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The Development of an Eco-Label for Software Products – a Transdisciplinary Process?

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Abstract: Research activities are mainly realized in exclusive academic contexts, excluding social actors. However, some disciplines gain a big social relevance and thus should include non-academics in the research process. One example could be the research in the context of environmental impacts of ICT. Hence, the following paper addresses the question if it stands to reason to apply a transdisciplinary project in the field of Environmental and Sustainability Informatics. To do so, attributes, requirements and a conceptual model of transdisciplinary research are applied to the case example of labelling green software products. The result of this theoretical analysis is that it is possible and promising to apply transdisciplinary ideas to sustainability informatics projects.

Keywords: Environmental Informatics, Transdisciplinary, Green Software Products

1 Introduction

Environmental and sustainability informatics can be basically understood as an interdisciplinary research field bringing together ideas of the chemical, biological, environmental, sustainable and even more disciplines with information and communication technologies (ICT). According to [Hi95] environmental informatics „combines computer science topics such as data base systems, geographic information systems, modeling and simulation, computer graphics, user interface design, knowledge processing, and neural networks, with respect to their application to environmental problems.“ Based on that, sustainability informatics can be seen as an advancement of environmental informatics, dealing with methods, models and information systems supporting a sustainable development [Na08].

In this paper, we differentiate between both – environmental and sustainability informatics – as follows: *Environmental Informatics* deals with e.g. environmental issues of ICT and ICT based applications for environmental and natural sciences. The focus is set on environmental related topic, namely so called “green issues”. Generally, there is a differentiation between “Green in IT” and “Green by IT”. *Sustainability Informatics* extends the activities and comes up with a holistic view of all aspects of sustainability: the environmental, economic and social dimension according to Brundtland. [Un87] Moreover, some approaches add an individual and a technical dimension. [Pe13] Here, one can differ similarly between “Sustainable in ICT” and “Sustainable by ICT”.

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Hence, both research fields deal with aspects that are socially relevant. Moreover, human and social behavior is an issue in applying new strategies, that could be outcomes of research activities, aiming at e.g. reducing environmental impacts of ICT (Green in IT) or at using ICT in order to react to environmental problems by means of ICT (Green by IT). Just to give one example: if the research community comes up with new ideas how to reduce the carbon footprint of using personal computers in offices, these ideas have to be implemented by those working in offices and being able to improve the carbon footprint here. Thus, there seems to be a dependence of scientific approaches and their implementation in practical applications. So far, this connection between research and the practice is just rarely represented in the research activities regarding green and sustainable ICT although it seems to be relevant. New ideas, concepts, models, methods and strategies addressing environmental impacts and sustainability issues of ICT are mainly driven by the science community and do hardly include the societal side.

As a consequence, the idea is to bring the principles of transdisciplinary projects into the sustainability informatics field. The idea of transdisciplinary research in context with green ICT is not new [Hi11]. However, corresponding structures and methods are still missing. Therefore, the following paper describes transdisciplinary research at first (Section 2) and reviews the possibilities of integrating those aspects into environmental and sustainable informatics with the help of this description and a case example. The case example comprises labelling green software products and will be introduced in Section 3. The analysis of the fitting of transdisciplinary characteristics and methods with sustainability informatics will follow in Section 4. So far, the idea of bringing together sustainable ICT and transdisciplinary research by using existing methods is just a theoretical approach. The implementation into practice is still missing. Nevertheless, the presented concept might be seen as a driver to integrate new principles into the research activities regarding sustainable (by) IT, depending on the results of the analysis. The paper closes with a conclusion and outlook (Section 5).

2 Transdisciplinary Research: A short Overview

Although the principles of transdisciplinary research are known for years, there is no commonly accepted definition for transdisciplinary so far [Ja12]. One possible definition is presented by Lang et al.: „*Transdisciplinarity is a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge.*“ [La12] In short, Klein et al. [Kl12] talk about „*Joint Problem Solving among Science, Technology and Society*“. Both definitions point out the importance of including the society into the research activities.

Transdisciplinary projects deal with „real-world problems“, going further than interdisciplinary projects and aim at producing knowledge that is more reflected than

results solely created in scientific processes [Ja12], [Kl12]. In order to do so, transdisciplinary processes have to „[go] across and through the different disciplines, and beyond each individual discipline“ and to „[transcend] each of their traditional boundaries“ [Al11]. By using “community-based, interactive or participatory research approaches” [La12] both the goals of the society and science should be met. Currently, various examples of transdisciplinary research projects can be found in sustainability science, generally known as a problem-driven and solution-oriented field.

By including the society, those stakeholders used to respond and react to the research activities play a bigger role since they become partners in applying these activities and coming up with solutions [Mo10]. At last, the problem definition is oriented towards the needs of non-scientific project participants. The difficulties and goals of a transdisciplinary research project are formulated in real-world contexts independently from scientific theories [Al08]. They are then addressed by actors from both areas – scientific as well as social. Thus, while researching the problems, one out of many challenges is to find a suitable way to communicate since all participants “have to become involved as persons who bring distinct interests, roles and practices of communication” [Ja12]. However, the increased effort might be relativized by realizing a learning process for both sides as well as empowering and motivating stakeholders to support the implementation of solutions [La12].

This description of transdisciplinary research just gives an overview of the research field. However, since standardized definitions and methods are missing, none of the descriptions that can be found in current literatures seem to be comprehensive. In the following (Section 4), some more characteristics will be presented and directly combined with the case example, belonging to the field of environmental informatics, that will be presented in the next Section 3.

3 Case Example: Labelling Green Software Products

While the awareness for the environmental impact of software products over their life cycles is addressed with different research activities, the society is still only slightly or not informed about resource consumption and similar effects of software. This is contrary to the fact that those who are developing software products in the majority of cases or constitute the biggest group of software users are non-academic actors.

Hence, the idea is to create a label for software products informing about their green characteristic. There could be a certification of software products in the sense of quality labels and based on standardized criteria to create awareness for the aforementioned topics. In order to reach this aim, the following steps are necessary:

- Finding a commonly accepted definition for the term “green software product”
- Defining criteria to characterize green software products

- Developing methods to measure and proof the greenness of a software product
- Preparing a communication strategy, informing about the green software label
- Nominating an audit committee to award green software products
- In [Ke15] we presented a summary of relevant aspects for the development of a product label for green and sustainable software products. The following aspects were addressed: definition, criteria, form of representation, target groups, and stakeholders. Thus, there are some ideas and approaches for a green software label. One of the findings was that a bold and simple label might be a first step and starting point for advancements. It could be characterized as follows:
- The label in mind should award environmental friendly products, i.e. the underlying criteria evaluate environmental impacts of the product but do not include social or economic aspects.
- It should award the product itself, i.e. without the development and distribution process, the surroundings, and the organization developing the product. The label refers to the whole life cycle of the product but does not include anything that is not part of the product. That means it values e.g. the algorithm and the modules of application software but not the packing of it.
- It should award "green in software" aspects. That means the product itself should be as environmental friendly as possible. Products that support environmental friendly processes or rather make them more environmental friendly ("green by software") but are not green itself are not included.
- Within this paper, these ideas should be taken as a case example to analyze if the idea of transdisciplinary projects fits into the context of environmental informatics.

4 Analysis: Transdisciplinary Development Process of an Eco-Label for Software Products?

In order to analyze if it stands to reason to apply a transdisciplinary project in the field of environmental and sustainable informatics, we will use different methods in the following section. These include applying transdisciplinary attributes as well as requirements to the case example and the description of possible activities in a labelling development process that could apply the process to a model for transdisciplinary projects. The results of the analysis will be discussed in Section 5.

4.1 Applying Attributes of Transdisciplinarity

As already mentioned, there is no commonly accepted definition for transdisciplinarity

[Ja12], [La12]. Consequently, corresponding quality standards as well as standardized guidelines, methods and characteristics for transdisciplinary research projects are missing so far. However, one can find various approaches for those in the current literature. For example, Kroeze et al. [Kr14] list main attributes of transdisciplinarity. In the following, these will be implied to the case example out of the field of environmental informatics presented in Section 3. The idea is to get an impression if characteristics of transdisciplinarity can be transferred to environmental and sustainable ICT research questions.

The following attributes are extracted from [Kr14] and interpreted in means of labelling green software products:

- *Collaborative nature: Collaboration of researchers from various disciplines, integrating various insights*
  In order to find criteria, corresponding measurement methods and guidelines to present a label for green software product, it is necessary to include stakeholders from different disciplines, e.g. computer science, life cycle assessment, communication science, etc. Above, it seems to be promising to include social scientists bringing in knowledge about behaviorism und addressing consumers. Thus, next to the inclusion of society, researchers from various disciplines should participate to find a well-funded solution. Here, just some examples of potential participating fields are given.

- *Goal: To solve problems; to change behavior significantly*
  Here, the problem is, among others, the high energy consumption caused by ICT. The consumption should be reduced and further environmental impacts should be addressed in a positive manner by changing the user's behavior while using ICT products. The idea behind the label for green software products is to create awareness for the environmental impacts caused by producing, using and deactivating software. This might be the first step on the way to a more environmental friendly dealing with software products. In the context of transdisciplinarity, Lang et al. [La12] go one step further and talk about aiming at an "intensive learning process" and "motivating stakeholders to contribute more actively to the implementation". This goal could be also persuade with a green software label.

- *Disciplinary nature: Across disciplines, beyond academic disciplines, looking outwardly*
  So far, the issue of green and sustainable software is mainly researched in scientific contexts. Here, different disciplines are coming together to find a solution. However, it seems to be necessary to additionally include ideas, requirements and approaches from those who should use the label to be developed.

- *Theoretical nature: Theoretical exercise leading to practical solutions*
  The main exercise in labelling green software products is to develop a theoretical concept, namely awarding criteria and a corresponding program. Based on this

theoretical construct, the challenge is to come up with a solution that can be transferred into a practical application field.

- *Source / cause: Stimulated by complex practical problems*
  The climate change is one big and complex problem that is related to the real-world. Thus, the motivation for green and sustainable ICT, including the hardware as well as the software side, is based on complex practical problems. Since the source of the challenge of addressing the climate change is not only a scientific issue, it fits with the characteristic of transdisciplinary research. [Al08]

- *Methods: Holistic approach to unify knowledge inputs*
  In order to create a green software label that will be accepted by scientific and societal actors, it is necessary to combine strategies and methods from different disciplines. It is important that societal actors act as partners in the joint research project [Ja12] to be able to run the project in a transdisciplinary way. Above, it is necessary to find a way of communication everyone can deal with.

- *Result: Better solutions for complex problems*
  Analyzing the impact of ICT onto the environment aiming at solutions to decrease is a challenge. Hence, better solutions are required. In this context, "better" means that the environmental impacts of software are realized by more actors. One step to go into this direction is to create a label for green software product in order to create and raise awareness. Therefore, the label should be accepted by many consumers who may promote it. The acceptance for the label should be created by integrating different stakeholders into the label development process as soon as possible to hopefully meet their interests as well as needs in a better way.

- *Scope: Society (broad)*
  On the one hand the labelling development project acts a part for the scientific community since it requires a definition of green software products as well as corresponding criteria and reference methods. It might be able to answer current research question. On the other hand the label can be understood as a tool for the society to bring transparence into the activities dealing with environmental impacts of ICT. For us, the second point should be the main target of the project so that the scope should be mainly laid on societal requirements and needs.

- *Properties: Evolving*
  Developing a label for green software project is an evolving project since one strategy is to develop a simple and bold label as a first run and start the information process to end users with this. Based on that, the next step could be a more detailed label, presenting more information and / or being based on more criteria. Find more about this strategy in [Ke15].

4.2 Applying Requirements for Transdisciplinary Research

Next to the listed attributes, Lang et al. [La12] come up with requirements that should be

met by transdisciplinary research. Similarly, these requirements will be brought together with the case example in the following:

- *Focusing on societally relevant problems*
  Generally, one of the issues addressed by research activities in environmental and sustainable informatics is the climate change. This can be seen as a societally relevant problem. Indeed, it is not proofed that the greenness of software or rather information technology can also be counted among this kind of problems, neither is the labelling of green software products.

- *Enabling mutual learning processes among researchers from different disciplines (from within academia, other research institutions, and outside academia)*
  Researchers coming from different disciplines and backgrounds are researching on joined projects in the environmental informatics field. Thus, it is possible to start corresponding learning processes. However, in order to meet the requirement of transdisciplinary, non-scientific actors need to be integrated in the activities. This seems to be possible or rather promising in case of labelling green software since different stakeholders from academic and non-academic areas are relevant in transferring to a more sustainable software usage.

- *Aiming at creating knowledge that is solution-oriented, socially robust, and transferable to both the scientific and societal practice*
  The knowledge that is developed in research projects focusing on environmental issues of ICT should be solution-oriented, socially robust, and transferable to practice. This makes an implementation of the generated approaches possible.

4.3 Applying a Conceptual Model for Transdisciplinary Research

Similarly to the characteristics of transdisciplinary research, standardized methods for this kind of research projects are still missing [Ja12]. However, Jahn et al. [Ja12] present an ideal-typical conceptual model for transdisciplinary project that is based on previous research and further developed by Lang et al. [La12]. Both of them apply the model to a finalized research project to outline the different phases. Since our case example is a concept for a research project so far, it is not possible to describe the results of the model phases. Thus, the following Table 1 lists possible activities for each of the phases to analyze if the concept is transferable to the project example.

Table 1 Applying a Conceptual Model for Transdisciplinary Research to the Case Example of Labelling Green Software Products

Phase	**Project activities**	**Possible answers**
Phase 1– Problem transformation		
Step 1.1: Framing the societal	- Brainstorming: Who are the stakeholders?	- Stakeholders: end user, software engineers, sustainability activists,

problem	- Stakeholder workshops and interviews in order to address the following questions: (a) Is there any knowledge about or rather awareness for the software side of Green IT? If so, what kind of knowledge and on which level? (b) How is the relevance of the issue valued? - Aim: framing the problem and projects, find a starting point and outline project targets	researchers, purchaser, politicians, etc. - Starting point: analyzing the existing research approaches
Step 1.2: Relating the societal problem description to scientific knowledge	- Clarifying how to deal with the results of step 1.1. - Analyzing where to find research approaches that can be further developed in a transdisciplinary research team - Finding a common focus for the project - Based on the focus, developing a strategy to frame the project team and to specify the stakeholders that should be involved.	- In order to find research approaches: start with the existing literature reviews - Project focus: finding the aspect of sustainable software that meets the scientific and social relevance in the best way
Step 1.3: Transformation of the societal problem into a boundary object	- Defining that project target(s) that should be persuade - Defining criteria to decide if the project was successful or not	- Project targets: creating a label for green software products - Project criteria: the label should be taken into account while buying new software products (empirical evaluation)
Step 1.4: Transformation of the boundary object into epistemic objects	- Specifying strategies and methods the project target should be addressed with - Updating the criteria defining the project success (if necessary)	- Transferring existing labels towards software products - Development of suitable criteria, measurement methods - …
Phase 2 – Interdisciplinary integration		
Step 2.1:	- Finding a way to allocate the	- Working groups

Clarification of the roles of researchers and stakeholders	project roles: who is doing what and when? - Specifying communication strategies between different stakeholders and outwards - Deciding if it would be helpful to use empirical methods to integrate the social point of view from extern (representatively)	comprising researchers and software users (being the critical reflection) - Communication through regular meetings - Evaluation of the ideas by a representative survey and / or focus groups
Step 2.2: Design of an integration concept	- Defining how to work in a collaborative way - Defining the way of dealing with the research question - Defining how to combine the results	- Assembling one working group for each life cycle phase of software products or related to the sustainability aspects - Evaluating the results of each group in a joined process
Step 2.3: Implementation of the integration concept	- Applying the different methods to the specific questions and project groups - Defining how to combine the results of different project groups - Finding solutions how to evaluate the results (tried and tested, accepted, verifiable, …)	- Development of criteria: creativity methods might be helpful - Evaluation by an external steering committee
Phase 3 – Transdisciplinary integration		
Step 3.1: Assessment of integrated results	- Retrospection towards the starting question and project definition to evaluate if the results are problem-solving - Finding ways … …to implement the results and transfer them to the scientific and societal practice … to present the results … to extract lessons learned, next steps etc.	The aspects are mainly depending on the kind of project team and should be addressed in a transdisciplinary way.
Step 3.2: Assembly of products for	- Preparing the results in order to make them available for everyone who is interested	

science and society	- Finding strategies to enable a dissemination and if possible a further development of the results	

4.4 Round-up: Transdisciplinary Projects in Environmental Informatics

Since information and communication technologies are a vital part of the everyday world and today's society, the idea is to integrate social actors into the movements of computer sciences. The view of the society seems to be especially important in context of environmental and sustainable topics since the environment could be understood as the basis of the life of society. Hence, the approach of transdisciplinary research seems to be appropriate.

Overall, the analysis shows that many of the attributes of a transdisciplinary project by Koerze et al. [Kr14] could be transferred to the case example of labelling green software products. By applying the characteristics of a transdisciplinary project to the case example it turned out that they seem to be easily transferable. Environmental informatics is already working together with different disciplines, the collaborative as well as disciplinary nature is given, the research field is solution-oriented by nature and evolving properties are not new. However, aiming at a change behavior and setting the scope onto the broad society might be unprecedented in many cases.

Additionally, the phases of the conceptual model for transdisciplinary research by Jahn et al. [Ja12] or rather Lang et al. [La12], can be transferred to the case example. However, this project strategy covering the described three phases seems to be new for most of the known Green ICT projects. Most of them are mainly research-oriented and implemented in research teams excluding society. Nevertheless, we see the potential to transfer an interdisciplinary project into a transdisciplinary one: there are already projects including stakeholders from different backgrounds, research results are published to a non-specific audience in some cases and teams are working in an interdisciplinary way. That means, it is possible to imagine an implementation of the development process of a green software label by applying the proposed phases of the model. Thus, it seems to be promising to run some projects of environmental informatics as transdisciplinary projects. One example for that is presented in our paper. Possible challenges in doing so will be pointed out in the last Section 5.

Working in an interdisciplinary way and above including the view of society may also drive the innovation of the different disciplinarians forward [Ja12]. Contrary to that, some critics argue that a joint research between scientific and non-scientific actors is not so much research but mutual learning [La12]. Even if this turns out true, we argue that learning from each other and together will lead to new ideas, approaches and innovations. If they are not scientific as it is understood traditionally, these results may influence the research activity addressing the same questions in a positive way.

However, transdisciplinary methods do not fit in all of the cases. Thus, we suggest verifying the matching of the concept in each single case. If possible, it seems to be helpful to analyses the social relevance of the research question before starting a transdisciplinary project. If this relevance is given, the interest and commitment of the society to participate in the project might be higher. In this context, the practice orientation is also an issue since it is assumed that more theoretical questions are less socially relevant at first appearance.

5 Conclusion and Outlook

This paper proposes to apply transdisciplinary projects to research questions from the field of sustainable and environmental informatics. Using the project of labelling green software products as a case example, we come to the conclusion that it is possible and promising to apply transdisciplinary ideas to environmental informatics projects. This conclusion is supported by the application of attributes, requirements and a conceptual model to the case example. We found that many characteristics of transdisciplinary research are compatible with current research challenges addressing environmental aspects of ICT.

Summarizing, we come to the following findings: (1) It sounds promising to address questions regarding environmental and especially regarding sustainable issues of ICT by transdisciplinary projects, i.e. to integrate non-academic persons into the activities. (2) The case example presented in our paper corresponds to transdisciplinary methods and ideas. Generally, we see requirements that have to be fulfilled and / or characteristics a problem should have in order to be researched by a transdisciplinary project. (3) The social relevance and, if possible, also the practice orientation should be given before starting a transdisciplinary project.

Next to these findings we see the following challenges in implementing a transdisciplinary Green ICT project: converting non-scientific stakeholders to join actively in the project, finding a common base of exchanging ideas during the project process, declining a collaborative learning environment, creating a structure including methods of computer science and transdisciplinary research, presentation of project results to non-academic fields and other disciplines.

The next step after the presented theoretical analysis should be a practical application of a transdisciplinary project in environmental informatics. Doing that, the theoretical approach could be reviewed. Next to the review an adaption of the conceptual model into the context of computer sciences might be an outcome of a practical implementation.

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