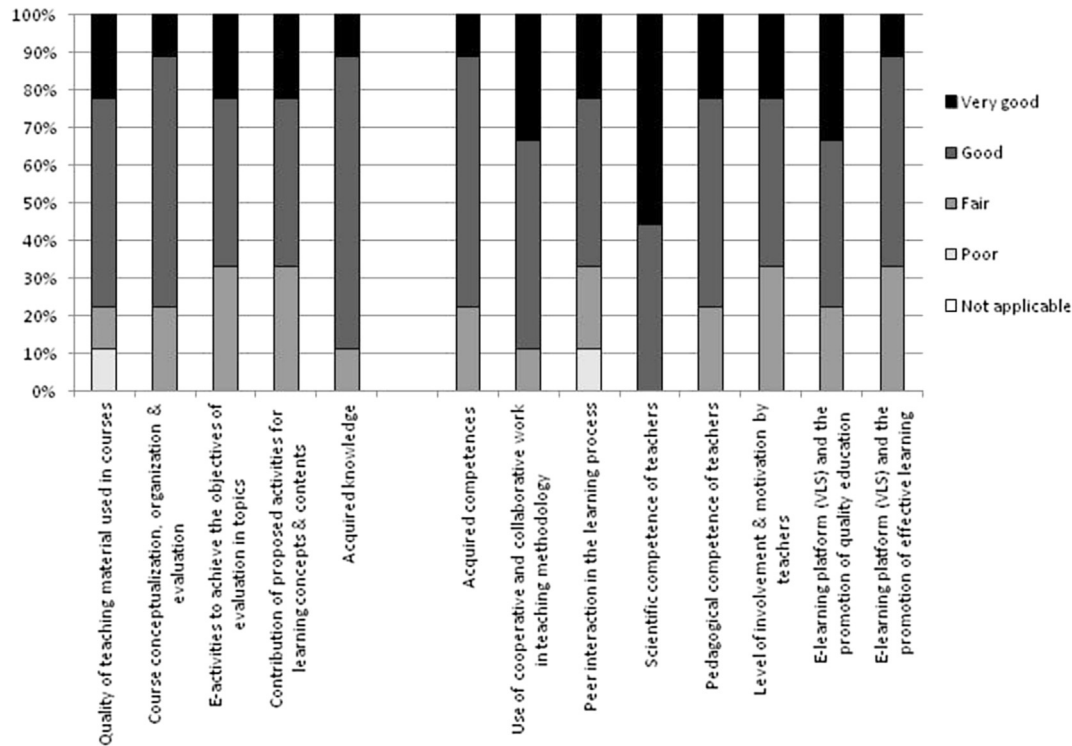
Fig. 2. Learning Quality (e-learning): structure and organisation (materials and e-activities, learning strategies and acquired competences, collaborative work, teachers and learning, e-learning).

When I started the programme I realized that there were many issues in my behaviour which were not the most correct; along the way I understood better these issues and how, in some cases, I was wrong.In scientific terms I gained many skills, both in terms of formulating scientific writing and in terms of knowledge of the various sciences per se. Field Work II had a very important role in learning how to present and prepare project work. Sure, there were things I could have learned (or wanted to learn), but in a 1st cycle they are not yet to learn."(Student #8)

The students had a high level of **satisfaction** regarding the e-learning pedagogical model. The results of the acquired competences compared to face-to-face learning are also satisfactory (67% of Agreement) (Fig. 5). Not surprisingly, students disagree or have no opinion about having greater ratings with Universidade Aberta courses. Almost 60% agree that at UAb they can develop the competences that they would develop in equivalent classroom courses.

The reasons for **pursuing training** in another Universidade Aberta's programme in the field of environment/sustainability is related to the pedagogical model flexibility and to previous positive learning experiences, together with the scientific coherence and pedagogical progression between the formal programmes:

"The difficulty in enrolling in a face to face course due to professional activities and family; positive experience, though very laborious, held in the 1st cycle; familiarity with teaching methods, the competence of some teachers, the existence of a course to allow for a career within the same academic scientific area." (Student #1)

Also scientific and professional upgrades were mentioned as reasons to pursuing studies:

"Opportunity to continue to learn in a systematic and target way, matters of personal and professional interest. Possibility to update, and participate in discussion forums with ac

cess to other perspectives in the study area". (Student #2)

"Answer to the professional and individual demands that I had." (Student #3)

5. Discussion

In line with the necessary adaptations entailed by the "Bologna process" and construction of an education European space, providing tools to connect and compare different educational systems, the Portuguese Distance Learning University (UAb), committed itself, beyond the integration of ESD in course curricula. In this way UAb created a complete three degree cycle system where the main aim is to develop skills and competences towards sustainability science (from more traditional science at BSc to inter- and multidisciplinary studies at PhD level). But, 'How effective within ESD is long term transverse training in an e-learning regime in terms of educational and pedagogic quality, student satisfaction, motivation and attitudes', was the main research question of this case study. As Karatzoglou (2013) stressed in a literature review of contributions of universities to ESD, case study research is useful to secure the capacity of the collaborative learning process to benefit both the actors involved in the process and those external parties who may be interested in gaining knowledge from it.

Our results built upon the earlier work of Bacelar-Nicolau et al. (2007, 2009, 2012) and showed that the surveyed students have a very high level of motivation and satisfaction with the programmes, and having reasons to return again for new training at Universidade Aberta. Also, most students had the perception of having reached an effective learning outcome of knowledge, competences, values, attitudes and behaviour, the central elements of education for sustainability (Shephard, 2008). As Zsóka et al. (2013) highlights, environmental education at university level should address the knowledge, attitudes and behaviour in a differentiated, targeted
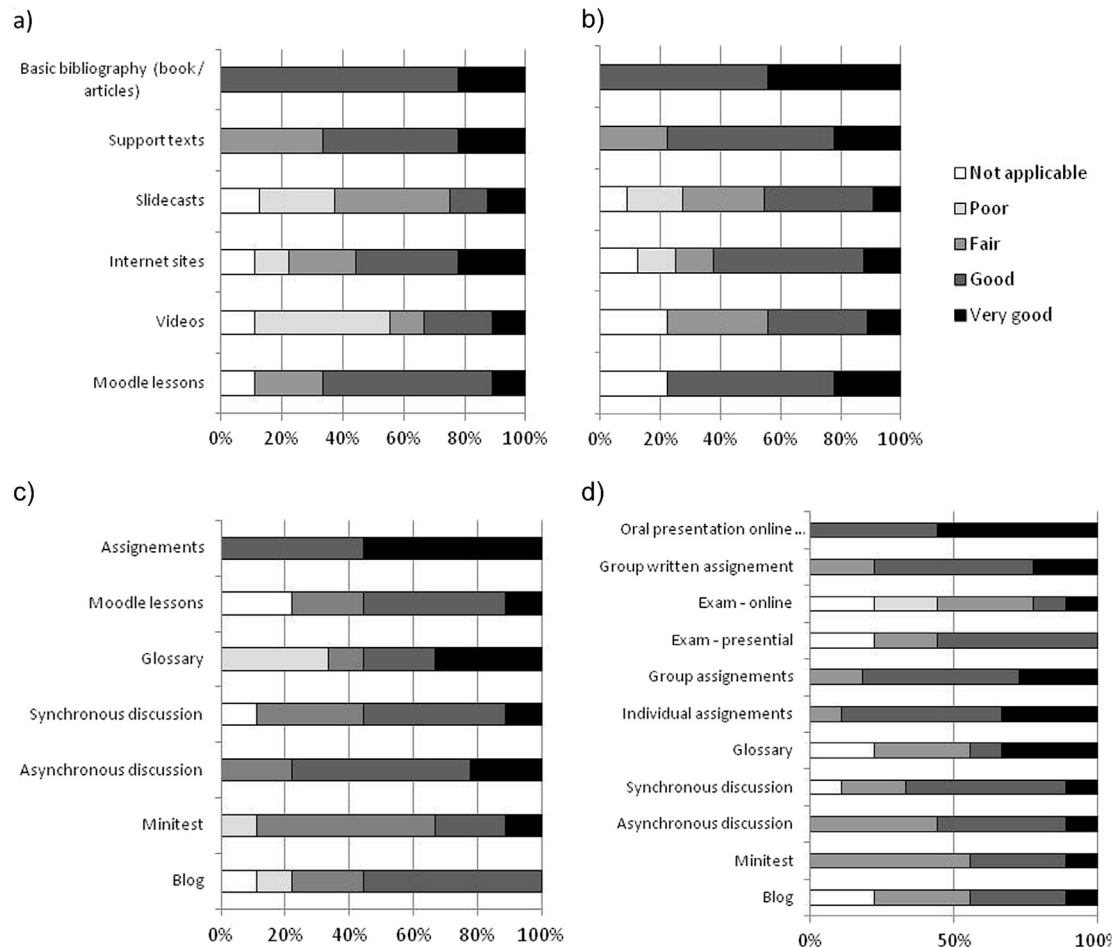
Fig. 3. Teaching resources, pedagogical tools and evaluation: a) pedagogical quality; b) scientific quality; c) acquired competences; d) evaluation tools.

and effective manner. Nevertheless, in terms of environmental attitudes, although environmental training is indeed needed, it is not sufficient to sustain environmental behaviour (Rodríguez-Barreiro et al., 2013). The results show that important sustainable development competences were acquired by the surveyed students (Fig. 4), such as those defined by Lambrechts et al. (2013) and Rieckmann (2012), for example, personal involvement, action skills, emotional intelligence, and interdisciplinary work. Also, those competences are implicitly integrated into the main courses of the analysed programmes, although the development of active citizenship is not fully satisfied by the tools provided on the programs (Fig. 4). Also, as Martinho et al. (2014) highlighted in an earlier assessment of the first degree programmes, some relevant competences, particularly interpersonal competences and competences related to the application of knowledge to practical situations, were not yet sufficiently developed.

UAb should continue to improve their programmes by proposing competencies with empirical evidence showing they enable successful real-world sustainability research and problem solving, in particular in the higher levels of post-graduation (PhD), as highlighted by Wiek et al. (2011). The encouragement of students to pursue more than one ESD program, using the new teaching tools and after teacher training, should contribute to this improvement. Nevertheless in this work behaviours were not evaluated, or real SD actions, these can only be assessed using other longer term research tools, and participant observations that are beyond the scope of this study. Structural equation modelling to test causal

models relating attitude to behaviours (see Rodríguez-Barreiro et al. (2013)) can also be tested in future developments. As Wiek et al. (2011) stress, continuous monitoring of performance within and beyond the programmes are fundamental issues to ensuring high quality education in sustainability and competence acquisition. In addition, assessment of sustainability's key competencies in higher education is also a field needing future research (Rieckmann, 2012).

The main factors identified by the surveyed students as contributors to student satisfaction (e.g. communication tools, teachers' expertise and motivating skills, learning e-activities), and to their perception of learning effectiveness, are similar to those reported by Palmer and Holt (2010), Paechter et al. (2010), as identified earlier for the MSc programme in Environmental Citizenship and Participation (Bacelar-Nicolau et al., 2012). Nevertheless, this later work only accessed at the master level, and not for students that pursue their studies at the same university.

At UAb the pedagogical strategies have been developed to engage students as active participants (Pereira et al., 2008). The pedagogical model includes principles permitting teaching and learning activities for each curricular unit to be performed at a distance, in a virtual learning environment. This learner-centred model, where students are responsible for knowledge building, is based on the flexibility of access without temporal or spatial constraints, a point that was strongly highlighted by the surveyed students as a great advantage of distance learning. Besides, this model is based on acquisition and development of competencies,
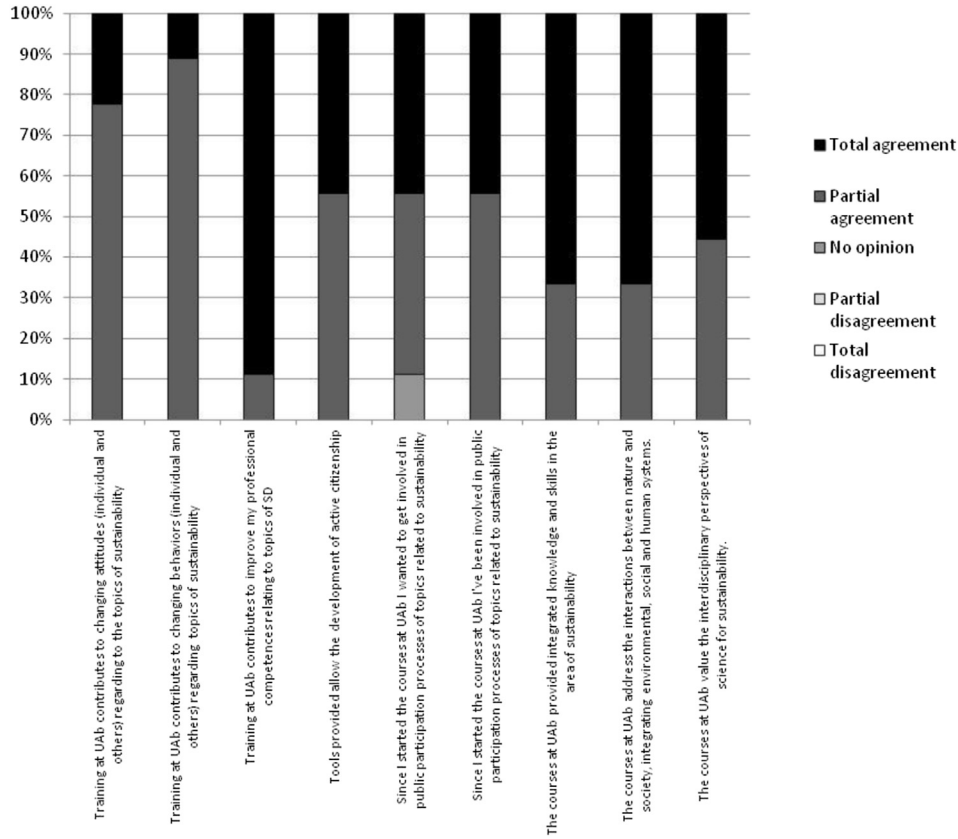
Fig. 4. ESD Acquired Competences (attitudes and behaviours, sustainable development competences, environmental citizenship and participation, interdisciplinarity and Sustainability).

according to the new demands of the European credit transfer system. It also relies on diversified student-teacher and student–student interaction, as well as students and learning resources in a social context. Those are issues that e-learning should guarantee, as highlighted by several authors (e.g. Arbaugh, 2000a; Garrison, 2000; Hansen, 2008; Paechter et al., 2010). The current pedagogical offer at UAb in the area of Environmental/Sustainability Sciences can be seen as a coherent and structured journey, where the
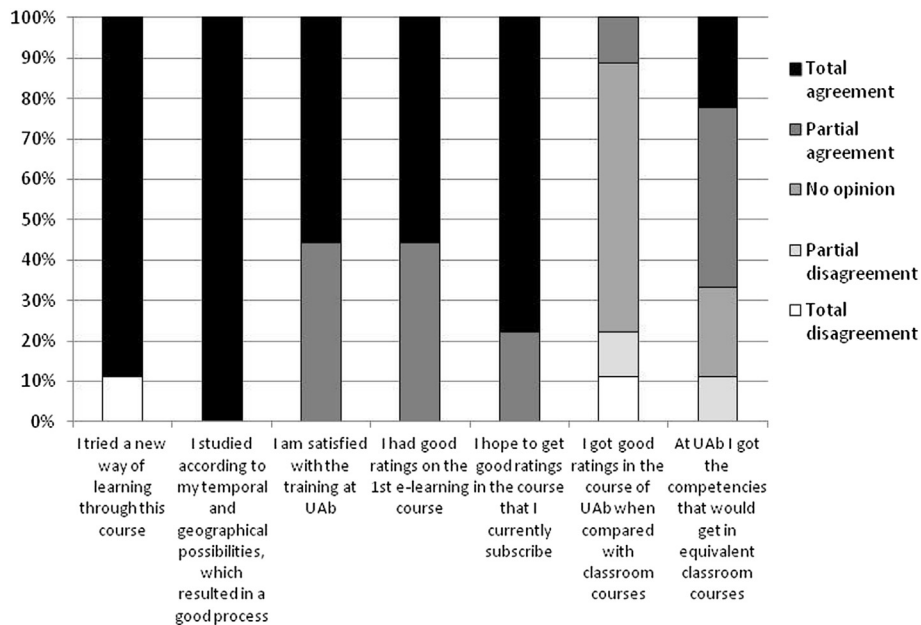

Fig. 5. Student's satisfaction with the courses.

sustainability concept is introduced with different perspectives. For example, in the undergraduate offer this concept assumes mainly an interdisciplinary focus, even if in the fieldwork courses the emphasis is on a transdisciplinary approach. Nevertheless, first degree programmes have tended to focus on conveying basic science and general principles, whilst at the postgraduate level the application of those principles can be explored against the constraints and complexities represented by the wider issues relating to sustainability (Cruickshank and Fenner, 2012). On the one hand, and as Amador et al. (2008) highlighted, the first year students on the environmental science programme at UAb have the opinion to miss out the sustainability science content from basic training modules in the fields of mathematics, chemistry, geology, or physics. On the other hand, for the UAb Master's the focus is more on transversal issues, such as environmental ethics, and exploring citizenship concepts in order to analyse the participation of communities and social organisations with respect to sustainable development issues. Within this context the roles of science and education are also tackled. At master's level education, in general, students bring with them a maturity and realism of outlook often based on their own experiences and they are more likely to take up positions of significant responsibility when leaving the course (Fisk and Ahearn, 2006). Finally, UAb's PhD is grounded on a deeper consideration of the different components of sustainable development, acknowledging also the methodological process for the study of these issues. From this point of view the researcher is seen as an actor in society, giving a real testimony of the existing relationship between theory and praxis. Many students enrolling in the postgraduate level come with a number of years of professional experience, in particular in distance learning universities.

According to the surveyed students some teaching resources like videos, internet sites and slideshows were rated lowest in terms of pedagogical and scientific quality (see Fig. 3). In the case of videos, this assessment related to students' demand for more, rather than better, videos. The challenge to improve the effectiveness of learning by using video lessons has become urgent, as web-based materials contain more and more videos and control tools for the learner (Bilbao et al., 2009). As Gery (2012) analysed in a study case, video lectures may indeed increase students' retention in distance learning. In the particular context of complex sustainability challenges, exposure to media documentaries can stimulate opinion and provoke debate (Diamond and Irwin, 2013). In contrast, slideshows, or internet sites, by themselves were not sufficiently effective in terms of pedagogical or scientific quality, although they may be useful as complementary materials to e-books or text documents.

In addition, individual on-line-exams (only applicable at MSc level) were not well rated by the students. Interaction is seen as central to an educational experience, and the focus on interaction in online learning emerges from the potential of technology to support sustained educational communication. Internet technologies provide communication through asynchronous interaction (Garrison and Anderson, 2003). The purpose of an educational experience, whether it is online, face-to-face, or a mixture of both, is to structure the educational experience to achieve the desired learning outcome. In this context, interaction must be structured and systematic. Some have argued that it is valid and even necessary in HE to create a community of inquiry where interaction and reflection are sustained. Interaction in such an environment goes beyond social interaction and the simple exchange of information, and must include various combinations of interaction between content, teachers, and students (Moore, 1989; Garrison and Cleveland-Innes, 2005). E-learning collaborative tools and approaches can then have an important and effective role in ESD. As Diamond and Irwin (2013) claimed in a review paper, e-learning

can have a special role in students' sustainability literacy, in particular in conceptual development, identity development, skill development, and the development of confidence. Modes of e-learning, based on students-centred learning and effective support for the development of personal identity, skills and professional confidence, in applying skills to real-world contexts, are encouraged to create more powerful learning experiences for students, and foster graduates who are confident in their ability to create more sustainable futures. E-learning tools such as audio-visuals, communication tools (e.g. asynchronous discussions, peer to peer or tutor to individual, and/or class feedback), and problem based learning (real or simulated) can be very useful to address sustainability literacy and ESD effectively.

Some of the surveyed students stated that e-learning provides an alternative to face-to-face programmes, allowing them to proceed with their studies at their own pace, and to arrange their own personal course timeline. This aspect, already mentioned by other authors, and the flexibility, interaction, teaching presence, collaborative learning and a great sense of community are very important in on-line students' discourses (e.g. Shanley et al., 2004; Hansen, 2008; Moura et al., 2010). However, as stated by Diamond and Irwin (2013), it is necessary that there is a pedagogical shift away from using e-learning for information delivery and practical communication, towards supporting rich, student-centred forms of learning in both blended and distance learning modes, creating more powerful learning experiences for students, to more effectively develop students' personal identities and skills, and yield graduates who are more confident in their ability to create more sustainable futures. Indeed, HE curricula in general can be adapted to respond to the challenges of sustainability through a collaborative and reflective approach to teaching and learning (Sibbel, 2014).

It was not the aim of this case study research to conclude that e-learning is better than face-to-face learning within ESD, but as being another valid and possible option, while considering the latest innovative trends in education. In addition, considering the interdisciplinary and up to date competences of ESD, ESD through e-learning regime, can be very useful for a working-student population, and for their career objectives. As stressed earlier, environmental/sustainability sciences have attracted growing interest from the working-student population seeking professional development in this field, and who have no available time or a university nearby to attend for face-to-face courses. In particular, in developing countries with a large geographical human population sprawl, ESD through e-learning could have an important role (see successful examples as in Africa, India, Azeiteiro et seq. 2014). Additionally, e-learning has the potential for reducing the environmental impacts from face-to-face education (potential resource savings can be found in the use of time, space heating and ventilation, transportation, paper, and generation of waste) (Martens, 2006; Roy et al., 2008).

As stressed by Lambrechts et al. (2013), the process of full integration of SD into competences and skills in HE is still too low, and according to Lozano et al. (2013 c) the challenge that remains is how to assess the contribution and impact that curricula and university life may have on the student's personal life during their studies, and for their subsequent professional life, in helping make societies more sustainable.

6. Conclusions

In this research the expectations, competences, attitudes and experiences reported by students enrolled in more than one programme in environmental/sustainability science offered by the Portuguese Distance Learning University (from BSc to MSc and PhD) were analysed, according to a long-term and transversal

assessment. UAb and its formal programs on ESD were used as a case study due to its use of the innovative, up-to-dateness and quality assurance of the e-learning pedagogical model used at this European distance learning university. The main results can provide insights into other educators and researchers in sustainability education toward the development and effective use of on-line technology for sustainability knowledge, assessment practices competences and outcomes assessment. The surveyed students showed a very high level of motivation and satisfaction with the courses, with reasons to return and enrol again for new training, allowing them to have long-term and interlinked ESD training. Most students had the perception of having reached an effective learning outcome in knowledge, competences, values, attitudes and behaviour, being central elements of education for sustainability. These results, complemented by earlier work developed by the authors, allow the conclusion that formal e-learning programmes, if properly organised and based on a validated pedagogical model, can provide an alternative to face-to-face courses, allowing students to progress their studies in a flexible, collaborative and interactive way, whilst pursuing, at the same time, full-time jobs. In this way ESD an e-learning regime can contribute to, and have a role in, the transition to sustainable societal patterns.

Nevertheless, there are pedagogical and learning issues that should be improved on in the UAb programmes, for example related to some competences of sustainable development, and further studies should be conducted considering the existing bias and the size of the sample used, namely assessing the effectiveness of e-learning in developing ESD, in particular the use collaborative approaches and problem-based learning. Research tools, other than questionnaire surveys for the assessment of competences development and behaviour changes, also need to be developed.

Acknowledgements

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