

Article

Could Education for Sustainable Development Benefit from a Systems Thinking Approach?

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Abstract: Sustainable development is not a novel concept. However, we continue with our unsustainable way of living. It is as though we cannot see our own part in the unsustainable system. Values, ethics and morals are connected to education and therefore education is in a key position to change the way we think and act for a sustainable future. Both education for sustainable development (ESD) and systems thinking are concepts connected to changes toward a sustainable future. However, they have proven to be conceptually problematic and are characterized by their complexity, making implementation more difficult. The purpose of this study is to discover whether it could be possible to interlace ESD and systems education to a strong and solid entirety in order to overcome the obstacles preventing the implementation of sustainability in education. This is done through a literature review in the fields of systems thinking and ESD. The literature review identifies two joint approaches that could be worth exploring more in order to develop an excellent instrument in the educational work toward sustainability.

Keywords: education for sustainable development; sustainability; systems thinking; teacher education; systems education

1. Introduction and Background

The concept of sustainable development is not a novelty. One of the founders of the Worldwatch Institute, Lester Brown, coined the concept of sustainable development through his book “Building a Sustainable Society” [1], published in 1981. The concept of sustainable development became more widely known in 1987 through the so-called Brundtland Report.

The Brundtland Report [2] in the 1980s also stated that the unsustainable problems society was facing then (and in many ways is facing still) consisted of two different types of problems; on the one hand, poverty, hunger, illiteracy, homelessness and increasing income gaps, and on the other hand, deforestation, the development of desert landscapes, acid rain, global warming and pollution. Nowadays, these problems are linked to and defined as the social and ecological dimensions of sustainable development. Additionally, it is now quite obvious that these dimensions or problems are interlinked. For example, deforestation, the development of deserts and climate change cause something called climate refugees and increase poverty.

In the 21st century, sustainability has become something of a buzzword used in varying contexts [3]. It is now commonly accepted by the scientific community that the concept of sustainable development consists of four commonly defined dimensions, i.e., the economic, social, ecological, and social dimensions. To make the concept of sustainable development even more complex, the four dimensions also include several different aspects and dimensions which are complexly interrelated [4]. If we go back a few decades in history, to the late 1980s and early 1990s when sustainable development became more widely known, there were also some ideas presented on how to achieve a sustainable development. For example, in the United Nation’s document “Agenda 21”, published in 1992,

education was mentioned as a key to achieving sustainable development and the concept “education for sustainable development” (ESD) became common in educational policy documents [4].

Many scientists are, however, critical of the use of the words “for” and “development” in the ESD concept, as they are considered to be normative. A new concept has subsequently become an alternative, named “sustainability education” [5,6]. The difficulty to find a common definition or agree on the name of the concept is one thing, but there is also no common consensus regarding the educational content of ESD, and this is probably one of the main reasons why it has been shown to be hard to implement in education [7]. A cold fact is that our planet Earth is still suffering, even after sustainable development became a common concept more than 30 years ago. It suffers from air pollution, biodiversity loss, deforestation and other problems [4] due to our continued unsustainable way of living [4]. Alarming global human issues today include overpopulation, access to water and sanitation and unequal distribution of food. One of the major environmental threats is climate change [4], which is interconnected with consumption [8] and thus a part of the unsustainable system. A Finnish research report [9] indicates that the Saami people, an arctic indigenous population, are particularly vulnerable to the effects of climate change. In a press release one of the researchers state that this is an ethical dilemma, as the Saami are one of the population groups living in interaction with nature and who probably bear less responsibility to climate change; however, the group will probably suffer most from the negative effects. To reunite man with the meaning of life, there is a need to change the prevailing mindset and change the relation to nature existing today toward living in interaction with nature as indigenous people often do [10].

But how can the mindset of humans be changed? Now, consumerism is the main focus of societies all over the world [11,12]. Consumerism is glorified as a requirement to achieving happiness, and according to the popular economic view, development and happiness are dependent on economic growth [13]. The common way to talk about prosperity is to identify prosperity with consumption and wealth. However, studies across countries show that increases in income per capita and levels of happiness are not correlating to any great extent [13,14]. In fact, research indicates that our consumerism is driving us in the opposite direction instead, toward illness and alienation from the social relations that increase our wellbeing [13]. It appears that values other than economics, for example living *with* (social relations) and *for* other people (doing things for others), are more important to human wellbeing [15]. This is an indication that our unsustainable lifestyles and consumption do not even give us the benefits we think they do and calls for a new way of thinking.

Changing the way we think is something that the United Nations Educational, Scientific and cultural organization (UNESCO) also touches upon in a more recent policy document, where education is highlighted as a key for transforming whole societies toward sustainable development in their Global Action Program on Education for Sustainable Development—Future Forward [16]:

“Sustainable development can be achieved but technological solutions, political regulations or financial instruments are not enough. Long-term sustainable development can be achieved only if individuals and societies change the way they think and act. Education is key to achieving this transformation.” [16]

Education is put in a key position to change people’s way of thinking and acting, but there is no deeper discussion about how education is supposed to manage this change other than by building networks of key stakeholders. To develop new perspectives in education, a holistic understanding of the sustainability phenomenon is necessary [17]. To change the unsustainable way of living, Koger and Winter [18] propose an action-oriented environmental education for youths to develop confidence, self-esteem, critical thinking and problem-solving skills.

One of the current problems within the system today is how people react when facing environmental problems and environmental concerns. According to Koger and Winter [18], a common psychological reaction is denial, which is just one of a lot of defense mechanisms that humans have developed to continue to harm the nature and environment, even though we know it is wrong and that

our actions will have bad consequences [18]. Apathy is also a defense mechanism that people have developed to continue with habits that affect the nature and environment in bad ways [18]. Almers [19] points at the importance of teachers' knowledge and behavior to prevent this form of paralysis when teaching about the effects and consequences of actions. She argues that to be able to develop an ability to make conscious choices, students need to have the opportunity to reflect on their own attitudes and actions in various issues.

Koger and Winters's [18] idea about an action-oriented environmental education relates to a great extent to Almers' [19] idea about learning and action competence, as she claims that the feeling of contribution through actions is important for students to develop confidence. She presents four aspects of teaching that are important to raise in every learning situation:

- What (descriptions of the effects and consequences of the problem)
- How (option on change and action strategies)
- Why (perspective on structural reasons)
- Where (goals and alternative solutions)

These four aspects are also to be found within systems thinking and systems education. Additionally, Salite et al. [20] highlight the action research approach and systemic collective thinking as possible contributors to the development of continuing education and reorientation toward sustainable development.

Critical thinking, problem-solving skills and action are often mentioned in literature from both the research field in systems thinking [21–26] and the research field in sustainable development [4,19,27–29]. Development of a critical approach is often mentioned within both research fields. In addition, systems education is highlighted as a possible solution to societal problems in the book "Systems Education for a Sustainable Planet" [30]:

"Systems education can help transition towards a sustainable planet, as it helps people appreciate that individual actions are not isolated events but contribute to an interconnected system that determines both the well-being of humans and the planet" [30] (p. 1)

Although systems education is crystallized as a possible pathway working toward sustainability, recent research [27] shows that Nordic student teachers possess low levels of systems thinking, indicating that the teacher education in the Nordic countries does not help student teachers to develop systems thinking. This is a remarkable issue as systems education requires systems thinking. Wolff et al. [4] also argue that the Finnish teacher education fails in sustainability. If the teacher education both ignores sustainability and does not manage to develop systems thinking within the student teachers, then systems education is far out in the shadows and could be very hard to establish within the present system of teacher education. As Fedosejeva et al. [17] state: the new generation growing up now has a completely different perception of the world than earlier generations. This calls for a complete re-organization of the study environment to develop the abilities and skills needed to live in and manage a culture that is different and unknown [17]. A re-organization of teacher education is crucial to re-organizing the study environment.

Perhaps systems thinking and systems education could be the missing tools needed to develop the holistic thinking required in the work toward a sustainable future. If that is the case, the big question is if and how it is possible to interlace ESD and systems education to a strong and solid entirety to overcome the obstacles preventing the implementation of sustainability at all levels of education.

This article will propose answers to this question through a literature review and research in the fields of systems thinking, systems education and ESD. The aim is to achieve a better understanding of the concept of systems education and to possibly advocate a change in the current way of trying to implement ESD at all levels of education.

2. The Characteristics of Systems Thinking and Systems Education

As systems thinking and sustainability are so closely linked, it is not practical to focus on them separately [23,26,30,31]. The basic idea in systems thinking is that the world is a complex system where everything is interconnected in the form of systems with interrelated parts [32]. According to Checkland [33], systems thinking is thinking in a holistic way, requiring that what the thinker perceives to be the whole might in fact be seen as a part of an even larger whole. Systems thinking is justified by the fact that any whole is built up by smaller wholes that exist only in relation to the complete whole [33].

Meadows and Wright [34] argue that the industrial world societies need to realize that systems thinking is not the key to prediction and control. The world is built up by complex systems and these systems are not controllable, even with the help of computers and logical data calculations. In other words, the systems can be understood in a very general way. This is because systems are inherently unpredictable. Instead, the ability to utilize the tools of systems thinking opens a world of possibilities to design and re-design systems. People must stop trying to predict and control the systems and instead learn how to dance with the systems, if we are going to find a sustainable relationship to each other and to nature.

“Systemic thinking is a mode of thinking that keeps people in touch with the wholeness of our existence” [35] (p. 282). This is a wide definition of systemic thinking or systems thinking, embracing also a spiritual level of the concept. According to Plate [36] and Monat and Gannon [37], there are a lot of well-educated members of society who have not developed the abilities and skills needed to understand complex systems. Sonnleitner, et al. [38] argue that a deep change in the educational system is necessary to enable the development of knowledge in complex systems and their systemic connections, which is crucial knowledge for a sustainable society. Additionally, Puk and Stibbards [39] highlight the importance of developing a comprehensive understanding of complex causal relationships, like the relations between natural systems and human systems might be. To develop this kind of understanding of the relation between nature and human, it is important for students to first develop an understanding of key ecological concepts. Such key concepts are the base for more complex concepts, which form the base for understanding complex relationships.

A UNESCO statement from 2005 stresses the importance as well as the problem with education: “We are faced with a paradox: Is education the problem or the solution in working toward a sustainable future? At current levels of unsustainable practice and over consumption, it could be concluded that education is part of the problem. If education is the solution, then it requires a deeper critique and a broader vision for the future.” [40] (p. 59)

This statement from UNESCO calls for rethinking within the educational system. Cook [41] argues that education, as a knowledge builder at the frontier, needs continual renewal and the purpose of education must continually be redefined in learning for an unknown future. Learners must develop the capacity for realizing alternative futures. A diversity of abilities, skills, beliefs and ideas among members of society will be crucial for handling the future. To research this idea, a research project in Sydney, Australia [25] was constructed as a trans-disciplinary research project, with participating students from different disciplines and different universities working together. The project was designed to overcome the narrow boundaries characteristic for disciplines enforced through problem-based learning with a systems thinking framework using Action Research as a methodology. The researchers state that the project created “some very successful spaces for creative student engagement, which promoted deep learning and sophisticated intellectual interactions in the sustainability sphere” [25] (p. 136).

Cavana and Forgie [30], who have reviewed a series of articles within the realm of systems education and systems thinking, point out that the above-mentioned project might be the best way presented so far to teach “systems education for a sustainable planet”, as Gray et al. [25] suggest in “teams”. The main idea with “teams” is that if every team member is taught and understands the same shared and common “systems language, structure and methods”, every team member can contribute

with their strengths from various areas in working together toward shared values and objectives. If students/scientists are educated to reach the same level of “systems understanding”, then scientists from different disciplines can come together, working to develop intricate models. One student cannot be expected to be an expert in all areas, but they can value their strengths and limitations working in teams with the same level of “systems understanding” to solve transdisciplinary problems [30]. “One of the reasons for using systems thinking to approach sustainability is because systems thinking is an appropriate education approach to complex problems and could provide a kind of common language for students from different disciplines” [21] (p. 3). Throughout the last decade, there have been several researchers arguing for an education with possibilities to enunciate an aim at a meta-level, advocating a kind of learning that raises awareness of social, individual, economic and environmental perspectives in a societal development [42–45]. The reasoning around systems education in this article coincides well with this demand for change in education.

These are important findings in the work ahead, as both ESD and systems thinking appear to be quite wide in their definitions and turn out to be conceptually problematic [30,37]. The intricate nature and wide definitions result in an obstacle for implementation [4].

Stave and Hopper [46] have, through a review of systems thinking literature, noted that there are seven systems thinking components that researchers seem to agree on. Moreover, Monat and Gannon [37] found through a review of key literature in systems thinking that many of the sources in systems repeat common themes. The components that Stave and Hopper [46] identify are:

- Recognizing interconnections
- Identifying feedback
- Understanding dynamic behavior
- Differentiating types of flows and variables
- Using conceptual models
- Creating simulation models
- Testing policies

The themes Monat and Gannon [37] found as common themes from their literature review and that can be directly connected to the components identified by Stave and Hopper [46] are: (1) systems thinking focused on relationships among systems components (connected to recognizing interconnections), (2) the dynamic nature of systems (connected to understanding dynamic behavior), (3) feedback mechanisms and feedback loops (connected to identifying feedback), (4) system dynamics/computer modeling (connected to creating simulation models), and (5) stock and flow diagrams as tools (can be connected to differentiating types of flows and variables). Instead of the component “testing policies”, Monat and Gannon [37] found systemic root causes analysis as a very useful tool in systems thinking, which is a tool that deserves to be highlighted in this context.

If these components and common themes could form a base for “systems understanding”, it would be crucial for ESD to adapt to these components and assimilate the idea of educating for the same level of “systems understanding”. This would overcome the obstacles that often seem to hinder the implementation of ESD today. Examples such as teachers’ lack of expertise, the intricate nature of sustainability and the interdisciplinary nature of sustainability are all found to be obstacles [4], but could be addressed through this way of thinking and working together in teams, as Gray et al. [25] propose.

If researchers could reconcile on these three points: (1) the seven components of systems thinking that Stave and Hopper [46] highlight, (2) adaptation of the thought about educating students for the same level of systems understanding and finally (3) highlight of the benefits of working in teams, it would make it easier to rethink and redesign curriculums and implement systems education promoting sustainability at all levels of education.

The next section focuses on obstacles hindering the implementation of the teaching of sustainable development. In particular, teacher education will be discussed as this is a crucial key to changing

teachers' knowledge and abilities. Possible solutions and a likely way forward will be discussed, based on the idea of reconciling ESD and system education.

3. Obstacles Hindering the Implementation of Sustainable Development in Education

"It is clear that systems education, from informal learning to formal educational programs, is at the foundation of the key leverages to develop new ways of more holistic thinking to ensure systemic decision and policymaking" [21] (p. 3.).

As sustainability education is characterized by a holistic approach [47], and research [47–49] indicates that school teachers in both Finland and Sweden are not able to adapt a holistic view of education for sustainability, due to their own lack of a holistic understanding of sustainable development as a concept [7,49], systems education could be an option to consider. Similar results are found, for example, in Australia [50]. Borg et al. [49], Hofman [7], and Wolff et al. [4] state that there is a problem within teacher education when it is not able to develop the holistic thinking needed for understanding the sustainability concept.

Wolff et al. [4] recently published an article, titled "High Performance Education Fails in Sustainability?—A Reflection on Finnish Primary Teacher Education", where teacher education in the Nordic countries, and especially in Finland, is discussed. The authors point out that it is not enough to raise and write about sustainability and education in various policy documents, since there will be no change if student teachers do not receive training in sustainability education. Through their research, Wolff et al. [4] found five issues why an exceptionally good education according to the PISA (The Programme for International Student Assessment of OECD) results does not successfully integrate sustainability into the education. The obstacles are probably similar in other countries around the world that are trying to implement sustainability education in the curriculums and teacher education. It is of great importance that universities take the responsibility to promote an ESD policy; a renewed elementary school curriculum is not enough if teachers do not know how to teach about sustainability or systems thinking.

The five identified obstacles for implementing sustainability in teacher education in Finland are [4]: (1) sustainability is in conflict with overall trends in society and politics, (2) teacher education takes place at universities, (3) teacher education is based on separate academic disciplines, (4) sustainability is intricate because it is strongly connected to ecological literacy and (5) it is value-dependent. It is obvious that several of these mentioned obstacles consist of characteristics that are not only discussed in research around ESD; some of the obstacles are touched upon and can be drawn from discussions about systems education as well. Especially the last three obstacles have connections with systems education. The obstacles will be briefly addressed in a couple of separate paragraphs below.

3.1. Societal Trends and Teacher Education Take Place at Universities

Economic values and consumerism have developed to become a paradigm of our time, while world politics, first and foremost, focuses on economic growth [11–13]. The reason for our overconsumption and unsustainable way of life is not only to be found at the individual level [4]. During the past few years, policies and economies have, through joint efforts, created a growing demand for goods [4]. In Finland, education is market-oriented and has become a consumer good; education is set as a tool to achieve economic success in the world market [4]. The universities in Finland have also adapted to this market-oriented thinking and share the same values as the business sector [4]. In this market-oriented kind of education, certain kinds of knowledge are valued higher than others [31]. The education focuses on core knowledge and tests to compete with each other instead of an education that evolves values and moral responsibility [31]. Teaching student teachers about sustainability is also in conflict with this market-oriented agenda [4]. Systems thinking could be an approach that addresses these problems and makes humans more conscious about how politics, economics and consumption patterns affect our society and different systems within it.

3.2. *Separate Academic Disciplines*

Unfortunately, universities often have a very conservative approach with strong subject orientation, where interdisciplinary research is still seen as challenging [4]. As such, sustainability is very hard to implement in higher education because of its interdisciplinary nature. For example, teacher education in Finland is based on separate academic disciplines and a traditional school curriculum [4], which is problematic regarding the importance of a holistic understanding of sustainability to develop new perspectives in education [17]. Christie et al. [51] argue that the slow implementation of sustainability in higher education is due to both the complexity of sustainability and epistemological differences between disciplines. An interdisciplinary meta-knowledge for solving sustainability problems is asked for [52]. Wolff et al. [4] argue that it is crucial that institutions offering teacher education regard sustainability as an important topic, but they also note that it is not enough for these kinds of educational institutions to write about sustainability in their policy documents and strategies. They call for a transdisciplinary implementation in teacher education involving both teachers, university leaders and students from different disciplines.

Similar issues are present in the research experiment conducted by Gray et al. [25] solving sustainability issues through problem-based learning with a systems thinking approach and action research as the methodology. Within the research experiment, transdisciplinary issues were solved by working together in teams. Working in teams may also affect the intricate nature of sustainability, for example, if team members from different disciplines come together working within their own strengths, sharing knowledge and information within the team.

Wakeland [53], Ison and Blackmore [22], Salite et al. [20], Gray et al. [25], and Kordova et al. [21] connect systems education with transdisciplinary learning. Wakeland [53] states that systems science is best described as transdisciplinary. Weber [54] also emphasizes the complexity and separate two interlinked dimensions, one with a focus on the planet Earth and the other with a focus on human societies. All of these claims demonstrate the transdisciplinary nature of sustainability and systems thinking offered by Kordova et al. [21] as an adaptable approach toward sustainability, as systems thinking is useful in complex problem-solving.

This reveals the impact an implementation of systems thinking or systems education could have on teacher education. It would require teacher education to transform from an education based on separate academic disciplines to a transdisciplinary education.

3.3. *The Intricate Nature of Sustainability*

The intricate nature of sustainability has already been discussed earlier in this paper. However, the reason why it is found to be that intricate is mainly due to its strong connection to ecological literacy [4,27,55]. During the last 20 years, people's knowledge and understanding of ecological key concepts have decreased [56–59] and a kind of ecological illiteracy has developed [39,60,61]. Puk and Stibbards [39] argue that one of the important things for students to develop during their studies is an understanding of key ecological concepts, so they can learn to understand the complex relation between human systems and systems in nature. The escalating development of ecological illiteracy implies that key ecological concepts are not addressed during elementary school, secondary school or higher education. Apparently, key ecological concepts are not addressed in the Nordic teacher education, either [27,56]. Systems thinking has been raised in this article as an extremely good approach to solving intricate problems through action-based teamwork. For example, Kordova et al. [21] argue that the reason to approach sustainability through systems thinking is because systems thinking is a suitable educational approach to complex problem-solving. Monat and Gannon [37] also highlight the great power of systems thinking in solving complex problems.

This reveals that the intricate nature of sustainability could be seen as less complicated through a development and adaption of systems thinking.

3.4. Value Dependent

As sustainability is a concept involving values [4,23,27,31,62] ethics and morals [4,31,62], it is a demanding topic to teach and is dependent on talented teachers [63]. Teachers do not become talented in these areas without adequate training [4,27]. The already highlighted issue of a market-oriented kind of education that embraces certain kinds of knowledge is also problematic regarding abilities to develop values and morality within students [31]. An ethically conscious teacher education is needed to develop an ethical consciousness within student teachers and to develop their ability regarding ethical deliberation, value discussions and to understand ethical sustainability issues like global equity, fairness and responsibility [4]. Systems thinking and teamwork could be an excellent tool in developing this kind of ethical consciousness.

4. Discussion and Conclusions

As research indicates, an ecological illiteracy has developed during the past few decades. Our planet suffers from overconsumption and an unsustainable way of life. In addition, this unsustainable way of life does not even seem to benefit our wellbeing. It appears obvious that there is something wrong in our system and our way of thinking. UNESCO calls for a change in how we think and act, but how do we manage this change? To enable this change, UNESCO places education in a key position, but so far, the desired results have not been achieved, even though ESD has been on the agenda for more than a decade. Perhaps ESD is not enough; possibly there is something still lacking that is crucial for a change to start.

The similarities in the nature of ESD and systems education are crystallized in this literature review. Some of the articles that have been reviewed agree that the required areas for sustainability are systems thinking, an action approach and teamwork. There are indications that ESD and systems education could benefit from each other. Systems education and ESD could obviously constitute an interlinked common ground for sustainability education throughout the world, instead of being bounded from each other.

This new learning approach with systems thinking linked to ESD could emphasize the development of different levels of systems understanding, such as learning how to work in transdisciplinary teams, teaching basic ecological key concepts and promoting value discussions, deliberation and action competence. It would now be extremely important to conduct more experiments and further research around this potential learning approach, in order to determine whether this is the optimal way to approach education for sustainability. As such, it could thus be stressed as being one of the most important changes to implement as quickly as possible, at all levels of education.

The main focus where change is very crucial is within teacher education. All newly qualified teachers could adapt to this new educational approach, especially as research indicates that the implementation of sustainability and systems thinking in Nordic teacher education has failed. In the work forward towards sustainability, teacher education institutions would need to emphasize both sustainability and systems thinking to a greater extent than now. A complete rethinking of teacher education would be preferable, but that would require a complete reorganization and very devoted leaders of the institutions.

Components that would be crucial to embed in teacher education for the student teachers to achieve a systems thinking knowledge base are listed below. It would be of great importance that all teacher students develop a systems thinking perspective, so the newly qualified teachers can teach systems thinking skills to children for a sustainable future.

- Recognizing interconnections
- Identifying feedback
- Understanding dynamic behavior
- Differentiating types of flows and variables

- Using conceptual models
- Creating simulation models
- Testing policies
- Knowledge about systemic root cause analysis

Beyond this change, teacher education should also adopt an action competence approach and highlight the importance of didactics underpinning the development of student teamwork. This approach enables students to learn from each other, particularly when every team member works from their own strengths in complex problem-solving. However, this kind of change is time-consuming. Adding some compulsory courses on the concepts of sustainability, ecological principles and systems thinking for all teacher students could serve as a stopgap, but in the long run, a reorganization of teacher education institutions toward a systems- and action approach for solving complex sustainability problems would be preferable.

In countries where teacher education institutions are not autonomous, as it is for example in Finland, governments can take action to promote the reorganizations needed for ESD and systems thinking to be implemented in teacher education. However, in countries where the teacher education institutions are autonomous, this kind of reorganization and change is dependent on the university leaders' interest. Finally, some suggestions are provided in the form of a list for facilitation of the recommended changes.

4.1. Governmental Regulated Teacher Education Institutions

- Investigate all teacher education institutions in the country: how is ESD implemented right now?
- Review the curricula of primary schools regarding implementation of ESD.
- Make changes in the laws regulating teacher education and primary schools if found necessary to promote ESD and systems thinking.
- Provide in-service training in both ESD and systems thinking for teachers educators at all teacher education institutions and for teachers in general education.
- Add compulsory courses on the concepts of sustainability, ecological principles and systems thinking for all teacher students.

4.2. Autonomous Teacher Education Institutions

- Even though teacher education institutions might be autonomous, there are often some performance agreements between a country's ministry of education and the institutions providing teacher education. It is here the government that can set higher requirements to promote ESD and systems thinking in teacher education.
- A ministry of education should gather all leaders of teacher education institutions to educate the leaders in systems thinking and ESD issues to awake the leaders' interest in these issues.
- If institution leaders' interest in ESD and systems thinking can be evoked, a total reorganization of teacher education could be possible.
- The components mentioned earlier in this section that would be crucial to embed in teacher education for the student teachers to achieve a systems thinking and ESD knowledge base would be possible to implement in teacher education if the leader of the institution is prepared to work for reorganization.

These suggested action items that could be taken by governments and universities to facilitate the recommended changes are purely general suggestions but they could be quite fruitful. Further research on reorganization of teacher education is needed and this will be the topic of a follow-on paper.

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