

Article

From Transdisciplinary Research to Transdisciplinary Education—The Role of Schools in Contributing to Community Well-Being and Sustainable Development

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Abstract: This article looks at transdisciplinary research and discusses the possibilities of translating this concept into a new type of education, which we will call *Transdisciplinary Education*. Following the adoption of the Sustainable Development Goals by the community of states, there has been increased international recognition of education as being a key driver for sustainable development. Considering the global grand challenges of the 21st century, the integration of Education for Sustainable Development at all school levels ought to be prioritized in order to empower young people to contribute to sustainable development. Collaborating with out-of-school partners and doing research on real-world problems within their lifeworld, help students develop the competences necessary for responsible citizenship, while at the same time contributing to community well-being. Both concepts transdisciplinary research and *Transdisciplinary Education* acknowledge the responsibility of addressing social relevant problems and the significant role of those who are and who will be affected by these challenges. The project *Science Education for Action and Engagement Towards Sustainability (SEAS)* aims at analyzing different partnerships between schools and out-of-school institutions in European countries. By comparing the collaborative formats and providing a concept and method pool for educators, *SEAS* targets facilitating the integration of *Transdisciplinary Education* in formal schooling in the future. This article gives insights into the Austrian research-education collaboration *k.i.d.Z.21*. Drawing on experiences of *k.i.d.Z.21* and taking up characteristics of transdisciplinary research, opportunities and challenges of integrating *Transdisciplinary Education* in formal schooling are discussed.

Keywords: transdisciplinary education; involvement of young people; (education for) sustainable development; community well-being; empowerment



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1. Introduction

«There is nothing permanent except change» (Heraclitus, 540 BC). This famous quote from the Pre-Socratic philosopher Heraclitus of Ephesus, made long before the beginning of the Anthropocene, can also be applied to the dynamics, world society has to address in the 21st century. Humans are increasingly faced with rapid changes and complex problems, like anthropogenic climate change (CC) or the current Covid-19 pandemic. However, in view of these challenges, which are among the great global grand challenges of the 21st century, humans not only suffer the repercussions of these challenges, but also bear responsibility, holding the power to significantly determine their further magnitude [1–4]. Technological breakthroughs and political regulation alone will not be enough to address these challenges. In this context, innovative forms of research and partnerships will be necessary, which transgress disciplinary and system boundaries and give space for new types of knowledge and competence development [4–6].

Against this backdrop, a claim in the world of science emerged, namely that science needs to become more socially responsible, recognizing the value to research problems in an inter- and transdisciplinary manner [7–12]. With regards to the social responsibility of science, the consideration of the needs, experiences, and values of those affected by a problem are significant. Thus, shifting away from research on people to research with people, should be the core of transdisciplinary (TD) research. This implies that scientists should regard society as an equal partner and research problems, like CC, which are socially relevant. Hence research becomes a mutual learning process for all partners involved and requires a shift from a unidirectional top-down information flow, to research that transforms all systems involved [8,13–15]. The significance of TD research to cope with current and future challenges and to create more sustainable and socially accepted solutions is also acknowledged by the European Commission and is considered in the concept of Responsible Research and Innovation, which is part of the research funding program Horizon 2020 [16].

The role of education as a key driver dealing with the challenges posed by anthropogenic CC and further sustainability challenges, has been acknowledged by the community of states for almost three decades. Both Agenda 21 and the Decade of Education for Sustainable Development (ESD), began connecting education and sustainable development. Debates on Sustainable Development Goals (SDGs) which have continued over the past five years have also centered on the important role education can and should play in achieving the set targets. The Paris Agreement (2016) affirmed that, SDG4 Quality Education is considered to be a central element for reaching all other SDGs [17–20]. Climate Change Education (CCE) in particular plays an essential role with regards addressing the challenges included in the SDG 13 Climate Action [21].

Considering the fundamental role of education and the value of TD research against the background of anthropogenic CC, the significance of the young generation in contributing to a sustainable present and future becomes apparent. Young people are not only the most affected by future sustainability challenges, but also the decision-makers of today and tomorrow [22,23]. Further, via the Fridays For Future movement, young people impressively demonstrate that they can be the pioneers and the creators of the momentum of change toward social transformation today [23,24]. A transformation of values and lifestyles is considered to be decisive in order to address the challenges posed by anthropogenic CC and further challenges of our time like inequality and poverty [4,25–28].

Although recognizing the value and responsibility of each individual domain—of TD research and of education—in addressing socially relevant issues [9,11,12,16,19], the potential which will be achieved by uniting both domains and integrating them in the form of a *Transdisciplinary (TD) Education* in formal schooling, is only minorly reflected in school reality. Until now, the concept of TD has predominantly been adopted in higher education [29–33], and is rarely found in everyday school education. Where TD does exist in formal schooling, it takes the form of relatively short-term, research or community-education partnerships (e.g., [34,35]).

This publication aims to introduce the new concept of *Transdisciplinary Education* and discusses its opportunities and challenges which are derived from the concept of TD research and TD in higher education. Additionally, experiences from the Austrian research-education collaboration *k.i.d.Z.21—kompetent in die Zukunft* (in English: *competent towards the future*) are presented. This publication also highlights system impedances, conflicts, and questions which might arise by introducing *TD Education* in formal schooling. These questions will be addressed in future research within the EU funded Horizon 2020 project *Science Education for Action and Engagement towards Sustainability (SEAS)* of which *k.i.d.Z.21* is a part of.

A short introduction to the concept of TD and its meaning for formal schooling now follows, along with a presentation of the Austrian research-education collaboration *k.i.d.Z.21*. Subsequently, there is a discussion how to implement *TD Education* in formal

schooling against the background of its opportunities and challenges. Finally, a general and for *k.i.d.Z.21* and *SEAS*, a specific conclusion is drawn.

2. From Transdisciplinary Research to Transdisciplinary Education

In order to achieve a social transformation toward a sustainable future, anthropogenic CC and its consequences require a powerful educational response [17–21,27,36]. Young people have to be empowered to address challenges like CC and to actively shape their lifeworld as responsible citizens. Responsible citizenship is interpreted in this publication as citizens who are able to reflect critically on own and others behavior as well as take responsibility for their own actions, while considering temporal and spatial impact of their actions today. This requires, on the one hand, scientific literacy, the ability to apply scientific knowledge and competences wisely in everyday life, and on the other hand, inter- and intrapersonal competences and values in line with ESD, both supporting transformative learning and allowing the making of informed and sustainable decisions [18,19,37–43]. Against this background, Paulo Freire claimed in 1970 that traditional teaching styles, as still commonly used in schools today, lead merely to short-term recall, with little or no lasting effect in the long run [44,45]. In a dynamically changing world these practices are inadequate, as they hinder adopting learning contents to new and uncertain situations [46]. Moreover, discipline-oriented knowledge is insufficient to deal with and pro-actively tackle current and future sustainability challenges, which require a multi-perspective approach [14,47]. Furthermore, the philosopher Ivan Illich, one of the most visionary political and social thinkers, stated in his radical book *Deschooling Society* (1971) that education has to support knowledge exchange between those who want to share and those who want to learn, as well as give everyone the opportunity to make her/his opinion and arguments known by the public [48].

In order to empower young people to cope with a continuously changing world, teaching approaches need to meet the needs of ESD. ESD promotes inter- and transdisciplinary, learner-centered, participatory, and locally relevant approaches [49,50]. TD partnerships which give students the opportunity to actively conduct research on real-world problems and develop sustainable solutions with out-of-school partners address the claims made by Paulo Freire and Ivan Illich and are in line with ESD [17,18,45,48,51–55]. Hence, TD partnerships allow students and teachers to collaborate with scientists, as well as further out-of-school partners in the fields of, for example, politics, economy, ecology, and civil society within the community that the school is located. Besides that, jointly conducting research on real-world issues fosters scientific literacy, while the exchange of knowledge and perspectives in collaborative processes encourages mutual learning of all partners involved and facilitates the generation of transformative knowledge [15,56–59]. The latter is fundamental for the change of current actions and behavior toward sustainability [51,60,61]. Moreover, TD collaboration allows the development of the competences needed, like the capacity to reflect on one's own and others perspectives and critical thinking, which are in line with the claim of ESD, and beyond that foster a responsible population [17,18,37–39,42,43,51,53].

Initial discourses about transdisciplinarity emerged against the background of economic and technological change in the 1960s, which in turn entailed innovation and transformation of research and educational systems [11]. Years later, environmental problems and arising debates about sustainability resulted in the evolution of the concept of transdisciplinarity, which moved away from a more interdisciplinary scientific perspective [62–64], beyond societal needs as the driving force of the research [65,66], toward partnerships between science and society [11,12,67,68]. Consequently, the perspective and contextual knowledge of those affected by a problem gained importance and led to an increasing involvement of civil society in the research process [11,14,67]. TD research contains three fundamental aspects: (1) The starting points are socially relevant issues, which are jointly identified and which are researched by means of integrative scientific methods, with the aim of developing interdisciplinary solutions or strategies for trans-

formation; (2) during the whole research process there is an exchange between scientific and non-scientific partners, the latter, e.g., politicians, require the generated knowledge for decision-making; (3) integration of non-scientific partners, like citizens (or in this case: students), to consider experiences and context-based knowledge [33,57,69,70]. Different forms of partnerships are possible, depending on the degree of integration of non-scientific partners [71].

Translating this concept into the educational context requires that socially relevant issues of students' lifeworld, which are jointly defined, should be considered as fundamental for formal schooling rather than as pre-defined educational content [43] (see Figure 1). Dependent on the age of the students and the type of school, teachers can draw from different collaborative formats and consequently enhance students' involvement in collaborating with out-of-school partners. Shaw et al. (2011) distinguish between young people as source of research data, young people are consulted about the research and young people as collaborators. The most autonomous form, according to Shaw et al. is that young people are empowered and take ownership of the research. The latter two are considered for *TD Education* as they originate from joint decision-making and consequently are in line with TD research which fosters research with people instead of research on people. The collaboration between students and out-of-school partners involves jointly developing and planning different research phases. If students get the opportunity to take ownership of the research, teachers and out-of-school partners give only support and guidance when needed [72]. Consequently, students design the research process on their own, from the development of the research question, to the selection of the evaluation method, and to the assessment as well as the presentation of results and solution strategies [54,73]. During this form of partnership, young people simultaneously take ownership of both their learning process and their lifeworld [74,75].

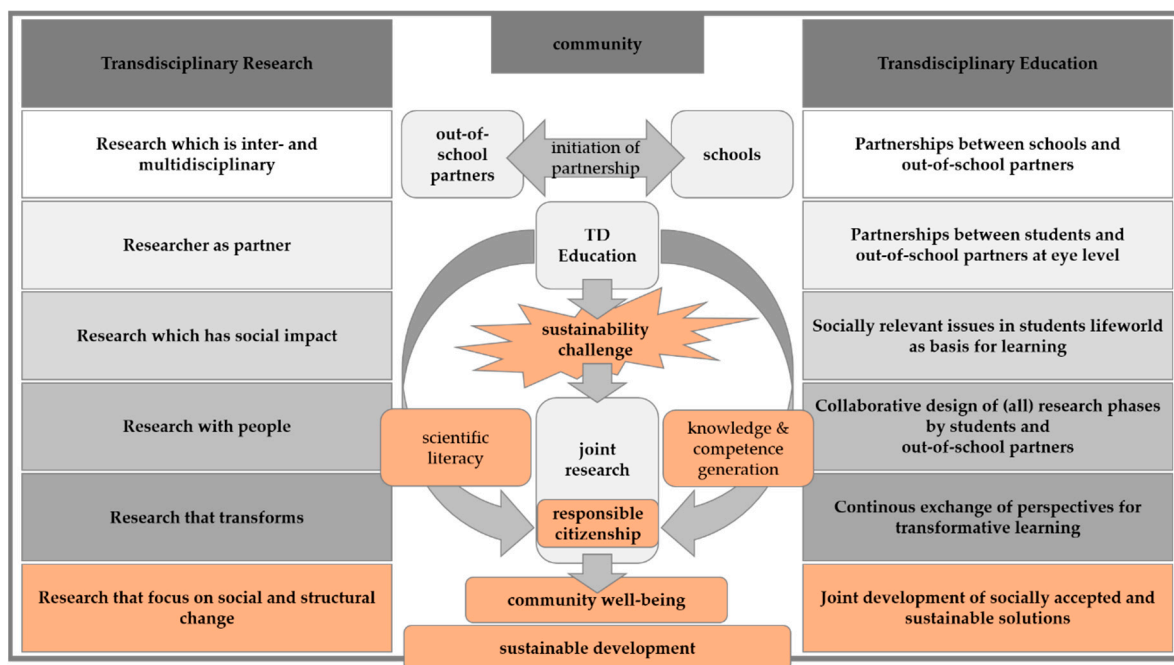


Figure 1. From transdisciplinary (TD) research to transdisciplinary education. Source: [13], modified.

Beyond that, scientists should be involved to monitor and support the collaboration process, teachers can additionally benefit of the partnerships with scientists and further out-of-school partners, to jointly work out with students, actual research findings and practical context-based knowledge.

Inspired by the approach of TD research and Responsible Research and Innovation [11,16,57], this paper argues that mandatory anchoring this new form of education

Transdisciplinary Education in formal schooling, offers schools the opportunity to play a part in having a social impact while educating a responsible student body.

The opportunity that TD Education offers community well-being and sustainable development, raises a few questions, which will partly be addressed in this paper and in future research within the project *SEAS*. These questions are as follows:

- What opportunities and challenges do schools face by introducing TD Education in terms of educational, staff and institutional development?
- How can TD Education be integrated into school reality? What developments does this necessitate in the fields of educational, staff, and institutional development?
- What opportunities and challenges do out-of-school partners face by co-operating with schools in the long-term? How can these challenges be addressed?
- What methods can be used within the collaborations in order to jointly research sustainability issues?

3. A Long-Term Research-Education Collaboration on Climate Change: The Example of *k.i.d.Z.21*

The research-education collaboration *k.i.d.Z.21*—*kompetent in die Zukunft* (translated as: competent toward future) was developed against the backdrop of today's youth being increasingly confronted with the global grand challenges of the 21st century, specifically with the consequences of anthropogenic CC [5,76]. Consequently, they have to adapt and go through a transformation process, for which young people, as today's and tomorrow's decision-makers, have to be prepared [77]. Besides raising awareness about CC and its consequences, *k.i.d.Z.21* aims at generating acceptance and the need for action, linked with a necessary social transformation, while at the same time strengthening young peoples' capacities to act and adapt to the challenges posed by societal, economic, and ecologic changes [78]. Since the foundation of the collaboration in 2012 between the Department of Geography of the University of Innsbruck, Austria, and the Karl-von-Closen Gymnasium, a southern German high school, the network has continuously grown with the addition of many more Austrian, German, and Italian schools. To date, almost 2,500 high-school students have been involved in the one full school-year project. The network includes more than 100 voluntary (scientific) experts in the fields of CC and environmental ethics, tourism, bio-, pedo-, and cryosphere. These are alongside established (scientific) CC experts as well as young scientists.

k.i.d.Z.21 is based on the idea of a transdisciplinary dialogue between students and (scientific) experts of different disciplines and on moderate constructivist approaches to learning [77,78]. Hence, the setting of *k.i.d.Z.21* fosters exchanges between students and (scientific) experts and gives students the opportunity to actively complete research on real-world problems within school and out-of-school settings [55,79].

The project consists of different modules (Figure 2), which, among others, are based on concepts of TD mentioned above [11,57,80–82]. During a school year, the students (aged between 12 and 18 years) are actively involved in these modules.

At the beginning of the project (and the school year), during the *kick-off event*, students have interactive *workshops*, *lectures + debates on CC* with CC experts and further out-of-school partners like politicians and peers, getting the opportunity to discuss CC and its consequences. During the school year, the students receive *classical school lessons on CC*. All teachers in the participating schools are asked to include the topic of CC in their school lessons. The teachers are autonomous with regards how far and by which methods they integrate this topic. Furthermore, for at least six months the students develop and work on their *individual CC research project*, which can be related to the human or social sciences (e.g., arts, history etc.) or related to the natural sciences (e.g., mathematics, biology etc.) or, even better, be interdisciplinary. The *individual CC research projects* are presented at the end of the project. According to the moderate constructivist approach [52,80,82], the whole concept is up to the students. This resulted in students creating their own creative learning projects, e.g., some students established an initiative at their school to encourage

other students to go to school by bike. The project year finishes at the end of the school year with an *Alpine Research Week*, where the students once again come in contact with experts in the fields of tourism, environmental ethics, alpine vegetation, and glaciology. The high Alpine environment offers an authentic setting, where students become researchers, doing research on the consequences of CC on the above mentioned fields [55]. Based on inquiry-based learning students are asked to develop their own research questions, find adequate methods for data collection and collect, analyze, as well as interpret the data. The (scientific) experts offer the students support during the whole research process. On the last day of the *Alpine Research Week*, the synthesis day, local experts are invited to discuss the questions remaining unanswered.

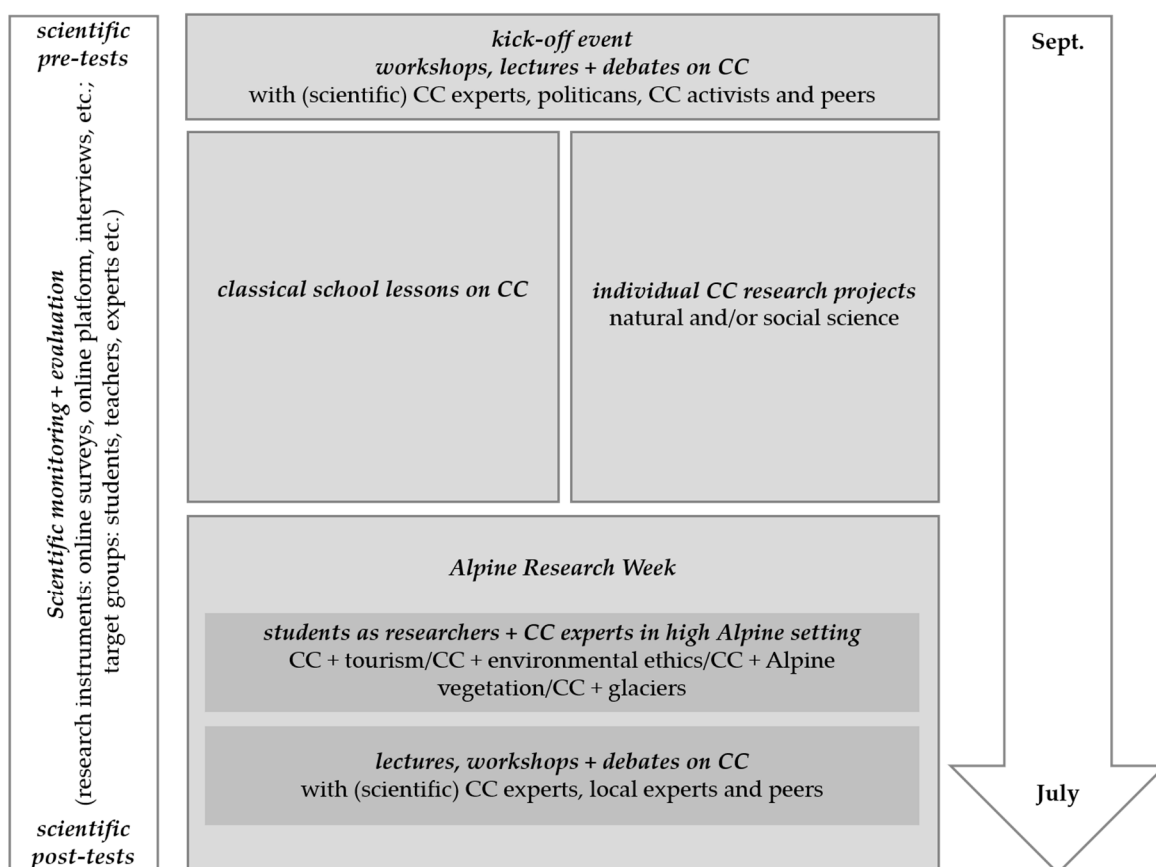


Figure 2. *k.i.d.Z.21* learning setting during a project year (one full school year) (source: [55], modified).

The continuous scientific monitoring and evaluation of the participating students via online questionnaires at the beginning (pre-test) and the end of the project year (post-test), helps modify the setting and already showed interesting results regarding students learning outcomes against the background of CC [55,79,83–85].

4. Beyond Requirements of TD Education to Opportunities and Challenges

Referring to the initial questions (see Section 2), the following section deals with the opportunities and challenges of *TD Education* for schools as well as requirements in the fields of educational, staff, and institutional development [86]. Moreover, it highlights system external implementation requirements in the context of teacher training. This discussion is based on the experience of the research-education collaboration *k.i.d.Z.21* and on a literature review of research in the field of TD in higher education and TD research.

4.1. Educational Development—From Theory-Based Teaching to Socially Relevant Issues

TD Education means a shift from theoretical predefined and discipline focused content as a starting point of learning to the joint definition of socially relevant issues within students' lifeworld [31,87,88]. This requires innovative forms of teaching and learning which are in line with ESD [18]. Moderate constructivist and inquiry-based learning approaches seem to be most adequate for *TD Education*, as they are, on the one hand, learner-centered and grant students the opportunity to use their analytic and creative skills and on the other hand allow exchange and reflection of different perspectives, which is essential in collaborative research processes [33,54,73,80,82]. These concepts are also approved by the TD modules within the *k.i.d.Z.21* project [55]. Nevertheless, TD settings require a high degree of self-reliance and active engagement of students as they evolve from a mere recipient to a co-designer of their school lessons [31,74,89–91]. The role of teachers in turn shifts from the classical role of knowledge mediator to coach and process manager, supporting students in their learning processes, enabling reflection among students and only intervening if necessary [33,92,93]. During the *k.i.d.Z.21* school year, students develop and do research on their *individual CC research project*. The project evaluation shows that even if the students invest a lot of effort in the development of their project, actively dealing with an issue within their fields of interest encourages effective learning in comparison to the classical school lessons as demonstrated by Keller et al. (2019). The same is true for the *Alpine Research Week*, in which students do research and are supported by experts and their teachers whenever needed. The TD dialogue and active involvement in an authentic learning setting during this week, raises students understanding of CC and its consequences and lead to an increasing learning effectiveness [55]. Moreover, this TD project raises awareness and self-efficacy of students which are important predictors for climate-friendly action [83,85].

Moreover, *TD Education* also requires the rethinking and the redefinition of learning objectives and evaluation modes, as the learning content is jointly agreed with the students at the beginning of the TD partnership. The determination of learning objectives and evaluation modes therefore requires some flexibility. Learning objectives should focus on competences generated during the process or should be defined together with students at the beginning of the collaboration. The same can be possible for the evaluation mode.

4.2. Staff Development—Consideration of TD in Teacher Education

The demands that *TD Education* makes on teachers' competences not only with regard to alternative pedagogical and didactical methods, but also in using different forms of student's involvement within partnerships, not only affect schools but also universities, since these need to be considered in teacher training programmes [94,95]. The same is true for the organizational competences which are required to plan and maintain the partnerships [31,94–97]. Consequently, according to Germ (2018) it is necessary that universities build academic capacities doing research on TD and necessary (didactical) competences, and consider these in the curricula for teacher training [98]. Following a learning-by-doing approach, it would be highly recommended that university students get in contact and do research with out-of-school partners [30,32]. The implementation of TD Education in schools further raises the question of how to re-train teachers already working within the classical education system. In the *k.i.d.Z.21* project, for example, the project team invests a lot of time in training the teachers how to apply innovative didactical methods like moderate constructivism and inquiry-based learning in the sense of CCE and ESD [19,54,55,81]. The teachers themselves take part at the *Alpine Research Week* and do research in this authentic TD learning within the teacher training programme [55]. As the respective working group is also responsible for teacher education of the subject Geography and Economies at the University of Innsbruck, TD, moderate constructivist approaches of learning and ESD as well as CCE are part of the teacher training. Moreover, students get the opportunity to support the working group in different modules of the project.

4.3. Institutional Development—Structural Anchoring of TD Education

Since TD partnerships require a continuous exchange between students, teachers and out-of-school partners and are very time-consuming [37,57]; one possibility to integrate TD Education in formal schooling would be a TD project seminar [96,99]. This in turn needs to be considered in school curricula. One of the *k.i.d.Z.21* schools for example, incorporates two hours each week for the students to work on their *individual CC research projects*, which would also be recommendable for a TD project seminar, in order to foster continuous exchange with out-of-school partners. Another possibility would be to allocate different periods within the school year for the TD exchange with out-of-school partners, as it is commonly handled in the *k.i.d.Z.21* project. The findings of the study by Keller et al. (2019) and of further studies within the project [83–85] support the fact that the dialogue with out-of-school partners within the TD modules have already a high learning effect.

4.4. Personal Development—Beyond Knowledge to the Generation of Competences for a Responsible Citizenship

TD Education leads to a democratization of learning as students get the opportunity to actively shape their own learning process, while contributing to the community well-being and sustainable development. Moreover, both by means of the process of collaboration and by researching, students may develop competences needed for responsible citizenship [31,39,42,43,47,54,100]. The findings of the study by Deisenrieder et al. (2020) also support an increased self-efficacy and climate change awareness among students taking part at the *k.i.d.Z.21* project. Furthermore, students' climate-friendly behavior is raised by doing their own research and being in dialogue with out-of-school partners in the project [85]. The latter is also confirmed by further studies beyond this project [101–103]. Moreover, actively researching an issue of interest raises scientific literacy and encourages students to identify with, take ownership of, and consequently responsibility for the issue [31,33,43,103–106]. Furthermore, as demonstrated by Parth et al. (2020), *k.i.d.Z.21* students also act as multipliers on their families in relation to climate-related knowledge attitudes and actions [84].

As mutual learning takes place within TD partnerships by continuous dialogue and exchange of different perspectives, not only students but all partners involved make progress and develop competences necessary for a responsible citizenship [42,103,107].

5. Conclusions

This publication aims to demonstrate that solving today's and the future's challenges are no longer a matter for scientists and politicians alone, but requires a responsible citizenry [38,39,41–43]. Therefore, new forms of research and education are necessary which allow mutual learning and foster new types of knowledge and competences generation for transformative learning [11,13,42,51,60,67]. However, traditional teaching styles as commonly practiced in formal schooling are inadequate to address the challenges in a dynamically changing world [45,47]. Approaches to teaching and learning need to be in line with the claims of ESD, which promote inter- and transdisciplinary, learner-centered, participative and locally relevant approaches [18,49,50].

Inspired by the concept of TD research [11,67] and Responsible Research and Innovation [16] and drawing on the experience within the research-education collaboration *k.i.d.Z.21*, this publication aims to introduce the new concept *Transdisciplinary Education* which should become an integral part of formal schooling. TD Education transgresses system boundaries and empowers young people, the ones who will be the most affected by future sustainability challenges [22,23], to actively shape their lifeworld by participating in the development of sustainable and societal accepted solutions within their community. Actively dealing with socially relevant issues within their lifeworld, collaboratively doing research and being in dialogue with out-of-school partners from science, politics, and further sectors within their community, students develop competences necessary for a responsible citizenship, as demonstrated by studies within the Austrian research-education

collaboration on climate change *k.i.d.Z.21* [83–85]. Within the international EU Horizon 2020 funded project *Science Education for Action and Engagement Towards Sustainability (SEAS)*, which was submitted in November 2018 under the call *Science with and for Society* different formats of TD partnerships both in regard to temporal, structural, and operative aspects will be analyzed in a cross-cultural setting from projects partners in Austria, Belgium Estonia, Italy, Norway, Sweden, and the United Kingdom. *K.i.d.Z.21* is representative of the Austrian TD collaboration. Comparing different methodological approaches and implementing different tools within the partnerships, *SEAS* aims at giving answers to the initial raised questions (Section 2) and providing a concept and method pool of good practice examples and lessons to be learned for educators to establish and facilitate the integration of *TD Education* in formal schooling.

In addition to having a great potential to contribute to community well-being and thus to sustainable development, *TD Education* also may challenge schools as it requires developments on educational, staff, and on an organizational level. These necessary developments lead to the need to rethink aspects of the traditional school system, especially in regard to the objectives of teaching and learning which are defined in school curricula and how to consider *TD Education* in school reality. Furthermore, anchoring *TD Education* in formal schooling involves a necessary development in higher education in the field of teacher training and also challenges out-of-school partners [98,107–109]. Consequently, different systems involved come into conflict which differ in terms of interests, time structures, and administrative aspects [107]. Analyzing and comparing the opportunities and challenges for schools, but also for out-of-school partners, of different formats of TD partnerships and finding solutions for the just named challenges, will be a demanding task for future research within *SEAS* and the country-specific partnerships. However, it will inform how to best integrate the concept of *TD Education* in formal schooling.

Yet, as TD research and the education of (young) people play an increasingly important role in dealing with the complex global grand challenges of the 21st century [11,16,19], this publication also aims at encouraging research beyond these projects to find innovative answers in order to translate the concept of Transdisciplinary Research into *Transdisciplinary Education*. Acknowledging the important role of education [18], educating a ‘powerful force for social change’ (Bentz & O’Brian 2019, p.1) [23], this publication concludes that schools not only have great potential, but also a responsibility to contribute to community well-being and beyond that to sustainable development.

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References

- Gössling, S.; Scott, D.; Hall, C.M. Pandemics, tourism and global change: A rapid assessment of COVID-19. *J. Sustain. Tour.* **2020**, *12*, 1–20. [CrossRef]
- Howarth, C.; Bryant, P.; Corner, A.; Fankhauser, S.; Gouldson, A.; Whitmarsh, L.; Willis, R. Building a Social Mandate for Climate Action: Lessons from COVID-19. *Environ. Resour. Econ.* **2020**, 1–9. [CrossRef] [PubMed]
- Lade, S.J.; Steffen, W.; de Vries, W.; Carpenter, S.R.; Donges, J.F.; Gerten, D.; Hoff, H.; Newbold, T.; Richardson, K.; Rockström, J. Human impacts on planetary boundaries amplified by Earth system interactions. *Nat. Sustain.* **2020**, *3*, 119–128. [CrossRef]
- Barnosky, A.D.; Ehrlich, P.R.; Hadly, E.A. Avoiding collapse: Grand challenges for science and society to solve by 2050. *Elem. Sci. Anth.* **2016**, *4*, 1–9. [CrossRef]
- Reid, W.V.; Chen, D.; Goldfarb, L.; Hackmann, H.; Lee, Y.T.; Mokhele, K.; Ostrom, E.; Raivio, K.; Rockström, J.; Schellnhuber, H.J.; et al. Environment and development. Earth system science for global sustainability: Grand challenges. *Science* **2010**, *330*, 916–917. [CrossRef]
- Rockström, J.; Steffen, W.L.; Noone, K.; Persson, A.; Stuart Chapin, F.; Lambin, E.; Lenton, T.M.; Scheffer, M.; Folke, C.; Schellnhuber, H.J.; et al. Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecol. Soc.* **2009**, *14*, 32. [CrossRef]
- Klein, T.J. Sustainability and Collaboration: Crossdisciplinary and Cross-Sector Horizons. *Sustainability* **2020**, *12*, 1515. [CrossRef]
- Keller, L. Sustainable Development?—Let us change concepts: Theoretical and Practical Contributions to the Transformation of Society, Science, Knowledge, and Education from a Geographer's Perspective. In *Habilitation Thesis for Geography*; University of Innsbruck: Innsbruck, Austria, 2017.
- Onwu, G. Towards a Socially Responsible Science Education. In *Science Education: A Global Perspective*; Akpan, B., Ed.; Springer: Berlin, Germany, 2017; pp. 235–251. ISBN 978-3-319-32351-0.
- Resnik, D.B.; Elliott, K.C. The Ethical Challenges of Socially Responsible Science. *Account. Res.* **2016**, *23*, 31–46. [CrossRef]
- Scholz, R.W.; Steiner, G. The real type and ideal type of transdisciplinary processes: Part I—Theoretical foundations. *Sustain. Sci.* **2015**, *10*, 527–544. [CrossRef]
- Klein, T.J.; Grossenbacher-Mansuy, W.; Häberli, R.; Bill, A.; Scholz, R.W.; Welti, M. (Eds.) *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society. An Effective Way for Managing Complexity*; Klein, T.J.; Grossenbacher-Mansuy, W.; Häberli, R.; Bill, A.; Scholz, R.W.; Welti, M. (Eds.) Springer Basel AG: Basel, Switzerland, 2001; ISBN 978-3-0348-8419-8.
- Merck, J.; Beermann, M. Wissensintegration auf Augenhöhe—Die Bedeutung praxisnaher, transdisziplinärer Lehre im Kontext nachhaltigkeitsbezogener Studienfächer. *UmweltWirtschaftsForum* **2014**, *22*, 227–231. [CrossRef]
- Hirsch Hadorn, G.; Hoffmann-Riem, H.; Biber-Klemm, S.; Grossenbacher-Mansuy, W.; Joye, D.; Pohl, C.; Wiesmann, U.; Zemp, E. (Eds.) *Handbook of Transdisciplinary Research*; Springer: Dordrecht, The Netherlands, 2008; ISBN 978-1-4020-6698-6.
- Scholz, R.W. The Mutual Learning Sessions. In *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society: An Effective Way for Managing Complexity*; Klein, T.J., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R.W., Welti, M., Eds.; Springer Basel AG: Basel, Switzerland, 2001; pp. 117–129. ISBN 978-3-0348-8419-8.
- European Commission. Responsible Research & Innovation. Available online: <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation> (accessed on 27 September 2020).
- UNESCO. *UNESCO Roadmap zur Umsetzung des Weltaktionsprogramms “Bildung für nachhaltige Entwicklung”*; UNESCO Publishing: Paris, France, 2014; ISBN 978-3-940785-69-5.
- UNESCO. *Education for Sustainable Development Goals: Learning Objectives*; UNESCO Publishing: Paris, France, 2017.
- UNESCO. Education for Sustainable Development. Available online: <https://en.unesco.org/themes/education-sustainable-development> (accessed on 14 July 2020).
- UN. The 17 Goals. Available online: <https://sdgs.un.org/goals> (accessed on 14 July 2020).
- UNESCO. *Climate Change Education for Sustainable Development*; UNESCO Publishing: Paris, France, 2010; Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000190101> (accessed on 29 September 2020).
- United Nations. *World Youth Report: The Global Situation of Young People*; United Nations: New York, NY, USA, 2003.
- Bentz, J.; O'Brien, K. ART FOR CHANGE: Transformative learning and youth empowerment in a changing climate. *Elem. Sci. Anth.* **2019**, *7*, 1–19. [CrossRef]
- Von Wehrden, H.; Kater-Wettstädt, L.; Schneidewind, U. Fridays for Future aus nachhaltigkeitswissenschaftlicher Perspektive. *GAIA—Ecol. Perspect. Sci. Soc.* **2019**, *28*, 307–309. [CrossRef]
- Fazey, I.; Schöpke, N.; Caniglia, G.; Patterson, J.; Hultman, J.; van Mierlo, B.; Säwe, F.; Wiek, A.; Wittmayer, J.; Aldunce, P.; et al. Ten essentials for action-oriented and second order energy transitions, transformations and climate change research. *Energy Res. Soc. Sci.* **2018**, *40*, 54–70. [CrossRef]
- Park, S.E.; Marshall, N.A.; Jakku, E.; Dowd, A.M.; Howden, S.M.; Mendham, E.; Fleming, A. Informing adaptation responses to climate change through theories of transformation. *Glob. Environ. Chang.* **2012**, *22*, 115–126. [CrossRef]
- WBGU. *World in Transition. A Social Contract for Sustainability*; WBGU: Bowling Green, OH, USA, 2011.
- Chapin, F.S.; Carpenter, S.R.; Kofinas, G.P.; Folke, C.; Abel, N.; Clark, W.C.; Olsson, P.; Smith, D.M.S.; Walker, B.; Young, O.R.; et al. Ecosystem stewardship: Sustainability strategies for a rapidly changing planet. *Trends Ecol. Evol.* **2010**, *25*, 241–249. [CrossRef] [PubMed]

29. Stauffacher, M.; Scholz, R.W. ETH-UNS case studies: A university course to develop transdisciplinarity and sustainability learning. *IpUBLIC* **2004**, *7*, 55–63.
30. Pohl, C.; Krütli, P.; Stauffacher, M. Teaching Transdisciplinarity Appropriately for Students' Education Level. *Gaia Ecol. Perspect. Sci. Soc.* **2018**, *27*, 250–252. [CrossRef]
31. Clarke, E.; Ashhorst, C. Making Collective Learning Coherent: An Adaptive Approach to the Practice of Transdisciplinary Pedagogy: The Art of Collaborative Research and Collective Learning. In *Transdisciplinary: Theory, Practice and Education*; Fam, D., Neuhauser, L., Gibbs, P., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 151–165. ISBN 978-3-319-93742-7.
32. Beecroft, R. Das "Transformative Projektseminar"—Didaktische Ansätze und methodische Umsetzung. In *Transdisziplinär und Transformativ Forschen, Band 2*; Defila, R., Di Giulio, A., Eds.; Springer Fachmedien Wiesbaden: Wiesbaden, Germany, 2019; pp. 293–303. ISBN 978-3-658-27134-3.
33. Stauffacher, M.; Walter, A.I.; Lang, D.J.; Wiek, A.; Scholz, R.W. Learning to research environmental problems from a functional socio-cultural constructivism perspective. *Int. J. Sustain. Higher Ed.* **2006**, *7*, 252–275. [CrossRef]
34. Sparkling Science. KiP—Kids Participation in Educational Research. Available online: [https://www.sparklingscience.at/de/projects/show.html?--typo3_neos_nodetypes-page\[id\]=2](https://www.sparklingscience.at/de/projects/show.html?--typo3_neos_nodetypes-page[id]=2) (accessed on 7 August 2020).
35. ENSI. CoDeS—School and Community Collaboration for Sustainable Development. Available online: https://www.ensi.org/Projects/Our_Projects/CoDeS/ (accessed on 15 October 2020).
36. O'Brien, K.; Selboe, E. (Eds.) Social transformation: The real adaptive challenge. In *The Adaptive Challenge of Climate Change*; Cambridge University Press: Cambridge, UK, 2015; pp. 311–324.
37. Stauffacher, M.; Flüeler, T.; Krütli, P.; Scholz, R.W. Analytic and Dynamic Approach to Collaboration: A Transdisciplinary Case Study on Sustainable Landscape Development in a Swiss Prealpine Region. *Syst. Pr. Action Res.* **2008**, *21*, 409–422. [CrossRef]
38. Jenkins, E.W. School science, citizenship and the public understanding of science. *Int. J. Sci. Educ.* **1999**, *21*, 703–710. [CrossRef]
39. Holbrook, J.; Rannikmäe, M. (Eds.) *Supplementary Teaching Materials—Promoting Scientific and Technological Literacy*; ICASE: Tartu, Estonia, 1997.
40. Wiek, A.; Bernstein, M.; Foely, R.; Cohen, M.; Forrest, N.; Kuzdas, C.; Kay, B.; Keeler, L.W. Operationalising competencies in higher education for sustainable development. In *Routledge Handbook of Higher Education for Sustainable Development*; Barth, M., Michelsen, G., Rieckmann, M., Thomas, I., Eds.; Routledge International Handbooks: London, UK, 2015; pp. 241–260. ISBN 9781138597549.
41. Werlen, B. (Ed.) From Local to Global Sustainability: Transdisciplinary Integrated Research in the Digital Age. In *Global Sustainability: Cultural Perspectives and Challenges for Transdisciplinary Integrated Research*; Springer International Publishing: Cham, Switzerland, 2015; ISBN 9783319164762.
42. Bell, D.V.J. Twenty-first Century Education: Transformative Education for Sustainability and Responsible Citizenship. *J. Teach. Educ. Sustain.* **2016**, *18*, 48–56. [CrossRef]
43. Holbrook, J.; Rannikmäe, M. The Nature of Science Education for Enhancing Scientific Literacy. *Int. J. Sci. Educ.* **2007**, *29*, 1347–1362. [CrossRef]
44. Freire, P. *Education for Critical Consciousness*; Continuum: New York, NY, USA, 1981.
45. Freire, P. *Pedagogy of the Oppressed*; The Continuum International Publishing Group Inc: New York, NY, USA, 1970; ISBN 0-8264-1276-9.
46. Dobozy, E.; Dalziel, J. Transdisciplinary Pedagogical Templates and their Potential for Adaptive Reuse. *J. Interact. Media Educ.* **2016**, *8*, 1–11. [CrossRef]
47. Pearce, B.; Adler, C.; Senn, L.; Krütli, P.; Stauffacher, M.; Pohl, C. Making the Link Between Transdisciplinary Learning and Research. In *Transdisciplinary: Theory, Practice and Education the Art of Collaborative Research and Collective Learning*; Fam, D., Neuhauser, L., Gibbs, P., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 167–183. ISBN 978-3-319-93742-7.
48. Illich, I. *Deschooling Society*; Harper & Row: New York, NY, USA, 1970.
49. Anyolo, E.O.; Kärkkäinen, S.; Keinonen, T. Implementing Education for Sustainable Development in Namibia: School Teachers' Perceptions and Teaching Practices. *J. Teach. Educ. Sustain.* **2018**, *20*, 64–81. [CrossRef]
50. UNESCO. *Education for Sustainable Development in Biosphere Reserves and Other Designated Areas. A Resource Book for Educators in South-Eastern Europe and the Mediterranean*; UNESCO Publishing: Paris, France, 2013.
51. Walter, A.I.; Helgenberger, S.; Wiek, A.; Scholz, R.W. Measuring societal effects of transdisciplinary research projects: Design and application of an evaluation method. *Eval. Program Plann.* **2007**, *30*, 325–338. [CrossRef] [PubMed]
52. Duffy, T.M.; Lowyck, J.; Jonassen, D.; Welsh, T.M. *Designing Environments for Constructive Learning*; Springer: Berlin, Germany, 1993; ISBN 978-3-642-78069-1.
53. UNESCO. *Shaping the future we want: UN Decade of Education for Sustainable Development (2005–2014); Final Report*; UNESCO Publishing: Paris, France, 2014.
54. Pedaste, M.; Mäeots, M.; Siiman, L.A.; de Jong, T.; van Riesen, S.A.N.; Kamp, E.T.; Manoli, C.C.; Zacharia, Z.C.; Tsourlidaki, E. Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educ. Res. Rev.* **2015**, *14*, 47–61. [CrossRef]
55. Keller, L.; Stötter, J.; Oberrauch, A.; Kuthe, A.; Körfgen, A.; Hüfner, K. Changing Climate Change Education: Exploring moderate constructivist and transdisciplinary approaches through the research-education co-operation k.i.d.Z.21. *Gaia Ecol. Perspect. Sci. Soc.* **2019**, *28*, 35–43. [CrossRef]
56. Sipos, Y.; Battisti, B.; Grimm, K. Achieving transformative sustainability learning: Engaging head, hands and heart. *Int. J. Sustain. High. Educ.* **2008**, *9*, 68–86. [CrossRef]

57. Lang, D.J.; Wiek, A.; Bergmann, M.; Stauffacher, M.; Martens, P.; Moll, P.; Swilling, M.; Thomas, C.J. Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustain. Sci.* **2012**, *7*, 25–43. [\[CrossRef\]](#)
58. Iyer-Raniga, U.; Andamon, M.M. Transformative learning: Innovating sustainability education in built environment. *Int. J. Sustain. High. Educ.* **2016**, *17*, 105–122. [\[CrossRef\]](#)
59. Laros, A.; Fuhr, T.; Taylor, E.W. (Eds.) *Transformative Learning Meets Bildung. An International Exchange*; SensePublisher: Rotterdam, The Netherlands, 2017; ISBN 978-94-6300-797-9.
60. ProClim. Forschung zu Nachhaltigkeit und Globalem Wandel—Wissenschaftspolitische Visionen der Schweizer Forschenden. 1997. Available online: <http://www.proclim.unibe.ch/visions.html> (accessed on 30 July 2020).
61. Pohl, C.; Hirsch Hadorn, G. *Gestaltungsprinzipien für die Transdisziplinäre Forschung. Ein Beitrag des td-net*; oekom Verlag: München, Germany, 2016; ISBN 978-3865810007.
62. Piaget, J. The epistemology of interdisciplinary relationships. In *Interdisciplinarity: Problems of Teaching and Research in Universities*; Apostel, L., Berger, G., Briggs, A., Michaud, G., Eds.; OECD Publications Center: Paris, France, 1972; pp. 127–139.
63. Nicolescu, B. *From Modernity to Cosmodernity*; State University of New York Press: New York, NY, USA, 2014; ISBN 9781438449647.
64. Nicolescu, B. *Manifesto of Transdisciplinarity*; State University of New York Press: New York, NY, USA, 2002; ISBN 9780791452622.
65. Jantsch, E. Towards interdisciplinarity and transdisciplinarity in education and innovation. In *Interdisciplinarity: Problems of Teaching and Research in Universities*; Apostel, L., Berger, G., Briggs, A., Michaud, G., Eds.; University of Nice: Nice, France, 1972; pp. 97–121.
66. Jantsch, E. Inter- and Transdisciplinary University: A systems approach to education and innovation. *Policy Sci.* **1970**, *1*, 403–428. [\[CrossRef\]](#)
67. Scholz, R.W.; Steiner, G. The real type and ideal type of transdisciplinary processes: Part II—What constraints and obstacles do we meet in practice? *Sustain. Sci.* **2015**, *10*, 653–671. [\[CrossRef\]](#)
68. Gibbons, M.; Limoges, C.; Nowotny, H. *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*; Sage Publications Ltd.: London, UK, 1994; ISBN 978-0803977945.
69. Renn, O. Geleitwort. In *Transdisziplinär und Transformativ Forschen, Band 2*; Defila, R., Di Giulio, A., Eds.; Springer Fachmedien Wiesbaden: Wiesbaden, Germany, 2019; ISBN 978-3-658-27134-3.
70. Defila, R.; Di Giulio, A. (Eds.) *Transdisziplinär und Transformativ Forschen, Band 2*; Springer Fachmedien Wiesbaden: Wiesbaden, Germany, 2019; ISBN 978-3-658-27134-3.
71. Krütli, P.; Stauffacher, M.; Flüeler, T.; Scholz, R.W. Functional-dynamic public participation in technological decision-making: Site selection processes of nuclear waste repositories. *J. Risk Res.* **2010**, *13*, 861–875. [\[CrossRef\]](#)
72. Shaw, C.; Brady, L.M.; Davey, C. Guidelines for Research with Children and Young People; 2011. Available online: <https://www.nfer.ac.uk/pdf/NCBguidelines.pdf> (accessed on 10 October 2016).
73. Schneider, R.M.; Wildt, J. Forschendes Lernen und Kompetenzentwicklung. In *Forschendes Lernen im Studium. Aktuelle Konzepte und Erfahrungen*; Huber, L., Hellmer, J., Schneider, F., Eds.; Universitäts-Verlag: Bielefeld, Germany, 2009; pp. 53–68.
74. Garzotto, F.; Gonella, R. Children’s Co-design and Inclusive Education. In Proceedings of the 10th International Conference on Interaction Design and Children, Ann Arbor, MI, USA, 20–23 June 2011.
75. Moser, S.C. Can science on transformation transform science? Lessons from co-design. *Curr. Opin. Environ. Sustain.* **2016**, *20*, 106–115. [\[CrossRef\]](#)
76. ICSU. Earth System Science for Global Sustainability the Grand Challenges. 2010. Available online: <https://council.science/publications/earth-system-science-for-global-sustainability-the-grand-challenges/> (accessed on 30 September 2020).
77. Stötter, J.; Keller, L.; Lütke-Spatz, L.; Oberrauch, A.; Körfggen, A.; Kuthe, A. Kompetent in die Zukunft: Die Forschungs-Bildungs-Kooperation zur Klimawandelbildung k.i.d.Z.21 und k.i.d.Z.21-Austria. *Gaia Ecol. Perspect. Sci. Soc.* **2016**, *25*, 214–216. [\[CrossRef\]](#)
78. Oberrauch, A.; Keller, L.; Riede, M.; Mark, S.; Kuthe, A.; Körfggen, A.; Stötter, H. “k.i.d.Z.21—Kompetent in die Zukunft”—Grundlagen und Konzept einer Forschungs-Bildungs-Kooperation zur Bewältigung der Herausforderungen des Klimawandels im 21. Jahrhundert. *Jhd. GW Unterr.* **2015**, *139*, 19–31.
79. Körfggen, A.; Keller, L.; Kuthe, A.; Oberrauch, A.; Stötter, J. (Climate) Change in young people’s minds—From categories towards interconnections between the anthroposphere and natural sphere. *Sci. Total Environ.* **2017**, *580*, 178–187. [\[CrossRef\]](#)
80. Tynjälä, P. Towards expert knowledge? A comparison between a constructivist and a traditional learning environment in the university. *Int. J. Educ. Res.* **1999**, 357–442. [\[CrossRef\]](#)
81. Pruneau, D.; Gravel, H.; Bourque, W.; Langis, J. Experimentation with a socio-constructivist process for climate change education. *Environ. Educ. Res.* **2003**, *9*, 429–446. [\[CrossRef\]](#)
82. Sinatra, G.M.; Kienhues, D.; Hofer, B.K. Addressing Challenges to Public Understanding of Science: Epistemic Cognition, Motivated Reasoning, and Conceptual Change. *Educ. Psychol.* **2014**, *49*, 123–138. [\[CrossRef\]](#)
83. Kuthe, A.; Keller, L.; Körfggen, A.; Stötter, J.; Oberrauch, A.; Höferl, K.-M. How many young generations are there?—A typology of teenagers’ climate change awareness in Germany and Austria. *J. Environ. Educ.* **2019**, *50*, 172–182. [\[CrossRef\]](#)
84. Parth, S.; Schickl, M.; Keller, L.; Stötter, J. Quality Child–Parent Relationships and Their Impact on Intergenerational Learning and Multiplier Effects in Climate Change Education. Are We Bridging the Knowledge–Action Gap? *Sustainability* **2020**, *12*, 7030. [\[CrossRef\]](#)

85. Deisenrieder, V.; Kubisch, S.; Keller, L.; Stötter, J. Bridging the Action Gap by Democratizing Climate Change Education—The Case of k.i.d.Z.21 in the Context of Fridays for Future. *Sustainability* **2020**, *12*, 1748. [\[CrossRef\]](#)
86. Buhren, C.G.; Rolff, H.-G. *Handbuch Schulentwicklung und Schulentwicklungsberatung*; Beltz: Weinheim, Germany; Basel, Switzerland, 2012; ISBN 978-3-407-83176-7.
87. Mauser, W.; Klepper, G.; Rice, M.; Schmalzbauer, B.S.; Hackmann, H.; Leemans, R.; Moore, H. Transdisciplinary global change research: The co-creation of knowledge for sustainability. *Curr. Opin. Environ. Sustain.* **2013**, *5*, 420–431. [\[CrossRef\]](#)
88. Mulcahy, D.; Cleveland, B.; Aberton, H. Learning spaces and pedagogic change: Envisioned, enacted and experienced. *Pedagog. Cult. Soc.* **2015**, *23*, 575–595. [\[CrossRef\]](#)
89. Kaplan, A.M.; Haenlein, M. Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Bus. Horiz.* **2016**, *4*, 441–450. [\[CrossRef\]](#)
90. Klein, T.J. Learning in Transdisciplinary Collaborations: A Conceptual Vocabulary. In *Transdisciplinary: Theory, Practice and Education the Art of Collaborative Research and Collective Learning*; Fam, D., Neuhauser, L., Gibbs, P., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 11–23. ISBN 978-3-319-93742-7.
91. Wamsler, C. Stakeholder involvement in strategic adaptation planning: Transdisciplinarity and co-production at stake? *Environ. Sci. Policy* **2017**, *75*, 148–157. [\[CrossRef\]](#)
92. Hofstein, A.; Lunetta, V.N. The laboratory in science education: Foundations for the twenty-first century. *Sci. Educ.* **2004**, *88*, 28–54. [\[CrossRef\]](#)
93. De Miranda, M.A. The Grounding of a Discipline: Cognition and Instruction in Technology Education. *Int. J. Technol. Des. Educ.* **2004**, 61–77. [\[CrossRef\]](#)
94. Bertschy, F.; Künzli, C.; Lehmann, M. Teachers' Competencies for the Implementation of Educational Offers in the Field of Education for Sustainable Development. *Sustainability* **2013**, *5*, 5067–5080. [\[CrossRef\]](#)
95. Barth, M. Kompetenzentwicklung angehender Sachunterrichtslehrkräfte zwischen disziplinärer Verortung und interdisziplinärer Herausforderung: Einlassungen aus der Sicht der Bildung für nachhaltige Entwicklung. *Beiträge Zur Lehr. Und Lehr.* **2016**, *34*, 294–304.
96. Künzli David, C.; Gysin, S.; Bertschy, F. Inter- und transdisziplinär konstituierter Sachunterricht—Theoretisch-konzeptionelle Überlegungen. In *Alles eine Frage der Sache—NMG-Unterricht Kompetent Planen. Theoretisch-Konzeptionelle Überlegungen und Studienmaterialien für die Lehrerinnen- und Lehrerbildung*; Bertschy, F., Gysin, S., Künzli, D.C., Eds.; FHNW: Basel, Switzerland, 2016; pp. 1–23.
97. Sleurs, W. Competencies for ESD (Education for Sustainable Development) teachers. A framework to integrate ESD in the curriculum of teacher training institutes. Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj9sLOThbtAhXK0qQKHQTBA-4QFjAAegQIBhAC&url=https%3A%2F%2Fwww.unece.org%2Ffileadmin%2FDAM%2Fenv%2Fesd%2Ffinf.meeting.docs%2FEGonInd%2F8mtg%2FCSCST%2520Handbook_Extract.pdf&usq=AOvVaw3RU4MQDyYgOX8D4d1BDjdW (accessed on 30 December 2020).
98. Germ, A. Transdisziplinärer Geographieunterricht—Diskussion und erste Anregungen. *GEOGRAZ* **2018**, *62*, 8–13.
99. Künzli David, C.; Gysin, S.; Bertschy, F. Sachunterricht als inter- und transdisziplinär konstituiertes Fach.—Ansprüche an die Unterrichtsgestaltung und Überlegungen im Hinblick auf die Lehrerinnen- und Lehrerbildung. *Beiträge Zur Lehr. Und Lehr.* **2016**, *34*, 305–316.
100. Kleihauer, S.; Führ, M. Herausforderung transdisziplinäre Lehre: Aufbau des praxisorientierten Master-Studiengangs RASUM an der Hochschule Darmstadt. In *Nachhaltigkeit in der Lehre*; Leal Filho, W., Ed.; Springer: Berlin/Heidelberg, Germany, 2018; pp. 449–468. ISBN 978-3-662-56385-4.
101. Jensen, B.B.; Schnack, K. The Action Competence Approach in Environmental Education. *Environ. Educ. Res.* **1997**, *3*, 163–178. [\[CrossRef\]](#)
102. Jensen, B.B. Knowledge, Action and Pro-environmental Behaviour. *Environ. Educ. Res.* **2002**, *8*, 325–334. [\[CrossRef\]](#)
103. Hanschitz, R.-C.; Schmidt, E.; Schwarz, G. *Transdisziplinarität in Forschung und Praxis. Chancen und Risiken partizipativer Prozesse*; VS Verlag für Sozialwissenschaften: Wiesbaden, Germany, 2009; ISBN 978-3-531-16029-0.
104. Chawla, L.; Cushing Flanders, D. Education for strategic environmental behavior. *Environ. Educ. Res.* **2007**, *13*, 437–452. [\[CrossRef\]](#)
105. Ernst, J.; Blood, N.; Beery, T. Environmental action and student environmental leaders: Exploring the influence of environmental attitudes, locus of control, and sense of personal responsibility. *Environ. Educ. Res.* **2017**, *23*, 149–175. [\[CrossRef\]](#)
106. Golja, T.; McClean, S.; Jordan, K. Collective Learning in an Industry-Education-Research Test Bed. In *Transdisciplinary: Theory, Practice and Education the Art of Collaborative Research and Collective Learning*; Fam, D., Neuhauser, L., Gibbs, P., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 185–199. ISBN 978-3-319-93742-7.
107. Darnhofer, I.; Auer, I.; Eckmüllner, O.; Gaube, V.; Kirchengast, A.; Loibl, W.; Pröbstl, U.; Prutsch, A.; Seebacher, U.; Vospernik, S.; et al. Forschungs-Bildungs-Kooperation—Erste Erfahrungen aus Transdisziplinärer Forschung mit Kindern und Jugendlichen. *Intern. J. Sustain. Commun.* **2008**, *2*, 45–59.
108. Labaree, D.F.; Labaree, D.F. The Peculiar Problems of Preparing Educational Researchers. *Educ. Res.* **2003**, *32*, 13–22. [\[CrossRef\]](#)
109. Schwarzl, I. Klimaforschung mit Schulen: Zwei Projekte an der Schnittstelle Wissenschaft und Bildung aus Sicht einer Naturwissenschaftlerin. In *Gemeinsam Forschen—Gemeinsam Lernen*; Radits, F., Rauch, F., Kattmann, U., Eds.; StudienVerlag: Innsbruck, Austria, 2005; pp. 277–305.