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Article

Adding the "e-" to Learning for Sustainable Development: Challenges and Innovation

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Abstract: Education for sustainability (EfS) poses new challenges to higher education as it necessitates various shifts: from teacher- to learner-centered pedagogies, from input- to output-orientation and from a focus on content to problem-solving and process orientation. E-learning, which follows the principles of situated, constructivist learning, addresses some of these challenges and offers opportunities to design powerful learning environments for EfS. In this conceptual paper, we elaborate characteristics of such e-learning environments that support competence development and education for sustainability. To illustrate and support our line of reasoning we use three mini case studies of our own educational praxis and critically discuss opportunities and threats of such e-learning settings.

Keywords: education for sustainable development; e-learning; higher education; intercultural communication; interdisciplinarity; self-directed learning; problem-oriented learning; collaborative learning

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1. Introduction

In 2000, former Nobel Prize winner Paul J. Crutzen and his colleague Eugene F. Stoermer proposed the term 'anthropocene' as a new way to describe a phenomenon that had become evident in the last couple of years [1]. The concept refers to fundamental social, cultural, economic and ecological

changes that humankind is confronted with, and that will lead to irreversible changes in our lives [2,3]. The last decade has witnessed the emergence of a growing awareness of these unsustainable changes both in the public as well as in the scientific community [4].

Since the publication of the 'Brundtland Report', the idea of sustainable development has been seen as a potential answer to these challenges: its long-term aim is the reconciliation of society's development goals with the planet's environmental limits [5]. Such a development requires fundamental societal transformations and can only result from shared learning and collaboration as a process of societal learning [6]. Thus, it is education that contributes to "learning our way out of unsustainability" [7] and to finding ways to improve the social capacity to guide interactions between nature and society toward more sustainable trajectories [8].

From the very beginning of the idea of sustainable development, education has been a crucial part of strategies and policy making. The concept of education for sustainability (EfS) first emerged on the international scene in 1992 with the publication of Agenda 21 as a result of the so-called Earth Summit held in Rio de Janeiro. This then led to the proclamation of the United Nations Decade of Education for Sustainable Development (2005–2014), which raised great expectations as stated in the Bonn Declaration, the final document of the UNESCO World Conference on Education for Sustainable Development: "Education for sustainable development is setting a new direction for education and learning for all. It promotes quality education, and is inclusive of all people. It is based on values, principles and practices necessary to respond effectively to current and future challenges'' [9].

These expectations mark nothing less than a paradigm change, which is brought out by Sterling in his typology, which focuses on education *about*, *in* and *for* sustainability [10]. While education *about* sustainability simply transmits 'factual' information about sustainability concepts and processes (leaving existing assumptions unchallenged), education *in* sustainability uses experiential and interactive learning processes (*i.e.*, a more learner-centered approach) to support the development of greater understanding. Education *for* sustainability, finally, is oriented more strongly towards a transformative approach to education, encouraging the adoption of sustainability principles, ethics and values.

In a similar comparison, Vare and Scott [6] distinguish between 'EfS 1' which promotes certain behaviors and ways of thinking, and 'EfS 2' which focuses on "building capacity to think critically about [and beyond] what experts say and to test sustainable development ideas" as well as "exploring the contradictions inherent in sustainable living" [6]. As such, EfS deals explicitly with values and thus separates itself from a point of view that sees the act of learning as a neutral process and learning as a self-evident good [11]. In sum, EfS proposes to consider the underlying values and support the learner's critical reflection on them.

In particular, EfS aims at enabling people not only to acquire and generate knowledge, but also to reflect on further issues such as the complexity of behavior and decisions in a future-oriented, global perspective of responsibility. The literature on EfS accordingly offers a number of approaches, such as sustainability literacy [12], sustainability skills [13], graduate capabilities [14], Gestaltungskompetenz (shaping competence) [15] or Gestaltswitching [16], that define the underlying cognitive and non-cognitive dispositions in greater or lesser detail [17]. Although the approaches differ to a certain degree, with different terms such as skills, literacy, competencies or capabilities being used, a broad consensus has nevertheless emerged as regards the main aspects to be incorporated. Thus, an important role is played across the different approaches by key competencies that are held to contribute to a more

sustainable future, e.g., the competence for anticipatory and systemic thinking, for inter- and transdisciplinary collaboration, for dealing with conflicting goals and, finally, the capacity for empathy and solidarity [16,18].

To facilitate the development of key competencies, which can "be learnt but hardly be taught" [19], it is necessary to create authentic learning processes and reflect upon the various shifts necessary: from teacher- to learner-centered pedagogies, from input- to output-orientation and from a focus on content to problem-solving and process-orientation. Such a socio-constructivist understanding of learning challenges the traditional view of the learning process [20,21]. Taking this into account, the emphasis in the learning process is not exclusively on knowledge creation but takes in various forms of experience-oriented and problem-based learning.

Such challenges to traditional formal learning have been met by innovative forms and new learning settings. In higher education for sustainable development, a distinctive number of good practice examples have been introduced and trialed, encompassing but not limited to experiential learning [22], service learning [23] or problem-based learning [24,25]. To guide educational design in EfS, what is of special interest is how such approaches can be adapted and used for the support of competence development. In this article, we want to introduce e-learning as a didactic approach that offers manifold opportunities for competence development and the design of suitable learning environments. The added value of such an approach is discussed and analyzed against three mini case studies from our educational praxis.

2. E-Learning

Today, the latest information and communication technologies (ICT) are, like the use of the internet, an integral part of our lives [26,27]. We are moving from an industrialized society towards an information or knowledge society [28]. The rise of ICT during the 'new economy boom' in the late 1990s brought huge expectations for the educational sector. Defined as a teaching and learning process that involves the use of ICT, e-learning was thus hoped to provide "information at your fingertips", "education on demand" and "just in time learning", to name only some of the most popular catchphrases of that time [29]. These rather optimistic expressions were based on two different lines of expectations: on the one hand, e-learning was expected to be a more efficient way of learning and teaching and on the other hand, e-learning was expected to bring an increased quality to the learning process. Schulmeister [30] critically deconstructs such expectations as 'pedagogical myths' that cannot be justified empirically (see also [31]). Thus, e-learning does not *per se* deliver more efficient or better learning processes compared with 'traditional' learning. On the contrary, an uncritical application often leads to low acceptance with students, unsatisfying learning results and less efficiency.

Nevertheless, e-learning has the *potential* to be a technology-based, pedagogical innovation in education (Seufert and Euler 2005). In the literature on learning theories three main approaches with relevance for e-learning can be identified: (1) learning as behavior modification, based on behaviorism [32,33]; (2) learning as information processing, based on cognitivism [34,35]; and (3) learning as active construction, based on situated learning and constructivism [36–38].

The socio-constructivist understanding of learning (3) has specific importance for e-learning because it focuses on the individual's learning environments. Since the individual as an autonomous

system cannot be 'changed' from the outside, it is the learning environment in which he/she is acting that needs to be designed in order to support intended learning outcomes [39]. Of particular value in this context is the concept of *open learning environments,* which acknowledges that learning takes place in manifold forms and depends of a variety of factors [40]. Open learning environments are based on authentic learning situations, offer a rationale and a starting point and, even more important, offer a frame for the whole learning process. In this way, learning processes are created that enable exploration and offer learner-centered as well as collaborative tools so as to give control over the learning process to the learner. The design of such learning environments for competence development is characterized by three key principles:

The first principle is *self-directed learning*. This acknowledges the central part played by the learner as the acquisition of competencies calls for autonomous and constructive learning processes in which knowledge is actively developed in a self-directed manner. The aim is to stimulate learning processes in which students construct their own knowledge base independently [41,42]. This principle is based on a view of learning which is not directly linked to teaching and which emphasizes the active *development* of knowledge rather than its mere *transfer*.

As the acquisition of competencies is both an individual and a social activity, *collaborative learning* is the second important principle. In contrast to cooperation, which focuses on dividing and sharing tasks, collaboration involves joint learning processes with participation and empathy as critical factors. It appears in different forms, varying from collaboration between learners and teachers, through learning between learners only, to learning between learners and learning tools and material [43]. Successful collaboration increases both individual and collective knowledge, based on shared experiences and jointly accepted learning objectives. Knowledge is seen as the result of shared group processes, and different opinions and approaches are not only tolerated but appreciated [44]. Thus, collaborative learning takes both cognitive and social-affective aspects into account and integrates an additional dimension of critical reflection [45].

The third principle *of problem-oriented* learning, finally, focuses on complex real-world situations and the development of creative solutions to facilitate the development of action competence. While traditional learning processes often encounter problems because of their exclusive focus on factual knowledge, which cannot be used for action in specific situations, a problem-oriented approach is especially suited to support action-relevant procedural knowledge and skills [46,47]. Such learning is facilitated by complex, authentic problems and different approaches and perspectives. Thus, the first two principles of self-directed learning and collaboration can be seen as preconditions for a problem-oriented approach.

E-learning, based on these key principles and following an approach of situated, constructivist learning, offers a great number of opportunities to support the development of key competencies and the acquisition of knowledge. What is crucial is to consider what form of implementation can trigger and facilitate competence development and what underlying learning method will support such applications. Incorporating e-learning into learning environments creates new opportunities of interaction with other learners and different media, and so gives a pedagogical meaning to a technological tool.

3. E-Learning and Education for Sustainability

The type of e-learning that follows the principles outlined above has much in common with the general orientation of EfS. Aspects like problem-orientation, situated and action-oriented learning are in both cases treated as preconditions of learning [48]. These preconditions demand some specific didactic approaches that incorporate multiple perspectives, enable open learning environments and support processes of competence development.

Linking e-learning with specific learning objectives of EfS brings a number of potential benefits that offer an added value. Among these are the following:

- *Intercultural perspective*
  A dialogue between different cultures, especially the north and the south is regarded as a necessity that will facilitate the development of competencies for the challenges of a complex globalized world and diverse cultural perspectives and their implications. E-learning environments allow for collaboration processes in which learners from different nationalities and different cultures can learn together.
  In view of the limited opportunities for intercultural exchange especially in formal education, e-learning and 'virtual mobility' is thought to offer a way to support the development of intercultural perspectives. Virtual mobility in this context can be understood as "a form of learning which consists of virtual components through a fully ICT supported learning environment that includes cross-border collaboration with people from different backgrounds and cultures working and studying together, having, as its main purpose, the enhancement of intercultural understanding and the exchange of knowledge" [49].
- *Interdisciplinary communication and knowledge generation*
  Communication across different disciplines is one of the key competencies for EfS in higher education. Collaboration and communication processes can be supported not merely by tools for online communication, but also by knowledge management tools, which facilitate the development of shared understanding. E-learning environments offer information resources on which participants can draw to reframe existing mental models, to construct new ones for new phenomena and at the same time to create new and additional knowledge collaboratively [50]. Given different forms and ways to generate, change and manage knowledge, e-learning applications can be used both individually and collaboratively.
- *Process and project management*
  Learning management systems offer many opportunities to structure working and learning processes and to facilitate the management of self-directed projects for students while at the same time supporting students' ownership of the learning process. File sharing, shared calendars and areas for communication and reflection here are simple but quite powerful project management tools. When there is a need for a shared working place for collaboration, e-learning is able to create virtual environments as an added value for learning processes.

Having outlined some of the general opportunities for EfS, we will now illustrate some specific approaches to EfS with examples from our own educational praxis.

4. The Praxis of E-Learning for Sustainability

The idea of open learning environments for EfS informs specific approaches in various learning settings. How e-learning can be used to facilitate EfS will be exemplified with three case studies of learning settings in higher education, which we have developed, implemented and evaluated over the last few years. In each case study we focus on a specific aspect, analyze how objectives have been addressed and discuss what we learnt. While each of these settings is slightly different in its approach and educational goals, they share some aspects on which our pedagogical praxis as theoretically informed practice builds. All three are based on a common understanding of learning as a social-constructivist process as outlined above.

In addition, all use a similar learning environment that is adapted to specific needs. Several types of commercial or open source platforms exist, which provide various options for the design of online environments in order to structure collaboration processes and knowledge generation. In all three studies we use moodle, an open source solution that was originally developed by Martin Dougiamas to help educators to create online courses with a focus on interaction and collaborative construction of content—based on principles of social constructivism. Moodle is widely used and has more than 70,000 registered installations worldwide. In the cases described below, we have used different building blocks and tools provided by moodle to set up learning environments.

4.1. An Intercultural Dialogue between the North and the South: Virtual Mobility in Higher Education for Sustainability

In higher education, two of the main objectives are intercultural exchange and an international perspective on learning. In Europe, however, only a minority of all students participate in international exchanges between universities. As a response to this state of affairs, 'virtual mobility' is promoted, offering intercultural learning settings independent of time and place. In addition, such mobility can facilitate intercultural dialogues and thus address a central concern of EfS as well.

Within the field of higher education for sustainability there are a number of first attempts in setting up e-learning seminars or even virtual campuses on sustainable development issues: among them are the *'Virtual Campus for a Sustainable Europe'*, a joint project of five universities to build up a virtual campus on sustainability at the European level; a *Virtual Campus about Sustainable Development and Environmental Management ('SUPPREM')*, developed by the Interfaculty Centre of the University of Geneva; and, within the PASDEL project (*'Practicing Sustainable Development through E-Learning')*, e-courses on sustainability in four European languages. While these approaches offer some examples of international e-learning, there are only a few projects that bring together students from the North and the South and focus explicitly on intercultural experiences.

In an attempt to address this shortcoming, we conducted an international virtual seminar on *'Sustainable Development in Europe and Latin America'* in the summer term of 2008 [51], based on a collaboration project between three European and six Latin American universities. The course's main objectives were the acquisition of knowledge about key elements of sustainability and about the strikingly different perspectives on that concept in Europe and Latin America. Additionally, the

seminar aimed at the development of interdisciplinary and intercultural competencies and the promotion of an intercultural dialogue.

The seminar had a total workload of 150 h over fourteen weeks and used a moodle-based learning environment (see [51] for a detailed overview of the seminar and an in-depth analysis). During the seminar, students from different disciplines and countries discussed various sustainability-related topics in the whole group and also worked on specific questions in smaller groups. After an initial phase in which students were introduced to the topic through a number of set texts, they were next asked to work on different aspects of the readings using specific guiding questions to stimulate and frame their discussion. This was followed by a stage in which they were asked to formulate statements and in collaboration to generate knowledge on specific sustainability-related sub-topics. The interaction was facilitated by asynchronous discussion forums in which students exchanged views with their colleagues. Separate forums supported work in smaller groups with read-only roles for other groups. A wiki was used for shared knowledge generation (see the next case study for more details on the use of wikis).

The students' feedback on the course and their personal learning outcomes were generally very positive and the intercultural setting of the seminar was seen as a major benefit that increased the level of their motivation. Although the lack of 'real contact' and asynchronous communication were seen as drawbacks by some, these problems were nevertheless accepted by a majority as a reasonable cost in exchange for the additional benefit of an intercultural exchange. All in all, students were inspired to deal with differing and critical perspectives on sustainable development, which helped to overcome difficulties in the learning process and problems caused by the relatively high workload of the seminar. They realized that the learning environment helped them both to become conscious of their individual 'blind spots' and to raise their awareness of different cultural perspectives, which resulted in a high degree of reflection and a more focused view on cultural differences.

The learning environment with its asynchronous discussion forums supported the learning process with a type of communication that offers at least four advantages:

- The flat hierarchy and lack of traditional roles in communication is perceived as a rather small barrier to participation;
- The opportunity to think things through thoroughly and to gather relevant information before contributing to the discussion allow a deeper and fairly detailed long-term discussion on the subject;
- The opportunity to deeply reflect on the topic of sustainability;
- The written form of all parts of the communication allows the storage and documentation of the communication process and the return to certain aspects if and when necessary.

In sum, the e-learning environment offers additional opportunities for reflection and a more participative discussion approach that enables a more in-depth intercultural exchange. Besides these benefits, discussion was also associated with negative aspects such as being time-consuming or the lack of nonverbal signals. For a number of students such an approach of virtual mobility seemed to be only a second-best solution. Nevertheless, they accepted these drawbacks, as the perceived benefits seemed for them to outweigh the disadvantages.

4.2. Knowledge Management and Interdisciplinary Communication

The focus of the second case study was on learning in an interdisciplinary student cohort and how communication and knowledge management can be facilitated in such a group. Funded as a research and development project with colleagues from Charles University in Prague, we developed the *"Interdisciplinary Study Program on Sustainability"* (ISPoS). The program consists of three e-learning modules, followed by a face-to-face summer school, and aims at creating a learning environment for students in which to develop competencies for the active contribution to and shaping of sustainable development. Some of the program's goals are therefore competencies like the ability to take a holistic systemic perspective (on a given problem) or cross linked thinking. In 2010/2011, a student group of 18 students from five different countries participated with a diverse academic background, coming from disciplines such as cultural-, computer- and environmental sciences, economics, or the humanities.

As such a group comes with a heterogeneous background and different sets of norms and beliefs, one focus was on ways to stimulate collaboration and the exchange of ideas and knowledge to facilitate interdisciplinary communication. Thus, in all e-learning modules specific discussions were planned at certain stages, e.g., about students' personal understanding of sustainable development or individual as well as disciplinary views on a specific aspect of a problem that was being looked at. The discussions were structured in different forums: For example, each participant was asked in a first step to express his/her own understanding of sustainability, whereas in a second step the whole group was invited to find a common understanding or a common description of that term. Within a given time frame, the group had to reach an agreement and finally deliver a commonly agreed on result.

Furthermore, to support and enhance interdisciplinary communication the program used a wiki as a specific form of a knowledge management system. During one of the e-learning modules in ISPoS, the participants performed a systems analysis of a complex problem (the extensive exploitation of resources in the Ore-Mountains, a region in the Czech-German border). In the course of this assignment, they had to identify influential factors and drivers in the system, such as different actors, legal regulations, demographic changes etc. These factors were visualized and summarized in a wiki but had later to be investigated in more detail so that the wiki pages behind the concepts were filled with background data and information. To structure the process of investigation we gave students some guidelines on how to structure their information and what types of information should be included in the articles. Responsibilities to fill in the wiki pages were divided among the participants, with each student was allowed to contribute to each page. After a given deadline, the wiki-pages underwent a form of 'peer-review': Each participant had to review and comment on a given number of other persons' contribution (with a different disciplinary background). In parallel discussion forums participants could ask question or ask the author to explain a particular phenomenon in greater detail, point out blind spots, comment on the structure of the article and much more besides. Later the original authors had to take up the feedback and revise their articles.

During the course, in that way a shared knowledge base was developed that built upon participant's prior knowledge but gradually evolved due to interdisciplinary collaboration. The participants were asked to perform investigations of their own but also to reflect on and contribute to different topics to develop the knowledge base.

The seminar faced a number of challenges: Interdisciplinary discussions and the content of the knowledge base were not on as high a level as in disciplinary contexts. In addition, input and intensive guidance by the moderator(s) was needed to support these construction processes. Guidelines and a scheme how to structure different kinds of information were quite useful during work on the knowledge base. In the interdisciplinary context, similar communication barriers could be noticed as in the case study described. Discussions took longer than offline ones, it is true, but arguments and perspectives did not diminish over time, as can be the case in face-to-face classes where they are more easily forgotten—and the reason was that detailed minutes were kept of proceedings. Shy and quiet persons find themselves in an environment where they can think and express their thoughts and arguments better than in face-to-face settings. These time demands need to be taken into account in the course design.

As concerns 'peer-review', students in the beginning were reluctant to critique their fellow students, not least because feedback was given in written form and so was visible for all course members. We concluded that a constructive atmosphere and scientific feedback culture needs to be promoted by the moderators to stimulate corresponding processes. Finally, it was observed that although it is meant to be the same, the actual workload of collaborative online seminars seemed to be higher than in face-to-face ones. Students for example have fewer chances to participate without being active or having prepared the reading assigned for a session. This aspect should also be included in the course description.

Overall, the benefits of using a wiki for knowledge management in interdisciplinary settings have been acknowledged. Students emphasize the relatively easy use and the ability to process large amounts of information collaboratively. The opportunity to deal with different disciplinary opinions and to have a transparent way of reaching agreements was seen as an additional benefit. The stronger these benefits have been experienced the higher the acceptance had been to use the wiki and invest time and labor.

4.3 Project Management

The third case study exemplifies the use of e-learning applications in blended learning environments so as to facilitate students' project work and support self-directed learning. The example that follows is taken from the study program 'sustainable humanities', a Minor Bachelor course offered at the Leuphana University of Lüneburg, which comprises six modules with a workload each of 150 h. It takes four semesters in which students work on a complex, sustainability-related topic (such as urban planning, agriculture, or sustainable tourism). The modules build upon each other and follow the sequence of sustainability research, *i.e.*, systems analysis, goal definition, systems transformation options and finally formulation and implementation of projects. The whole program is a face-to-face course which is complemented by an e-learning platform to support offline teaching, which gives students the opportunity to use online tools in order to enhance collaboration, knowledge and project management.

The focus in the last semester is exclusively on project work: students spend a workload of 300 h to conduct transdisciplinary projects. The semester starts with a kick-off weekend in which their project ideas are discussed and developed further as various methods of project management are introduced. The whole semester is dedicated to self-directed group work with only two face-to-face

sessions, a mid-term presentation of work in progress and a final presentation of the project. In addition, weekly coaching sessions are offered for the student groups to get support and monitor the project's progress.

Project management within the groups is monitored in a relative simple yet efficient way: the groups are asked to take minutes of their project meetings and to upload them to a shared wiki. With this online diary (which could also be set up as a blog), the group processes and the groups' progress can easily be followed and feedback can be provided as soon as possible.

To support collaboration and student project management, a number of different tools like wiki, forum, file-sharing and calendar were made available within the platform. While the use of none of these tools were compulsory, it was the intention to offer a wide range of opportunities to support a 'virtual office' and meeting place for the students which addresses the needs of the different student groups in a learner-centered way.

Over the last few years, the way students have made use of these tools has changed significantly. More and more students started to use tools outside the initial platform as they had been either already used to these tools or considered them especially useful. On the one hand, this is an indication that their computer literacy has increased and more open-source project management tools are easily available online, which can fulfill very specific needs. On the other hand, this development demonstrated to us that once you aim for self-directed learning not all processes can any longer be fully 'controlled' or monitored, as students take full ownership of their own learning process. However, as basic monitoring of their working progress was made available we never restricted such developments and encouraged independent solutions.

In terms of supporting project management, the challenge is less of a technical nature, e.g., one regarding the most-suited e-learning environment, but again more a pedagogical issue: how to balance control of the learning progress to keep students somehow on track and to remind them of milestones and overall objectives on the one hand, and ownership and facilitating learner-centered approaches on the other.

Students' feedback showed that the less they were convinced to know the right way to tackle a problem, the more important the online environment became as a place for discussion and reflection. At the same time the more students were active and the more the problems they dealt with were, in their perception, complex, the more intense was their use of process management tools. Students took the chance to creatively use these tools for their individual process management and increased the ownership of their problem solving process.

5. Conclusion

In this article, we introduced e-learning, which follows the principles of situated, constructivist learning as a didactic approach for EfS that facilitates open and collaborative learning. E-learning itself does not as such support the development of specific competencies, but it delivers tools for the support of learning processes. In addition, e-learning can help to reach the specific learning objectives of EfS.

In the mini-case studies cited, we illustrated how learning objectives can be translated into the design of an e-learning setting and described some of the challenges encountered and the lessons learned. It became apparent that e-learning has the potential for pedagogical innovation but also that it comes with certain challenges.

It is especially the collaboration processes mentioned that are hard work both for teacher and students. Students need to be made familiar with the idea of learning environments and self-directed learning as they far too often are only used to "traditional" teaching and their role as passive recipients. This shift towards an active ownership of their learning process and success needs strong support from educators so as to allow a systematic development of necessary skills as well as learner confidence. At the same time, the role of the teacher evolves towards that of a moderator who heavily influences students' satisfaction and learning outcomes. This development again is a learning process, and professional development and support for teachers will be needed to sustain such changes successfully [52].

By recognizing and meeting these challenges, we believe that substantial benefits can be derived in higher education from the use of e-learning as a facilitator of on-going innovation in education for sustainability. To balance the specific benefits and barriers of each mode of learning, blended learning environments in which e-learning is embedded in face-to-face learning settings, seem to be of special interest.

Conflict of Interest

The authors declare no conflict of interest.

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