# Using research methods courses to teach students about sustainable development – a three-phase model for a transformative learning experience

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## Abstract

**Purpose** – Learning about sustainable development in dedicated curricula can be beneficial for students' personal and professional development and societies alike. However, for various reasons the implementation of sustainable development modules in existing curricula can be difficult in many fields of study. This paper aims to propose an alternative route to give students the chance to learn about sustainable development without the need to change the structure of their study program.

**Design/methodology/approach** – The current paper elaborates on the idea that many fields of study have mandatory courses on empirical research methods and these courses can function as a platform to teach applied empirical research methods in combination with education on sustainable development. A three-phase model is proposed to implement sustainable development topics in existing curricula, taking students' current methodological competency level into account.

**Findings** – The proposed model provides a chance to combine education on sustainability with thorough training in scientific research methods. Example projects and evaluation results from an existing social science curriculum and its integration into a real-world laboratory on sustainable energy use illustrate the different phases and their goals.

**Originality/value** – The model offers the opportunity to implement education on sustainability into existing curricula without the need for difficult structural changes. It extends students' learning on sustainability without impairing their learning of research methods. A discussion of the model's limitations and boundary conditions helps to understand its potential use cases and challenges.

**Keywords** Project-based learning, Transformative learning, Higher education for sustainable development, Empirical research methods, Real-world laboratories

**Paper type** Research paper



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## 1. Introduction

Teaching and researching sustainability development is often an inclusive, practice-based and challenging initiative, which is designed to promote system innovation through social learning (Sengers *et al.*, 2016). Teaching in this manner about sustainability development can be beneficial for both students and society (Wiek *et al.*, 2014), as it forms a truly transformative learning environment (Mezirow, 1991, 1997) and creates a change in *frame of reference*. In this paper, the authors want to illustrate how such transformative learning on sustainability development can be integrated into existing curricula without the need for structural changes. This flexibility is especially important given the lack of integration that sustainability development topics face in current concepts of higher education transformation (Leal Filho *et al.*, 2018), the lack of curricula reform to address these topics (Von Blottnitz *et al.*, 2015) and the complex management of such change processes (Hoover and Harder, 2015).

One way to achieve such transformative learning environments is to not only focus on the content of sustainability development but also to integrate it into teaching on scientific methods and empirical research processes. This integration creates a desirable situation in which students can develop their scientific competencies while also learning about sustainability topics. Thus, focusing on methodological education gives students the chance to form their own, individual ideas and attitudes about sustainable development. This creates a truly transformative research and learning environment, fitting in with the idea of Sterling (2010) that the primary goal in sustainability development education is the critical, reflective learning process itself. This learning process also fits closely with the idea of *learning through research* (Huber, 2009), with its focus on autonomy and self-determination for the learner, deep learning processes stimulated by elaboration and application, and high reflexivity about the value of one's findings and knowledge. Such a setting can facilitate students' competencies in dealing with complexity and uncertainty (Hallitzky, 2008), which are core competencies in sustainable development education (Hornstein, 2001). The development of scientific competencies can also profit highly from such an approach. It has long been apparent that lectures and "cookbook" (laboratory) experiments are not sufficient to facilitate scientific competency development and need the support of more active learning strategies (Handelsman *et al.*, 2004). Additionally, such real-world learning settings, focusing on self-organized discovery and collaboration in groups, also help to develop personal and social competencies (cf. Brundiers *et al.*, 2010). Being able to create viable scientific research projects, however, requires a certain level of knowledge of empirical methods and practical project-management skills that students initially lack. Therefore, the authors propose a three-phase model that continuously builds up students' methodological competencies and increases their level of autonomy and self-determination to create a truly transformative learning experience for them in a problem- and project-based learning environment. This model should help to integrate motivating and adaptive sustainability development education in existing curricula without the need to change these curricula. The model also offers a framework how problem-oriented learning of empirical research methods can be conceptualized.

## 2. Problem- and project-based learning in higher education for sustainable development

Problem- and project-based learning environments have a long tradition in educational science (Blumenfeld *et al.*, 1991; Barron *et al.*, 1998). They also have a considerable history in higher education for sustainable development (Singer-Brodowski *et al.*, 2018; Wiek and Lang, 2016). Meta-analytic research on the effectiveness of teaching methods in higher education shows that effective learning needs conceptually demanding learning tasks that are related to students' lives, experiences, and aims (Schneider and Preckel, 2017). All of these learning task characteristics can be achieved in problem- and project-based learning environments. The question of interest here is how problem- and project-based learning environments focusing on sustainability development can be integrated into already existing study programs without the need for difficult structural curricular changes.

Focusing on experimentation is one obvious way of setting up problem- and project-based learning in higher education. In the natural sciences, experiments are the core of the scientific toolbox. Manipulating certain features in a strictly controlled environment helps to identify causal links. In parts of the social sciences, this orientation toward experimentation is a more recent development (Overdevest *et al.*, 2010). Building on the natural sciences approach, social sciences today have developed additional experimental methodologies, adapted to their specific challenges. For example, socio-technical experimentation heavily engages with society and real-world actors to identify alternative technologies and practices as a basis to re-shape social and material realities (Sengers *et al.*, 2016). Research in sustainability sciences, unlike research in other fields, also explicitly engages norms and values (Caniglia *et al.*, 2017). Caniglia and colleagues (2017) even created a typology for experiments in sustainability sciences that distinguishes the different types of possible experiments from other projects and initiatives, and they demonstrate the broad scope in which experiments can be used in sustainability sciences.

Today, these experimental methods have found their way into transdisciplinary research on sustainable development and form the methodological underpinnings of real-world labs (RWLs) (Singer-Brodowski *et al.*, 2018; Wiek and Lang, 2016). Such RWLs can play a crucial role in efforts to educate students about sustainable development. Within RWLs, most of students' and researchers' learning is based on experimentation and empirical projects. When setting up such project-based learning environments in RWLs, the focus of educators is often on the content of the project. For RWLs on sustainable development, this content can be the actual research on the topic, such as reduction in energy consumption. However, this content orientation creates a dilemma described by Jickling (1992). Education on sustainable development can run into the problem of being normative and deterministic, thus opposing the underlying values of transformative education (Singer-Brodowski, 2016). Transformative learning environments such as RWLs should not primarily encourage learning about sustainable behaviors and environmental protection, but help the learner to develop the ability to critically reflect on the learning process itself (Singer-Brodowski *et al.*, 2018). In scientific education, this ability often encompasses a critical reflection on the scientific process itself.

Previous research has identified the potential of RWLs as an educational setup to teach content related to certain issues – e.g. sustainable development (Wiek and Lang, 2016). Recent studies focus on how teaching content can be integrated into RWLs (Krütli *et al.*, 2018). In fact, Singer-Brodowski *et al.* (2018) see RWLs as full learning environments as defined by Land *et al.* (2012). RWLs nurture students' ability to reflect and learn and also create new scientific insights as well as societal learning by integrating and transforming knowledge. While such an approach is a highly effective tool for the learning of certain content, it can also function as a platform for students to learn empirical research techniques. Learning in such a context involves the direct application of newly acquired methodological competencies to real-world problems. Students can experience scientific research processes as active participants and have the opportunity to contribute scientific insights to an organization or society. Such an approach extends the current debate on how to use RWLs as a tool in sustainable development education (Singer-Brodowski *et al.*, 2018) and creates the possibility of integrating such topics into existing curricula – e.g. into social sciences curricula. A three-phase model is proposed that takes students' current (methodological) competency level into account (Table I). Exemplary projects from an existing RWL illustrate the different phases of the model and their goals.

## 3. A three-phase model for a transformative learning experience

In the first phase of the proposed three-phased model (Table I), basic research competencies (such as simple experimental designs or univariate statistics) are applied to specific problems from the field of sustainable development under the supervision of an experienced researcher. This setup gives students the opportunity to apply and develop their new competencies in the context of a meaningful, and thus, motivating field of research. In the second phase, more complex interdisciplinary and transdisciplinary research questions can be addressed. Here, the senior researcher's support shifts toward coaching – giving the students a higher degree of autonomy in the identification of the relevant issue, the problem-solving process and developing a solution. In this phase, the focus of the learning experience is to broaden students' scope of exposure to knowledge and approaches of other disciplines. This phase bears some similarities to case study methods such as the *transdisciplinary case study* (Scholz and Tietje, 2002; Stauffacher *et al.*, 2006; Stauffacher *et al.*, 2008). However, the second phase is still more focused on the research process itself than on a specific topic from the field of sustainable development. In the last phase, autonomous and self-determined research within the structure of a transdisciplinary research environment is encouraged to give students the chance to follow up on their own research ideas. In this phase, the students' involvement with sustainability issues is the highest.

The proposed phasic model continuously increases the complexity of real-world problems and the level of inter- and transdisciplinarity (Figure 1). At the same time, students' autonomy, competence and engagement are continuously fostered. Based on the findings of self-determination theory, this approach should lead to high levels of intrinsic motivation and satisfaction (Ryan and Deci, 2000). Thus, such a setup should not only lead to a deeper understanding of scientific methods but it should also foster a long-term and intrinsic involvement in the field of sustainability development. The proposed framework closely corresponds to recent work on environmental participation (Zimmermann *et al.*, 2018a), which defines five stages of engagement based on the existing intrinsic involvement, prior knowledge and attitudes of participants. The three-phase model also builds on Arnstein's *Ladder of Citizen Participation* (Arnstein, 1969) and its increasing self-determination and cooperativeness. The model also fulfills the three requirements of effective real-world learning opportunities (Brundiers *et al.*, 2010):

(1) A stepwise program taking the starters' low competency level into account.

(2) A highly collaborative design with active stakeholder integration.

(3) Comprehensive coordination with other parts of the curriculum.

The proposed framework allows an easy integration of education on sustainable development into many existing curricula ranging from natural sciences to engineering to the empirical social sciences. The integration would be feasible in all fields of study that have a strong empirical background. Most research courses teach empirical methods with no specific content focus. Thus, integrating sustainable development topics would be

| Phase | Phase description | Learning settings | Scientific research methods trained | Competencies trained | Complexity of research project | Level autonomy | Students' involvement in sustainability issues | Disciplinary focus |
|---|---|---|---|---|---|---|---|---|
| 1 | Application of basic research methodology in an interdisciplinary context under supervision | Lectures in classroom setting<br>Group work on experiment or survey<br>Group coaching by lecturer | Basic experimental and survey designs<br>Complete research cycle (guided) | Basic methodological competency for empirical research<br>Social competencies (e.g., collaboration) | Low | Medium | Low | Inter-disciplinary |
| 2 | Self-determined transdisciplinary research project with coaching on intermediate level of complexity | Collaborative group setting<br>Self-determined individual learning<br>Group coaching by lecturer | Strategies of diagnostics and evaluation<br>Complete research cycle (assisted) | Intermediate methodological competencies<br>Social competencies (e.g., collaboration)<br>Personal competencies (e.g., self-organization) | Medium | High | Medium | Trans-disciplinary |
| 3 | Complex autonomous research project in a collaborative transdisciplinary setting | Self-organized individual learning<br>Self-determined collaboration<br>Individual coaching by lecturer | Complete research cycle (self-organized)<br>Advanced statistical methods (if suitable for project) | Advanced methodological competencies<br>Social competencies (e.g. cooperation)<br>Personal competencies (e.g. self-organization) | High | High | High | Trans-disciplinary |

**Table I.** Characteristics of the different phases in a transformative learning experience

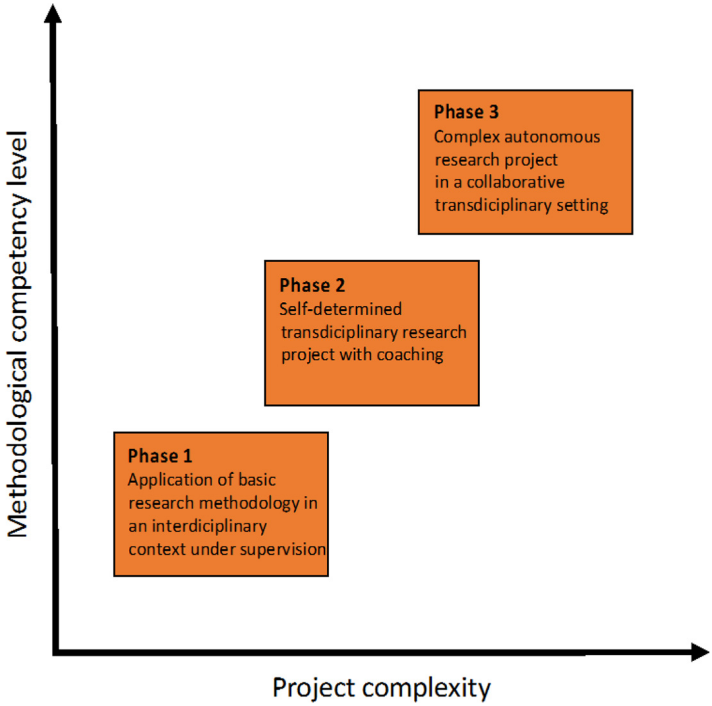



**Figure 1.**
A three-phase model for student research participation in real-world laboratories focusing on sustainable development

possible without changing the structure and curricula of existing study programs. Therefore, this approach could help achieving the goal of including sustainable development education into existing curricula in the natural and social sciences. However, the model could also allow for deeper methodological education in existing programs on sustainable development. As can be seen in many programs that are associated with the global classroom initiative (Elkana *et al.*, 2010), effective curricula in sustainability education include a range of different learning areas – e.g. subject learning, collaborative learning, professional learning, personal learning and research learning (Wiek *et al.*, 2013; Caniglia *et al.*, 2018). Here, research learning is understood as a way to enable students to produce actionable knowledge on a real-world issue by means of state-of-the-art research methods (Caniglia *et al.*, 2018). Such a focus on research methods is advisable, as it can successfully facilitate learning and progress in the field of sustainability research (Luederitz *et al.*, 2016). Additionally, the proposed model could also help to achieve other types of learning like cooperative learning, subject learning, and personal learning.

## 4. Implementation of the three-phase model in an existing social sciences curriculum

An initial implementation of the described phasic model was realized in a bachelor study program in business psychology. The goal was to incorporate a transformative learning experience with a strong focus on sustainability into the existing program. As an empirical social science program, the curriculum has a strong focus on empirical research methods, with courses in statistics, research methods, and research projects included throughout the three-year study program. The implementation of the sustainability focus was done by means of an RWL ("EnSign" project) on transitioning to a carbon-neutral campus (Botero *et al.*, 2017), and it involved a transdisciplinary research project in which different departments at the university collaborated with one other and with external organizations. The Business Psychology Department at the University of Applied Sciences (HFT), Stuttgart, was one of these departments and focused on describing and possibly altering the behavior of university staff and students to support the carbon neutrality goal of the overall project. Exemplary projects from all three phases of the proposed model included survey and interview projects, field experiments on energy conservation and usability studies of mobile learning apps providing information on sustainability issues. The sample projects were implemented in the years 2016 to 2018.

During the *first phase*, students should be exposed to real-life problems in a relatively sheltered environment with clear guidance. This was done with second-term business psychology students at HFT. Students could apply their statistical knowledge (from terms 1 and 2) within a course that is designed to enable them to develop their competencies on conducting experimental research. In this course, students not only learned these research methods on a theoretical level but also designed and conducted their own experiments. The topic of the research was broadly defined by the lecturer but still left room for students to come up with their own ideas. This relatively guided approach has proved to be optimal for students with a basic competency level. In the past, projects with clearly set goals have demotivated students because they could not develop "ownership" of the topic (Zimmermann *et al.*, 2018a). However, giving them too much freedom in choosing their own topic at this point in their scientific career was overwhelming and, therefore, also demotivating. Giving no topics at all to students also lead to topics, which were not always compatible with the goals of the research agenda. Most importantly, giving to much flexibility did not have the intended effect that students learn more on the topic of sustainable development while learning simultaneously about experimental research in social sciences. One example for a research topic in the above-mentioned course was the question of how energy-saving behavior can be influenced. The aim was to persuade students to switch off computers in the computer labs after using them. Multiple student groups created their own research ideas, communicated and cooperated with other disciplines, developed experimental setups and interventions, measured the effects of their interventions, analyzed the data, and presented the results to the rest of the class (and the university). The lecturer clearly outlined each step of the project in advance, gave students input on how to proceed, and counseled them if problems arose. This strongly guided approach was used to make sure that students could successfully conduct their first experiment and develop their methodical competencies and scientific self-esteem at the same time. In this course, students went through the complete experimental research cycle – from coming up with a research question to the presentation of the results. Lecturers also encouraged students to critically evaluate their research strategy, experiment and findings. Furthermore, students learned about energy conservation, recycling and waste management while working on the projects. This opportunity to simultaneously learn on both a content and a methodological level was highly valued by students (Zimmermann *et al.*, 2018b). The Computer Science Department uses a similar setup to teach programming in project teams. The results of one such project – an online measurement tool for energy consumption in computer labs – were even used by the student projects mentioned above. This approach fosters interdisciplinary communication and cooperation and is highly motivating for all involved.

Projects for the *second phase* were also integrated into the business psychology program. In term 4, the students, who then had advanced competencies in research methodology, were asked to do their first consulting project in which they work with an external project partner on a given topic. Lecturers proposed the projects, but students could choose between different proposals to make sure they were highly motivated to work on a certain project. An example for such a topic was to evaluate and make recommendations for future usability improvements of an augmented reality app. The app was designed to teach students about energy consumption and conservation, and it was developed during another series of student projects in the Computer Science Department. As mentioned above, in this phase, lecturers do not steer the projects themselves but, rather, assume a coaching role. Students were encouraged to communicate with their clients, set up a research program to evaluate the usability of the app, and report the results to the client all on their own. Within such a project, students further developed their methodological research competencies and, at the same time, developed a better understanding of the topic of energy consumption and conservation, as well as behavioral change in these areas. The project also strengthened their communicative and collaborative competencies. Reflecting on the research strategy as well as on the effectiveness of the proposed solutions is also an essential part of such a project. All of this was done within a transdisciplinary setting with multiple stakeholders.

In the *third phase*, the task complexity and autonomy with which students conduct their research reach their highest level. In this phase, autonomous and self-determined research within the structure of a transdisciplinary research team is encouraged. Here, the focus of the learning experience is to broaden students' scope of exposure to knowledge and methods from other disciplines. In the business psychology program at the HFT Stuttgart, this phase was implemented by giving students the opportunity to conduct their thesis projects within the framework of the "EnSign" project. No specific topic was given to the students, but interested students were encouraged to come up with their own research ideas. This approach was used to make sure that students can create self-determined research, substantiate their knowledge about sustainability, and that the RWL is truly open to ideas from outside the core research team. To encourage critical and reflexive discussions on research methods and content of the study, multiple rounds of individual coaching by supervisors were implemented. Currently, a voluntary research internship in the third term of the Master's Program in Business Psychology is also being tested; students can work on their own research ideas for six months without the pressure resulting from the requirements and deadlines of a master's thesis project. In addition to focusing on self-determined research on sustainability topics, inter- and transdisciplinary research collaboration is strongly encouraged by involving other departments as well as external organizations and companies interested in the reduction of energy consumption.

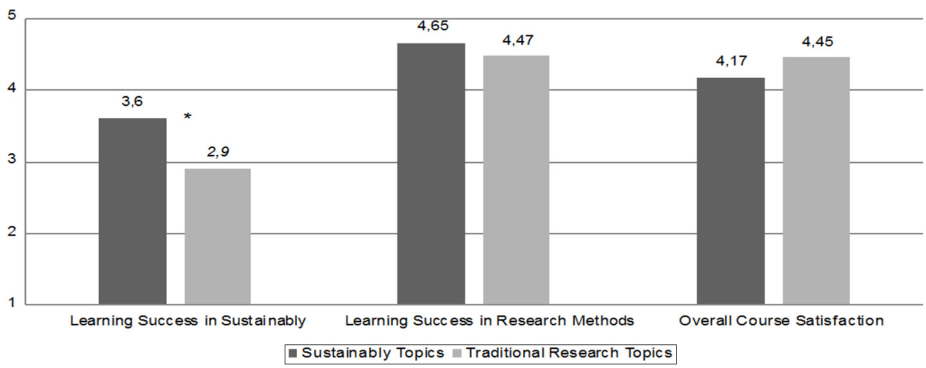
The overall outcome of the different projects based on the framework can be seen as a step toward a transformative learning environment. The changes were easily implemented into the curriculum and did not require any structural changes in the study program. Students, researchers, and lecturers alike positively evaluated the student projects. Evidence on competency development is still rather descriptive and lacks thorough pre-/post-testing, as can be seen in other research on this topic (Remington-Doucette and Musgrove, 2015). In a pilot evaluation study from the start of the implementation in 2016/2017, 37 students (term 2) in *phase 1* participated in a course evaluation of their four-month course (for details, see, Zimmermann *et al.*, 2018b). Of these students, 19 had already participated in the sustainability projects described above. The remaining students had participated in projects with traditional research questions developed by themselves or the lecturer. After the end of the course students filled out an evaluation questionnaire. The self-assessed learning success in sustainability was recorded with 5 items (5-point scale from 1 = "disagree at all" to 5 = "fully agree") and the total mean was calculated. One example item is "My interest in sustainability issues has increased as a result of the course." Cronbach's alpha for the scale was 0.85. Learning success in research methods was assessed with the item "I found the learning of scientific working techniques within a project helpful". This item was also evaluated on a 5-point scale from 1 = "disagree at all" to 5 = "fully agree". The overall satisfaction rating of the course was assessed with two items and the overall mean (5-point scale from 1 = "disagree at all" to 5 = "fully agree") was calculated. One example item is "Overall I found the course instructive." Cronbach's alpha of the scale was 0.71.

Results showed a statistically significant higher rating by the students in the sustainability projects of their learning success in sustainability topics ($M = 3.60$, $SD = 0.84$) compared to the control group ($M = 2.90$, $SD = 1.07$; $F(1, 35) = 4.83$, $p = 0.035$, $\eta_p^2 = 0.12$, see also Figure 2). For the ratings of learning success in research methods ($M = 4.65$, $SD = 0.78$ *vs* $M = 4.47$, $SD = 0.51$; $F < 1$) and the overall course satisfaction rating ($M = 4.17$, $SD = 0.71$ *vs* $M = 4.45$, $SD = 0.47$; $F(1, 35) = 2.05$, $p = 0.161$) no significant differences were found. Therefore, it can be concluded that the sustainability projects helped the students to learn more about sustainability without negatively impacting on their learning success in research methods and their overall satisfaction with the course.

The initial results highlight the usefulness of the proposed model but are in no way sufficient. Further evaluation studies are needed to replicate these findings for all phases and with different methodologies not only relying on self-reports. Especially, the question, which competencies students developed, should be studied in more detail. As Singer-Brodowski (2015) and Caniglia *et al.* (2016) point out, research on students' sustainability learning often lacks a systematic analysis of conditions for and processes of competency development. The current model could contribute to this research by providing a framework to elaborate on this topic.

## 5. Limitations and boundary conditions of the current model

Despite this successful initial implementation, there are some limitations to the presented model. The biggest challenge within the model is the difficulty in generating relevant research questions for such a project- and problem-based learning process. Creating research questions that are not only testable in a rigorous scientific way but which also have a high social relevance and give students the opportunity to learn about sustainability topics




**Note:** $*p < 0.05$

**Figure 2.** Mean self-assessment of learning success in sustainability, learning success in research methods and overall course satisfaction, grouped by sustainability and traditional research topics

is a challenging task, even for experienced researchers. For students, especially at the beginning of their scientific career, creating research questions on their own can be overwhelming. To prevent major disappointments and setbacks that would demotivate students to further pursue research on sustainable development, it is recommended to support students in the first phase with relatively specific research questions. In the following two phases, when giving students the freedom to pursue their own research ideas, providing them with structured process tools is recommended, as these can help them to identify meaningful transdisciplinary research questions – as, for example, with the *10-step approach* proposed by Pohl and colleagues (Pohl *et al.*, 2017). The independence and high autonomy of the students in creating their research ideas in the last phases also make it difficult for the lecturers and researchers to create a sustainability curriculum with few gaps and redundancies. The best way to achieve such a curriculum is to clearly define topics in sustainability education that are linked to a certain term (e.g. projects in term 4 are always about energy consumption and conservation).

Another challenge for lecturers and researchers is the role conflict in which they find themselves. In the current three-phase model, which describes a certain sequence of various courses, researchers/lecturers need to be transparent with students and research partners (and themselves) about the dual role a researcher has within their research project and the students' education. This also means that researchers/lecturers need to be transparent about the role they play in each of the projects (e.g. an educator giving grades, a coach and facilitator of transformative research, a project manager for a research program). Sometimes, this role transparency even means changing roles over the course of the project. Researchers also need to see students as equal partners in the project, especially in RWLs. In sum, researchers should be willing and able to deal with conflicts that can arise from the different perspectives, roles and motivations they are confronted with during such a project. These projects can create a complex and demanding situation for the lecturer or researcher (often the same person). However, it is worth dealing with the challenges of this demanding form of educational research to conduct meaningful research and teach motivating and empowering courses on sustainability at the same time.

Finally, the three-phase model also has a challenge common to problem-oriented learning environments, how to make sure that necessary basic knowledge, in this case about sustainable development, is learned by all students. Therefore, especially in the first phase of the model, the need to teach certain sustainability topics and integrate other integral issues of a sustainability curriculum, as, for example, discussions about ethics (Biedenweg *et al.*, 2013), will be necessary. This takes away teaching time from given course content (here about research methodology), which can increase complexity of the implementation. Future research could address this problem, for example, by complementing existing courses with online curricula on sustainability issues (Yuan *et al.*, 2014).

## 6. Conclusions

The proposed model provides an opportunity to combine education on sustainability with thorough training in scientific research methods. It also offers the opportunity to incorporate education on sustainability into existing curricula without the need for difficult structural changes. Thus, no course descriptions or module handbooks have to be changed. Due to the three subsequent phases, the model can be applied early in students' scientific careers, when they have limited knowledge about both sustainability and scientific research methods. The model also promotes a critical and reflexive learning process in both fields of interest. Furthermore, it provides sustainable development study programs with a framework for implementing education on empirical research methods. Future research can extend this framework by integrating more specialized courses and course modules on sustainable development as a whole or single topics (e.g. ethics) into the concept. Therefore, the proposed phasic model has the potential to create truly transformative learning experiences when teaching students about sustainable development.

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