

Key Competencies for Sustainable Development: a European-Latin American Perspective

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Abstract

Against the background of global change, Engineering Education for Sustainable Development (EESD) aims at developing key competencies that enable future engineers to contribute to sustainable development. In the last years, different approaches for the definition and selection of key competencies crucial for sustainable development have been developed, e.g. shaping competence, sustainability literacy, and OECD's DeSeCo key competencies. However, it can be stated that in the international debate does not exist an agreement about the most important key competencies and the question of the global relevance and validity of these key competencies is still up for debate.

Given this background, the study asks: Which individual key competencies are crucial for understanding the central challenges of the world society and for shaping it in terms of sustainable development and thus should be fostered through (Engineering) Education for Sustainable Development? The empirical design of the study is related to a Delphi study. In a multi-round questioning procedure key competencies relevant for the research question have been defined by selected ESD experts (both from science and educational practice) from Europe (Germany, UK) and Latin America (Chile, Ecuador, Mexico).

The results of the Delphi study show that twelve key competencies can be distinguished which are crucial for sustainable development and thus should be central objectives of "learning for transformation" in engineering education. Both for experts from Europe and Latin America the most relevant key competencies are systemic thinking, anticipatory thinking and critical thinking. However, European experts attach more importance to empathy and change of perspectives, while Latin-American experts focus particularly on competencies for cooperation and participation.

Introduction

Today, humanity is facing a range of global social, economic, cultural and ecological changes which in the long term threaten the survival of the human species: "For the first time in human history we have the potential to make irreparable changes to the entire global fabric, including [...] climate, water distribution, land use and biodiversity" [1]. The German Scientific Advisory Council on Global Environmental Change (WBGU) describes these worldwide transformations as "Global Change". This reflects the manner in which global environmental change is closely intertwined with economic globalisation, cultural change and a growing North-South divide. According to the WBGU [2], the key problems of global change are particularly climate change, ozone depletion and persistent organic pollutants, loss of biodiversity and deforestation, soil erosion, scarcity and pollution of freshwater, overfishing and pollution of the oceans, threats to food security and world health, and widening gaps in development. Sotoudeh indicates interrelated problems, different interests and needs of those involved and uncertainty as main challenges for "Engineering in Sustainable Development", and, furthermore, she points out the linkage between potential impacts of technologies and global environmental problems [3].

In our time, the interconnectedness of ecosystems, societies and economies is growing quickly and complexity is increasing rapidly. Hence, the trends of global change call for re-shaping relationships,

those between ourselves and those with nature. Because of the global environmental crisis “the development model of the North is historically obsolete” [4]. However, it is also the failure of conventional development strategies to eradicate poverty and overcome inequality that shows the concept of copycat development as no longer useful and suggests the necessity of a new development path. Such a new direction has been seen, since the Rio Earth Summit in 1992, in the ideal of sustainable development, which involves and requires fundamental societal transformations. As sustainable development can be understood as a societal process of communication, learning and transformation [5], it is only if as many people as possible are actively involved that sustainable development can be realised. Consequently, Agenda 21 (chapter 36) points to education and communication as key factors in achieving sustainable development. The United Nations Decade of Education for Sustainable Development (2005-2014), agreed upon by the UN General Assembly in December 2002, can also be seen in this perspective [6] [7] as can the United Nations Economic Commission for Europe Education for Sustainable Development strategy which was accepted in spring 2005 by over 50 countries, from North America to Europe to Central Asia [8].

The fundamental reorientations and transformations in terms of sustainable development require a far-reaching change of consciousness in individuals. This can only be brought about by learning; hence sustainable development has to be understood as a learning process [9]. In order for individuals to be in a position to engage with sustainability-related issues, a change of perspective in education is required, a re-orientation towards “Education for Sustainable Development” (ESD). ESD aims at developing key competencies that enable individuals to contribute to sustainable development [10] [11] [12] [13]. Consequently, the goal of *Engineering Education for Sustainable Development* (EESD) “is to stimulate and enable students for sustainability-oriented engineering practice and agency” [14] and to provide them with competencies which are required in this context. However, it can be asked which key competencies are most relevant for sustainable development and hence should be developed in (Engineering) Education for Sustainable Development.

Theoretical Framework

(Engineering) Education for Sustainable Development

Education is expected both to make people more aware and better qualified to take part in shaping future developments responsibly, and to raise their awareness of the problems related to sustainable development and bring forth innovative contributions to all economic, social, environmental and cultural issues. Given the “development state of the world society” [15], education should enable individuals to reflect on their own actions by taking into account their current and future social and environmental effects – from a global perspective – and to intervene productively in shaping them in a sustainable manner. Individuals should be empowered to act in complex situations which may require the individual to strike out in new directions.

Against this background, Education for Sustainable Development, in general, aims to develop (key) competencies that enable individuals to participate in socio-political processes and hence to move their society towards sustainable development [10] [11] [12] [13]. Engineering Education for Sustainable Development, in particular, “is expected to prepare future engineers to investigate complex issues not only for the optimisation of the present techno-economic systems, but also for the transformation of the socio-technical system to consider short- and long-term environmental, social, and cultural benefits and risks associated with technical solutions” [3]. Vare and Scott argue that instead of promoting certain behaviours and ways of thinking (“ESD 1”), the competence-oriented concept of ESD focuses in particular on both “building capacity to think critically about [and beyond] what experts say and to test sustainable development ideas” and “exploring the contradictions inherent in sustainable living” (“ESD 2”) [9]. This competence orientation is also emphasised by Scheunpflug and Asbrand [15] who contend that the aim of a system-theory based approach of global education is to support learners in developing “adequate competencies for life in a world society”, enabling them to cope with an uncertain future and complexity.

Competencies and Key Competencies

The term “competency” is discussed not only within the work environment or in the context of educational issues, but has also become a concern in personal and societal everyday life. Societal change, the progress of technology and globalisation are accompanied by new challenges which have to be mastered: increasing individualisation and growing societal diversity, accompanied in parallel by expanding economic and cultural uniformity, the availability of a rapidly growing amount of information as well as the necessity to cope with increasing complexity and uncertainties [16]. However, no agreement exists about *what* (key) competencies actually are and *which* are of importance.

In general, competencies may be characterised as dispositions to self-organisation which include cognitive, affective, volitional and motivational elements and are realised in specific contexts. What is needed, therefore, is an interplay of content-specific knowledge and cognitive skills with motivational tendencies, volitional control systems and personal value orientations. Competencies facilitate self-organised action in various complex situations, dependent on the given situation and context. Competencies can be advanced: They are acquired during action – on the basis of experience and reflections [17].

Furthermore, the term *key* competency seems of importance as it represents a qualitative extension that points out the special significance of certain competencies. Key competencies can be understood as transversal, multifunctional and context-overall competencies which are considered to be particularly crucial for implementing societal goals important in a defined normative framework (e.g. sustainability) and which are important for all individuals [18]. They do not replace domain-specific competencies which are necessary for successful action in certain situations and contexts. They rather bear a different, a wider focus, pooling different competency classes and being situated transversely to them; and they comprise different domain-specific competencies and point out the most relevant competency fields.

In order to render this concept relevant in practice, we need not only a defined understanding of the term, but also information about which key competencies are of particular importance. The attempt to compile a comprehensive scheme about all possible and necessary key competencies is bound to fail right from the start since such a list must end in arbitrariness [17].

Sustainable Development as a Normative Framework for Selecting Key Competencies

Sustainable development can be seen as a normative starting point for selecting relevant key competencies. On the international level, the concept of Education for Sustainable Development is – amongst others – shaped by the foundational documents of the UNESCO. Here, the acquisition of life skills is particularly emphasised and focused on. Thus, UNESCO formulated in its “draft international implementation scheme” about the ESD World Decade: “ESD requires a re-examination of educational policy [...] in order to focus clearly on the development of the knowledge, skills, perspectives and values related to sustainability. This [...] requires a review of recommended and mandated approaches to teaching, learning and assessment so that lifelong learning skills are fostered. These include skills for creative and critical thinking, oral and written communication, collaboration and cooperation, conflict management, decision-making, problem-solving and planning, using appropriate ICTs, and practical citizenship” [6]. Moreover, further approaches for the definition and selection of key competencies crucial for sustainable development have been developed, e.g. sustainability literacy [19] [20], sustainability skills [13] [21], and OECD’s DeSeCo key competencies [22]. Concerning “lists of skills, knowledge, and approaches geared toward a sustainable future”, Kastenhofer et al. [14] furthermore mention, among others, the European “Dublin” Descriptors [23] and abilities presented in the “Declaration of Barcelona” [24].

In Germany, developing “Gestaltungskompetenz” (“shaping competence”) [12] has been discussed as the central educational objective of ESD. “Shaping competence” encompasses a set of key competencies which are expected to enable active, reflective and co-operative participation toward

sustainable development. Those who possess this competence can help, through their active participation in society, to modify and shape the future of society, and to guide its social, economic, technological and ecological changes along the lines of sustainable development [12]. According to de Haan [12] [25], “shaping competence” comprises the following key competencies:

- competency in anticipatory thinking
- competency in interdisciplinary work
- competency in cosmopolitan perception and change of perspectives
- competency in handling incomplete and complex information
- participatory competency
- competency in cooperation
- competency in dealing with conflicts of goals
- competency in self-motivation and motivating others
- competency in distanced reflection on individual and cultural models
- competency in independent action
- competency in ethical action
- capacity for empathy and solidarity

Sustainable development necessitates societal modernisation and may only be realised via the active participation of competent citizens; therefore the concept of “shaping competence” is characterised in particular by key competencies that are required for forward-looking and autonomous participation in sustainable development.

Although different approaches for the definition and selection of key competencies which are crucial for sustainable development have been developed, it can be stated that in the international debate does not exist an agreement about the most important key competencies and the question of the global relevance and validity of these key competencies is still up for debate [22]. Thus, there is a need for the selection and definition of the relevant key competencies for sustainable development and the conceptual elaboration of the global perspective of (E)ESD.

Research Question and Objective

Given this background, this paper asks: Which individual key competencies are crucial for understanding the central challenges of the world society and for shaping it in terms of sustainable development and thus should be fostered through (Engineering) Education for Sustainable Development?

Consequently, the research objective is to select and define key competencies which in the North as well as the South are relevant for the participation in shaping the world society in terms of sustainable development and hence should be developed in future-oriented (engineering) education. Given that a central constitutive element of sustainable development is its global orientation [26], with a discourse among ESD experts from countries of the North and the South, a global perspective on key competencies crucial for sustainable development should be facilitated. Against the background of different economic, socio-cultural and political conditions in the North and the South, furthermore it is of importance to analyse which particular key competencies are relevant for different regions of the world. This paper aims to contribute to the conceptual foundation of the global perspective of (Engineering) Education for Sustainable Development, the further development of the (E)ESD competence debate, the North-South dialogue on education in the world society and last but not least, the definition of the learning objectives of future-oriented (engineering) education.

Methodological Approach

The empirical design of the study is related to a Delphi study [27] [28] [29] [30]. It is a multi-round questioning procedure which relies on a panel of experts. The main idea of the Delphi method is that

in each round the experts answer questionnaires, then in the next round get an anonymous summary of the experts' answers from the previous round and are encouraged to revise their earlier answers in light of the replies of other members of their panel. It is believed that during this process the range of the answers will decrease and the quality of the results will be improved. The Delphi method facilitates the solution-oriented analysis of uncertain phenomena by initiating and structuring a process of group communication and is characterised by a consensus-orientation and the prevention of the dominance of one opinion in the group of experts.

In a two-round questioning procedure – using an internet-based questionnaire – key competencies relevant for the research question have been selected and defined by ESD experts (both from science and NGOs, foundations and public authorities) from Germany and Great Britain – as countries from the North – and Chile, Ecuador and Mexico – as countries from the South. The dimensions of the questionnaire were: global problems, understanding of sustainable development, objectives of Education for Sustainable Development, key competencies for sustainable development, and individual possibilities for participating in sustainable development. The study was carried out in English, Spanish and German.

The questionnaire of the first Delphi round contained primarily open questions. The qualitative analysis of the data was carried out based on the coding paradigm of Qualitative Content Analysis developed by Mayring [31]. Subsequently, the categories built in this qualitative data analysis formed the basis for elaborating item batteries used in the second round's questionnaire. This data was analysed statistically with the software SPSS. Frequency analyses as well as reliability and factor analyses were conducted and the mean values of the European and Latin-American experts as well as the rankings of the items for each of these expert groups were compared.

Sample

From September to October 2008, the first, explorative round of the Delphi study was conducted in which 17 experts from the selected countries participated. This means a response rate of 65%.

Table 1. Sample of the first Delphi round.

		Germany	Great Britain	Mexico	Chile	Ecuador
Science	female	1	0	1	0	1
	male	1	2	2	1	0
NGOs/public authorities	female	1	1	1	0	1
	male	3	2	0	0	0
Total		6	5	4	1	2

In the second Delphi round, which was realised between December 2008 and February 2009, 70 experts from the selected countries participated which means a response rate of 36%.

Table 2. Sample of the second Delphi round.

		Germany	Great Britain	Mexico	Chile	Ecuador
Science	female	3	2	11	0	2
	male	8	5	7	3	2
NGOs/foundations	female	4	1	0	1	1
	male	6	1	0	0	0
Public authorities	female	1	0	2	0	1
	male	6	1	0	2	0
Total		24 (34,3%)	11 (15,7%)	23 (32,9%)	6 (8,6%)	6 (8,6%)

Results

As is not possible to present all results of the Delphi study in this paper, only selected results related to objectives of ESD and key competencies for sustainable development are shown in the following sections.

Objectives of Education for Sustainable Development

Data show that Education for Sustainable Development is seen both as a central instrument and a precondition for sustainable development by the experts. All experts name “creating and changing values, attitudes and awareness” and “developing competencies” as the most important objectives of ESD. However, European experts attach relatively more importance to “transferring knowledge and understanding” than their Latin-American colleagues (cf. Table 3).

Table 3. Objectives of Education for Sustainable Development (Question: In your opinion, what are the essential objectives of education for sustainable development?; 10 = I fully agree, 1 = I do not agree at all).

Rank	All Experts	European Experts	Latin-American Experts
1	creating and changing values, attitudes and awareness (9,3)	creating and changing values, attitudes and awareness (8,9)	creating and changing values, attitudes and awareness (9,7)
2	developing competencies (9,1)	transferring knowledge and understanding (8,7)	developing competencies (9,5)
3	more just and sustainable society (9,0)	developing competencies (8,7)	more just and sustainable society (9,5)
4	promoting sustainable behaviour and responsible action (9,0)	more just and sustainable society (8,6)	promoting sustainable behaviour and responsible action (9,4)
5	transferring knowledge and understanding (8,8)	promoting sustainable behaviour and responsible action (8,5)	changing educational institutions (9,2)
6	changing educational institutions (8,7)	empowerment (8,4)	facilitating motivation (9,1)
7	facilitating motivation (8,6)	changing educational institutions (8,3)	transferring knowledge and understanding (9,0)
8	empowerment (8,4)	facilitating motivation (8,2)	empowerment (8,3)
9	imposing pressure upon political actions (7,6)	imposing pressure upon political actions (7,3)	imposing pressure upon political actions (8)

A factor analysis shows that three factors can be distinguished (75,4 % explained variance; reliability analysis: Cronbach’s alpha 0,84, 9 items):

- Factor 1 „*Education: awareness creation and competence development*“: facilitating motivation; developing competencies; changing educational institutions; creating and changing values, attitudes and awareness; transferring knowledge and understanding
- Factor 2 „*Promoting sustainable development*“: imposing pressure upon political actions; promoting sustainable behaviour and responsible action; more just and sustainable society; changing educational institutions
- Factor 3 „*Empowerment*“: empowerment

Thus, direct (individual) and indirect (societal) objectives of Education for Sustainable Development can be differentiated.

Key Competencies for Sustainable Development

The experts involved in the Delphi study select and define 19 key competencies which are critical for sustainable development. In their opinion, the most important key competencies are the competency for systemic thinking and handling of complexity, the competency for anticipatory thinking and the competency for critical thinking (cf. Table 4).

Table 4. Key competencies for sustainable development (Question: In your opinion, which individual key competencies do persons need for understanding global problems of unsustainability and contributing to the shaping of the world society in terms of sustainable development?; 10 = I fully agree, 1 = I do not agree at all).

Rank	All Experts	European Experts	Latin-American Experts
1	Systemic thinking and handling of complexity (9,5)	Systemic thinking and handling of complexity (9,3)	Systemic thinking and handling of complexity (9,7)
2	Anticipatory thinking (9,3)	Anticipatory thinking (9,2)	Cooperation in (heterogeneous) groups (9,6)
3	Critical thinking (9,3)	Critical thinking (9,0)	Participation (9,5)
4	Acting responsibly (9,1)	Empathy and change of perspective (8,9)	Critical thinking (9,5)
5	Recognising and analysing problems of unsustainable development (9,0)	Recognising and analysing problems of unsustainable development (8,7)	Acting responsibly (9,5)
6	Cooperation in (heterogeneous) groups (9,0)	Acting responsibly (8,6)	Anticipatory thinking (9,5)
7	Participation (8,9)	Open-mindedness and disposition to innovations (8,6)	Interdisciplinary work (9,4)
8	Empathy and change of perspective (8,9)	Handling of intercultural relationships (8,5)	Recognising and analysing problems of unsustainable development (9,4)
9	Open-mindedness and disposition to innovations (8,8)	Cooperation in (heterogeneous) groups (8,4)	Understanding of nature (9,3)
10	Interdisciplinary work (8,7)	Participation (8,4)	Recognising one's own role in the global community (9,1)
11	Recognising one's own role in the global community (8,7)	Concern and acting for justice (8,3)	Open-mindedness and disposition to innovations (9,1)
12	Concern and acting for justice (8,6)	Recognising one's own role in the global community (8,2)	Concern and acting for justice (8,9)
13	Handling of intercultural relationships (8,6)	Interdisciplinary work (8,1)	Empathy and change of perspective (8,9)
14	Understanding of nature (8,5)	Evaluation (8,0)	Handling of information (8,8)
15	Handling of information (8,3)	Handling of information (7,9)	Planning and realising projects (8,7)
16	Communication and use of media (8,2)	Understanding of nature (7,8)	Handling of intercultural relationships (8,7)
17	Planning and realising projects (8,1)	Ambiguity and frustration tolerance (7,8)	Communication and use of media (8,7)
18	Evaluation (8,0)	Communication and use of media (7,7)	Evaluation (8)
19	Ambiguity and frustration tolerance (7,5)	Planning and realising projects (7,5)	Ambiguity and frustration tolerance (7,2)

Data show that the experts from Europe and Latin America attach varying degrees of relevance to different key competencies. While the European experts give relatively more importance to the competency for empathy and change of perspective, their Latin-American colleagues indicate a relatively higher relevance for the competencies for cooperation in (heterogeneous) groups and participation.

A factor analysis results in six factors which can be understood as competence categories (77,7 % explained variance; reliability analysis: Cronbach's alpha 0,89, 19 items):

- Factor 1 „*Analysis and responsibility*“: recognising one's own role in the global community; recognising and analysing problems of unsustainable development; understanding of nature; concern and acting for justice; acting responsibly

- Factor 2 „*Management of processes*“: participation; planning and realising projects; handling of information; handling of intercultural relationships
- Factor 3 „*Cooperation and communication*“: interdisciplinary work; communication and use of media; cooperation in (heterogeneous) groups
- Factor 4 „*Handling of differences and conflicts*“: ambiguity and frustration tolerance; evaluation; empathy and change of perspective
- Factor 5 „*Critical reflection on and involvement with the world*“: critical thinking; open-mindedness and disposition to innovations
- Factor 6 „*Handling of complexity and future developments*“: systemic thinking and handling of complexity; anticipatory thinking

In addition to the question *which* key competencies are crucial, the experts were also asked *why* the key competencies indicated by them are important for sustainable development. Their answers show that especially the complexity, uncertainty, risks and the high velocity of societal (global) change are seen as challenges which make necessary and relevant the indicated key competencies.

Conclusion

The impacts of Global Change result in the necessity of a paradigm shift in the global endeavours for development – a re-orientation towards sustainable development. Education for Sustainable Development aims to enable individuals to cope with the challenges of the world society. Only knowledge is not sufficient to be able to act in a global context, individuals also need competencies which include knowledge, skills and capacities as well as motivational, volitive and affective dispositions and which facilitate self-organisation in complex contexts and situations. However, the question is *which* key competencies should be fostered through Education for Sustainable Development.

The data gained in a Delphi study which involved 70 ESD experts from Germany and Great Britain as well as Ecuador, Chile and Mexico show firstly that it is possible to identify key competencies which are important for sustainable development both in the North and the South, and secondly indicate which competencies are of particular importance.

The 19 key competencies selected by the 70 experts can be subsumed in a set of twelve key competencies which include all relevant dispositions and aspects which were identified in the study:

- Competency for systemic thinking and handling of complexity
- Competency for anticipatory thinking
- Competency for critical thinking
- Competency for acting fairly and ecologically
- Competency for cooperation in (heterogeneous) groups
- Competency for participation
- Competency for empathy and change of perspective
- Competency for interdisciplinary work
- Competency for communication and use of media
- Competency for planning and realising innovative projects
- Competency for evaluation
- Competency for ambiguity and frustration tolerance

Both for experts from Europe and Latin America the most relevant key competencies are those for systemic thinking, anticipatory thinking and critical thinking. However, on the one hand the competency for empathy and change of perspective has a relatively higher importance in the opinion of the European experts, and on the other hand, the competencies for cooperation in (heterogeneous) groups and participation have a relatively higher importance in the opinion of the Latin-American experts. These differences correspond with varying focuses in the European and Latin-American

discourses on sustainable development. For instance, participation is a key element of Latin-American approaches to sustainable development [32].

In conclusion, it can be said that this study contributes to further develop and internationalise the ESD competence debate, as it has involved ESD experts from selected European and Latin-American countries in a discourse, and hence goes beyond the often Eurocentric focus of the ESD competence debate and highlights blind spots of existing competence concepts. It reveals the common ground for the selection and definition of sustainability key competencies in a North-South context. Although the Delphi study has not a particular focus on EESD, it contributes also to the discussion about what competencies engineers should develop to be able to address complex global problems by technological means. Additionally, the study has proved the validity of the Delphi method for selecting and defining sustainability-relevant key competencies. Finally, this paper can be understood as a conceptual basis for the elaboration and implementation of (technical) university curricula which are oriented to the acquisition of key competencies critical for sustainable development.

In this paper, the question remains open how the identified key competencies can be developed through (Engineering) Education for Sustainable Development. Barth et al., for instance, analyse processes of developing sustainability key competencies in formal and informal learning settings at universities [10]. Kastenhofer et al. give some hints on different learning modes and learning outputs in EESD [14]. However, further research on how to foster the development of the identified key competencies through (E)ESD is still needed.

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