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Towards meta–competences in higher education for tackling complex real–world problems – a cross disciplinary review

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Abstract

Purpose – Climate change, poverty and pandemics are some of the complex real-world problems that are increasingly challenging higher education institutions (HEIs) to equip future graduates with meta-competences that have hitherto not been demanded. These graduates need to be able to capture and operate within complex systems and relationships. By focusing on complex real-world problems, this study aims to systematically review competences and frame meta-competences supporting curricula development in HEIs.

Design/methodology/approach – This study applies a systematic literature review according to the review protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The review process resulted in the selection of 39 articles, which were subjected to qualitative synthesis to identify competences for tackling complex real-world problems. These competences were grouped into meta-competences and aligned with the Sustainable Development Goals (SDGs).

Findings – Scientific disciplines commonly describe four competences for tackling complex real-world problems including domain-specific competence, inter-relation competence, intrapersonal competence and normative competence.

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Originality – This study found that inter-relation competence is in line with all the SDGs, which is considered important for tackling complex real-world problems across disciplines.

Research limitations/implications – A study in a survey design across disciplines and a weighting of these competences in respect to complex real-world problems aligned with the SDGs could contribute to a more consolidated and common understanding of the meta-competences identified.

Keywords Meta-competences, Higher education, Complexity, Real-world problems, SDGs

Paper type Literature review

1. Background and introduction

Challenges from climate change, migration, loss of biodiversity or pandemics are complex real-world problems affecting our day-to-day reality. These and other global threats to humanity have shaped the UN Decade of Education for Sustainable Development (ESD) 2005–2014. UNESCO (2021) defines ESD as "a lifelong learning process and an integral part of quality education" and recognizes ESD as a key enabler to achieving the Sustainable Development Goals (SDGs). In total, 17 SDGs, which are aimed to be attained by 2030, emerged from the analysis of globally defined problems. They are intended to help identify and clarify the links from a discipline or between disciplines to the challenges of addressing complex real-world problems. SDG 4 (quality education) is understood as a key enabler for all other SDGs (UNESCO, 2021), which puts competences into the focus as a main vehicle to develop curricula in higher education addressing one or more interlinked SDGs (Albareda-Tiana *et al.*, 2018; Bartlett, *et al.*, 2020).

The growing need to educate graduates capable of contributing to the SDGs is hampered by a number of ongoing debates about competences for sustainability. Firstly, there is a lack of understanding of the concept of competence across disciplines (Le Deist and Winterton, 2005; Barth *et al.*, 2007; Mulder, 2011). Secondly, the ongoing discussion about the means of integrating sustainability education spans a wide range of arguments from bolt-on to build-in approaches or the entire redesign of curricula (Sterling and Thomas, 2006). Thirdly, there is a possible lack of engagement within some disciplines or professions coupled with a limited understanding by educators about how to teach the complex issue of sustainability (Filho *et al.*, 2021).

The starting point of this study are real-world problems, whose common denominator is complexity as they are ill-defined, multifaceted, highly interconnected, cutting across jurisdictional boundaries and uncertain with respect to their developments and dynamics, but certain in respect to their irreversible consequences (Rockström *et al.*, 2009; Risopoulos-Pichler *et al.*, 2020). As a consequence, higher education institutions (HEIs) need to foster academic excellence with contextual knowledge demanding a transdisciplinary process with a balanced inclusion of scientific disciplines and stakeholders with divergent interests (Scholz, 2020). It is for this reason that the teaching agenda and competences required across disciplines needs to be changed. Addressing complex real-world problems is a dynamic process in which the solution cannot be reduced to achieve a specific outcome but is reflected in the problem-solving process itself.

As the SDGs emerged from the search for solutions for a wide range of complex real-world problems, it is no surprise that they too are characterised by "complex interlinkages, uncertainty and conflicts of values" (Filho *et al.*, 2019, p. 286) challenging HEIs to provide students with competences accordingly. While some members of disciplines or faculties may not be familiar with competences to drive ESD or sustainability and reluctant to align their curricula with the SDGs (Levesque and Wake, 2021), the sheer complexity of the SDGs and the challenge of establishing a link with competences to achieve transformative learning puts not only further pressure but also opportunity on educators. The study's aim is to provide a review of scientific literature on individual competences across disciplines needed to tackle complex

real-world problems and to develop meta-competences solving complex real-world problems in alignment with the SDGs.

Section 2 presents the research design followed by the review procedure and method application in Section 3. Subsequently, the results of the analysis are presented in Section 4, which includes the development of meta-competences to address complex real-world problems in alignment with the SDGs. The article finishes with a discussion and suggestions for further research in Section 5.

2. Research design

2.1 Research procedure and terms of competence

Meta-competences represent the highest conceptual level. These are considered as overarching areas of competence (Cheetham and Chivers, 1996; Le Deist and Winterton, 2005; Wiek *et al.*, 2016; Engle *et al.*, 2017, p. 290). The next conceptual level is competence and by reviewing the literature, the authors note that the terms competence and competency are used inconsistently. In this study, the authors are following the distinction made by Eraut (2004) in which competences refer to a person's overall capacity also indicating a range of individual skills and knowledge and competencies represent specific skills, knowledge or abilities and contribute to a specific competence or competences (Eraut, 2004, p. 179).

To satisfy the need for a consistent set of terms in our analysis, the authors transform the recognizable hierarchy of terms on the topic of competences/competencies in the literature to our set of terms as following:

- identification of scientific articles on complex real-world problems, which also address the necessary competences, independent of their use of terminology as competence or competency, by using a methodological tool for a systematic literature analysis;
- identification of competences by consolidating competencies from the scientific literature on real-world problems – as a result of a qualitative synthesis of the competences in the literature;
- alignment of the scientific articles to scientific disciplines and analyse the distribution of the competences across these disciplines;
- identification and discussion of those competences as meta-competences which are relevant to solving complex real-world problems in the disciplines represented by the scientific articles of the literature review; and
- assigning the complex real-world problems of the reviewed articles to the SDGs and analyse the significance of the competences for the SDGs.

2.2 Empirical analysis and methods

This article applies a systematic literature review according to the review protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). This protocol originates from a guidance called the quality of reporting of meta-analyses statement, in which the author has to follow a 27-item checklist and produce a four-phase flowchart (Moher *et al.*, 2009). Because of its pre-defined approach, transparency and accuracy, the application of this protocol has become popular across a number of scientific fields including those identifying skills or competences (Shahruddin *et al.*, 2021; van Laar, 2020). The PRISMA protocol is applied because the reviewing process is a wide-ranging approach across disciplines. As the chosen method provides a clear and stringent framework, it avoids biases in the identification and

selection process. Articles are screened with respect to competences that tackle complex real-world problems and thereby follow a concise path of structuring a wide pool of contributions.

3. Review process

Three databases were screened: Web of Science, ABI/Inform and EBSCO. Web of Science was selected because of its multidisciplinary and comprehensive coverage including natural, technical and social sciences. ABI/Inform and EBSCO were included to reveal further findings in the field of business or management as management theorists have initiated the discussion of competences (Boyatzis, 1982; McClelland, 1973; Spencer and Spencer, 1993). This study aims to identify competences beyond the sustainability field by focusing in the search on the complexity of real-world problems and to align them with the SDGs. Therefore, the authors conducted two search steps: firstly, applying the keywords as complex problem or complexity and then, used the keywords sustainability or sustainable development. Because of the alignment of complex real-world problems to the SDGs, the review includes publications from 1992 onwards. The year marks the Rio Declaration, the first global agreement made on sustainable development (Shi *et al.*, 2019). The declaration addresses complex real-world problems as described in the SDGs, encouraging research in this field from that point onwards.

The PRISMA method consists of four stages including database searching, abstract screening, full text assessment for eligibility and final study inclusions.

In a first phase of the database search, abstracts were screened with keywords within the sources of data by Web of Science, EBSCO and ABI/Inform. Within this search, the keywords "competenc* AND complex problem OR complexity AND framework OR model OR profile" were applied and resulted in 2,282 findings. The second search with the keywords "competenc* AND sustainability OR sustainable development AND framework OR model OR profile" resulted in another 734 articles and was restricted to Web of Science because of its emphasis on natural, technical and social sciences. In total, 3,016 articles were selected through the search process.

The confinement process according to PRISMA (Figure 1) resulted in 246 articles, of which 214 articles were excluded because of the following criteria:

- No complex real-world problem described in the article (n = 91): these articles did not address one or more complex real-world problems and therefore fall short in establishing a link with one or more SDGs.
- No framework of competences (n = 42): these articles were excluded that argued only for one competence and not a model, framework or profile to reduce an over-representation of specific competences.
- Other educational issues addressed (n = 68): these articles were excluded because they addressed other issues about competences in the field of education.
- Organisational competences (n = 13): articles addressing organisational competences were excluded as this study is limited to the identification of competences needed by individuals.

3.1 Complex real-world problems

Complex real-world problems were identified in the selection and allocated to the corresponding SDGs by the authors of this review (Table 1). Thereby, the identification of complex real-world problems was undertaken according to the outline of the problem and the related challenges in the article and not with regard to a specific complex real-world problem definition. Most frequently, complex real-world problems or related challenges were mentioned in the selected

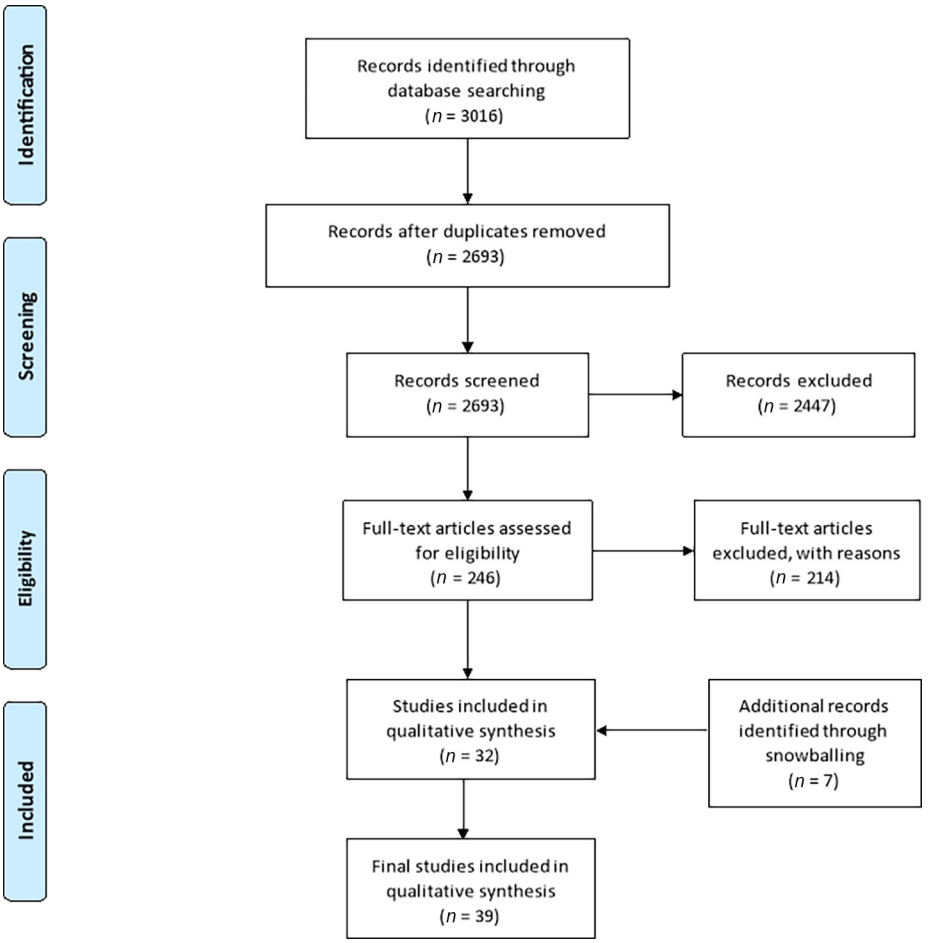

Figure 1.
Flowchart of the review process based on Moher *et al.* (2009)

articles which could be assigned to SDG 1 (no poverty), SDG 13 (climate change), SDG 14 (life below water), SDG 15 (life on land) and SDG 16 (peace, justice and strong institutions).

3.2 Identification of competences

The expressed competences were extracted in a qualitative synthesis. This synthesis included the following steps:

- In total, 39 articles were screened with respect to competences independent on the application of the terminology as competence or competency used by the authors. In total, 272 descriptions of competencies were identified.
- In line with the existing literature and the empirical findings, these descriptions of competencies were combined to make nine competences.

The 39 articles cover competences for a variety of disciplines. The articles were classified into disciplines according to a guideline published by the OECD (2015, p. 59) such as:

Author	Complex real-world problem and related challenges	SDGs
Biberhofer *et al.* (2019)	Ecological, social, political and financial crises	1, 9, 13, 16
Brown (2012)	Impact on climate, significant changes in organisations and social systems	8, 9, 11, 13
Coleman (2018)	Conflicts in an increasingly challenging world	16
De Haan (2010)	Loss of biodiversity, climate change, consumption of resources and balance between rich and poor	1, 12, 13, 15
Demssie *et al.* (2019)	Climate change, social problems and poverty	1, 2, 13
Dentoni *et al.* (2012)	Survival in current global agri-food systems	2, 12
Evans (2019)	Socio-ecological crises that permeate all facets of human life, institutions and the natural world	1, 2, 13–16
Flynn (2014)	Complex information and communication technologies	8, 9
Giangrande *et al.* (2019)	Loss of biodiversity and climate change	13, 15
Glasser and Hirsh (2016)	Environmental protection, responsive governance, improved health care, meaningful work, peace, partnership and social justice	3, 8, 13–17
Hesselbarth and Schaltegger (2014)	Social and ecological problem	1, 10, 13–15
Hind *et al.* (2009)	Damage and abuse of all the ecosystems on the planet, from fisheries to forests	1, 10, 13–15
Leslie *et al.* (2018)	Inequality within countries	10
Macaulay and Lawton (2006)	Ethical challenge in public administration	16
Malheiro *et al.* (2019)	Fostering of sustainable development and socio-professional ethics in engineering	8, 11
Mukhtar *et al.* (2019)	Degradation of ecosystem, loss in biodiversity, depletion and destruction of natural resources, pollution and poverty	1, 13–15
Mulder (2017)	Challenges to feed the global population	2
Nurius (2017)	Ensure healthy development for all youth, health gap, family violence, long and productive lives, social isolation, homelessness, social responses to a changing environment, technology for social good, economic inequality and equal opportunity and justice	1, 3, 5, 8–10, 16
Ogden *et al.* (2021)	Increase in preventable, non-communicable chronic illness and increasing ethical and professional challenges	3
Ortiz-Marcos *et al.* (2020)	Water supply, deforestation, climate change and sanitary issues like COVID-19	3, 6, 13–15
Osagie *et al.* (2016)	Balance in the environmental, social and business practices	12
Palaima and Skaržauskienė (2010)	Global warming, destruction of the ozone layer	13
Ploum *et al.* (2017)	Education of sustainable entrepreneurs to manage the triple bottom line	12
Rieckmann (2012)	Range of global social, economic, cultural and ecological changes which in the long term threaten the survival of the human species, societal change, progress of technology and globalisation	2, 3, 13–16
Roy *et al.* (2020)	Dams causing an ecological toll that disrupts the flow of water, fish and sediment in rivers	14

(*continued*)

Table 1.
Complex real-world problems and related challenges identified

Author	Complex real-world problem and related challenges	SDGs
Sang *et al.* (2018)	Resource shortages and environmental degradation, increasingly serious resource and environmental problems	13–15
Sawleshwarkar and Negin (2017)	Improving health of the global population in the context of SDGs	3
Schellhammer (2016)	Conflict/pure survival	16
Sharma (2017)	Intensified competition, advancing technology, increasing workforce diversity and accelerating complexity	8, 10, 12
Shinnaranantana *et al.* (2013)	Balancing planet, people and profit	12
Stefl (2008)	Increase of people with growing expectations and more complex medical needs with relatively fewer resources	3
Steiner *et al.* (2013)	Civic problems (social, economic or environmental issues)	1, 8, 13–15
Sumter *et al.* (2020)	Linear production system	12
Uhlenbrook and Jong (2012)	Water problems	6, 14
Valley *et al.* (2020)	Injustices related to the food system	5, 8, 10
Valverde (2018)	Social problems, access to justice system for the disadvantaged	16
Wesselink *et al.* (2015)	Global warming, poverty, hunger and biodiversity decline	1, 2, 13, 15
Wiek *et al.* (2011)	Climate change, desertification, poverty, pandemics and war	1, 3, 13, 15, 16
Williams (2002)	Community safety, poverty, social inclusion, health inequalities, teenage pregnancies, urban regeneration, substance misuse, climate change and homelessness	1, 3, 10, 11, 13, 16

Table 1.

- natural sciences;
- technical sciences;
- human medicine, health sciences;
- agricultural sciences, veterinary medicine;
- social sciences; and
- humanities.

Most of the selected articles originate in the field of social sciences and none were revealed in the field of humanities. Therefore, this class is not further covered in this review.

4. Results

4.1 Competences for complex real-world problems

The descriptions of the nine competences are based on existing literature and empirical results (Table 2). Inter-relation competence is the capability to apply empathy, to communicate and to collaborate (Wiek *et al.*, 2011; Brundiers *et al.*, 2020). Normative competence enables individuals to identify moral issues and to make good moral judgments based on ethical norms (Blok *et al.*, 2016). Domain-specific competence means to have the knowledge and skills and to be able to apply the corresponding methods in a specific field

Competence	Description	Examples for competencies
Inter-relation competence	The ability to apply empathy, to communicate and to collaborate	"Managing through influencing and negotiation" (Williams, 2002) "Work collaboratively with individuals and organisations" (Nurius, 2017) "Communication and relationship management" (Stefl, 2008) "Awareness of others and one's interactions with them" (Valley *et al.*, 2020) "Identifying, mapping, facilitating and managing the collaboration between external stakeholder in operationalizing a circular business model" (Sumter, 2020)
Normative competence	To be able to identify moral issues and to make good moral judgments based on ethical norms	"Assessing and improving the sustainability of social ecological systems based on values and principles" (Dentoni *et al.*, 2012) "Understanding and reflecting on values" (Leslie *et al.*, 2018) "Ability to work with professional and ethical responsibility" (Malheiro *et al.*, 2019) "Understanding of and inability to resolve common ethical issues and challenges" (Sawleshwarkar and Negin, 2017) "Value-led professionalism" (Ogden *et al.*, 2021)
Domain-specific competence	To have the knowledge, skills and method in a specific field	"Disciplinary competency" (Mulder, 2017; Demssie *et al.*, 2019) "Having an understanding or knowledge about the addressed field of education" (Stefl, 2008; Uhlenbrook and Jong, 2012; Sang *et al.*, 2018; Valverde, 2018) "Content knowledge" (Roy *et al.*, 2020)
Intrapersonal competence	To self-manage and self-reflect, to understand one's own thinking, norms and values leading to inclusive goal-oriented actions	"Self-management and career competency" (Mulder, 2017) "Self-learning competency" (Demssie *et al.*, 2019) "Self-knowledge and regulation" (Coleman, 2018) "Awareness of self" (Valley *et al.*, 2020) "Scan and engage the internal environment" (Brown, 2012) "Self-knowledge competencies" (Ortiz-Marcos *et al.*, 2020) "Embracing openness, diversity and tolerate ambiguity" (Dentoni *et al.*, 2012; Glasser and Hirsh, 2016; Rieckmann, 2012)
Transformative competence	The ability based on critical, forward and strategic thinking, to be actively involved and to put plans into action	"Actively involving in responsible actions to improve the sustainability of social ecological systems" (Dentoni *et al.*, 2012) "The ability to inspire individual and organisational excellence, to create and attain a shared vision and to successfully manage change to attain the organisation's strategic ends and successful performance" (Stefl, 2008)

(*continued*)

Table 2.
Competences for complex real-world problems

Competence	Description	Examples for competencies
		"The ability to collectively envision, develop, implement and assess transformative interventions for sustainability" (Evans, 2019) "Strategies for dismantling inequity" (Valley, 2020)
Functional competence	To be competent in activities, which are not directly connected to the individual's qualification, but necessary to deliver his or her job successfully	"Operational planning" (Schellhammer, 2016) and "organisational competencies" (Ortiz-Marcos *et al.*, 2020) "Communication and use of media" (Rieckmann, 2012) "The effective use of written and modern communication technologies" (Ogden *et al.*, 2021) "Ability to perform a range of work work-based tasks" (Uhlenbrook and Jong, 2012)
Advanced methods competence	To be able to stretch beyond traditional methods and procedures of problem solving including transdisciplinarity and creativity	"Ability to apply knowledge creatively to solve problem" (Malheiro *et al.*, 2019) "Analytic evaluation/measurement competency" (Flynn, 2014) "Transdisciplinary competence" as the ability to apply it as a tool and skill to work with experts from other disciplines and beyond disciplines into real-world cases (Demssie *et al.*, 2019)
Nature and life competence	To understand how life on the planet developed and the ability to consider the planet's boundaries and the link to key political issues in the process	"To understand the dynamics of working in a global context" (Nurius, 2017) "The identification with all life" (Glasser and Hirsh, 2016) "Ability to consider economic, environmental and sustainability constraints" (Malheiro *et al.*, 2019) "Awareness of systems and oppression" (Valley *et al.*, 2020)
Systemic competence	To understand complex systems, to apply appropriate modeling methods and to analyse future scenarios	"Systems thinking" (Dentoni *et al.*, 2012; Wiek *et al.*, 2011; Brown, 2012; Palaima and Skaržauskienė, 2010; Rieckmann, 2012; Demssie *et al.*, 2019; Giangrande *et al.*, 2019; Roy *et al.*, 2020) "Systemic competency" (Biberhofer *et al.*, 2019) "Systems awareness, thinking and contribution" (Ogden *et al.*, 2021)

Table 2.

(Steiner, 2013). Intrapersonal competences comprises self-management and self-reflection and thereby, to understand one owns thinking, norms and values leading to inclusive goal-oriented actions (Brundiers *et al.*, 2020). Transformative competence requires the ability to be actively involved and take over responsibility, reconcile tensions and dilemmas and to put plans into action and thereby create new value. This necessitates the capability to think in long term and anticipate future scenarios by considering risks and consequences. This competence combines strategic thinking, forward or anticipatory thinking as well as critical thinking (Wiek *et al.*, 2011; Rychen, 2019; Brundiers *et al.*, 2020;). Functional competence means to be competent in activities, which are not directly connected to the individual's qualification, but necessary to deliver his or her job successfully and thereby differentiates from domain-specific competence (Cheetham and Chivers, 1996). Advanced methods competence represents

the necessity to be able to stretch beyond traditional methods and procedures of problem solving. It synthesises competences deriving from transdisciplinary competence, creativity and problem solving (Steiner, 2013). Nature and life competence supports the understanding of life on the planet, the planet's boundaries and the link to key political issues. It refers to competences addressing world dynamics thinking, sustainability and planetary issues (Glasser and Hirsh, 2016; Levesque and Blackstone, 2020). Systemic competence refers to the ability to understand complex systems, to apply appropriate modeling methods and to analyse future scenarios (Steiner, 2013).

The 39 articles resulting from the systematic literature review were assigned to five scientific disciplines. Assigning the competences to these disciplines (Table 3) demonstrates that inter-relation competence, normative competence, intrapersonal competence and domain-specific competence can be found across disciplines.

4.2 Competences in relation to Sustainable Development Goals

The second part of this study sought to assign the SDGs to the articles with the cross-disciplinary competences described before. The results are shown in Figure 2 demonstrating the frequency of competences in relation to the SDGs. It can be seen clearly that individuals across the disciplines need inter-relation competence in context of the SDG. Intrapersonal, normative and domain-specific competence also appear to be highly relevant in relation to a range of SDGs, including SDGs 1–3, 8, 10 and 12–16. However, no relation was found between systemic competence and SDGs 5, 6 and 17, normative competence and SDG 5, domain-specific competence and SDGs 5 and 11, transformation competence and SDG 6, intrapersonal and functional competence and SDG 17, nature and life competence and SDGs 6 and 11 as well as between advanced method competence and SDGs 5, 11 and 17.

5. Discussion

The point of departure for this study was the identification of terms of competences in the scientific literature thematizing complex real-world problems. By focusing on the complexity of real-world problems, the study aimed to include also findings beyond the sustainability discussion by addressing the pressing need to leave no one behind in the debate over future approaches (Levesque and Wake, 2021). In a next step, the discussion was returned to the sustainability agenda by aligning the complex real-world problems described in the reviewed articles with the SDGs. There is cross-disciplinary common understanding that four meta-competences exits, whereby inter-relation competence reveals as the unique competence needed to address any type of complex real-world problem aligned with the SDGs identified in this study.

Complex real-world problems do not have a simple or predictable relation between input and output (Williams, 2002) and they are challenging disciplines making them realize to emphasize collaboration in dealing with these problems (Crofton, 2000; Daicoff, 2012; Buse and Hawkes, 2015; Dlouhá, 2019). Individuals therefore need to be capable of looking beyond their own disciplinary knowledge and skills to pool expertise to achieve a sustainable solution. Inter-relation competence, especially when faced with finding the solution to a complex problem, involves mutual learning processes that require the ability to crossing both cultural and disciplinary boundaries. In turn, this process of collaboration demands empathy and the ability to connect and bond with other people through literal and emotional communication. This competence includes social intelligence (Boyatzis, 2008) or the ability to motivate, enable and facilitate collaborative and participatory sustainability research and problem solving (Wiek *et al.*, 2011).

Table 3.
Competences across disciplines

Discipline	Normative competence	Domain-specific knowledge	Inter-relation competence	Intrapersonal competence	Nature and life competence	Systemic competence	Transformation competence	Advanced method competence	Functional competence
Agricultural sciences, veterinary medicine	x	x	x	x	x	x	x		
Human medicine, health sciences	x	x	x	x	x	x	x	x	x
Natural sciences	x	x	x	x				x	x
Social sciences	x	x	x	x	x	x	x	x	x
Technical sciences	x	x	x	x	x		x	x	x

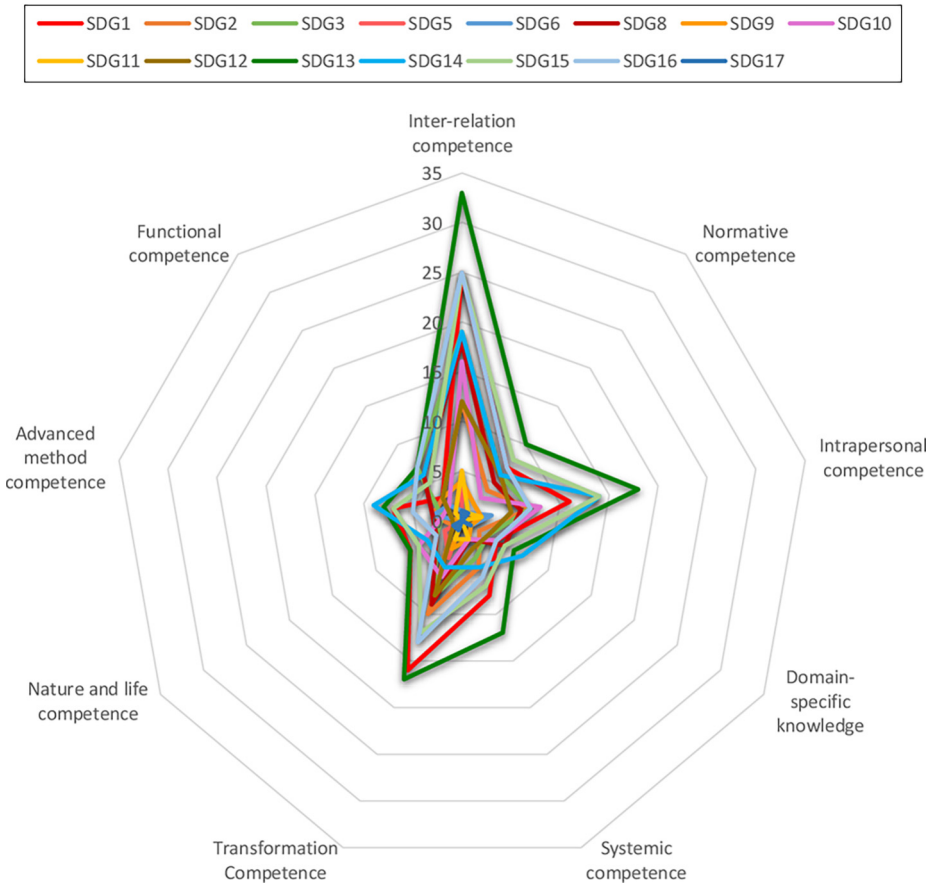

Figure 2.
Competences in relation to SDGs

Inter-relation and normative competence complement each other. The demand for increasingly inter- and transdisciplinary collaboration entails not only actors and stakeholders from different backgrounds, requiring cultural sensitivity, but also an understanding of values, moral issues and principles even in an unfamiliar context. Inter-relation competence is therefore a requirement to put normative competence into practice, whereas the ability to evaluate actions based on values is an ability to put inter-relation competence into practice. Authors across disciplines describe the importance of normative competence, acknowledging the normative characteristics or dilemmas arising from complex real-world problems (Stefl, 2008; Sawleshwarkar and Negin, 2017; Uhlenbrook and Jong, 2012). An increasing challenge to deal with ethical dilemmas combined with the need for rapid decision-making in the case of complex real-world problems has further moved the discussion in the direction of norms and values and the ability of individuals to behave responsibly (Blok *et al.*, 2016). However, in spite of the broad agreement on the importance of normative competence, there is still wide uncertainty concerning the best content and means to develop this competence.

On an individual level, normative competence has effects upon self-awareness and on the ability to evaluate one's personal attitude, emotions and behavior as they constantly affect

intrapersonal competence. An awareness of justice and fairness and the willingness to challenge constantly one's own feelings, knowledge and attitude have a vital role to play in effective collaboration and the ability to facilitate constructive interaction (Stefl, 2008; Wiek *et al.*, 2011). However, the research undertaken for this study demonstrates that solving complex real-world problems requires more than self-awareness from individuals, it demands a self-decentring state of mind because of the need to turn one's attention to other approaches, habits, techniques and forms of understandings. It also requires high level of tolerance to accept other viewpoints that in turn fosters the necessary exchange of ideas. This competence asks for openness to embrace diversity to achieve cultural and disciplinary overarching results.

A shared understanding on the importance of domain-specific competence reveals much common ground across disciplines. This competence denotes the ability to refer to a certain domain of specific knowledge, skill and method (Cheetham and Chivers, 1996). A solid and an in-depth expertise in one's field of education constitutes one of the main pillars to tackle complex real-world problems. As Steiner (2013) points out, domain-specific competence has its root in a specific discipline and historically represents one of the main competences found in the process of curricula development and delivery in higher education. Consequently, the ability to address complex real-world problems requires a deep understanding of the subject within the discipline in hand as well as the ability to apply this knowledge within a complex context. Thereby, normative competence and inter-relation competence influence domain-specific competence and how it is selected, evaluated and processed. However, individuals need to understand the limits of their knowledge and consequences of mistaken understanding, which might lead to contradictory actions. Correspondingly, individuals need to develop their perspective on different outcomes based on in-depth knowledge but challenge these outcomes continuously *vis-à-vis* their values and norms. The involvement of different actors and stakeholders complicates the process further, as they may have different values and norms, meaning that shared norms must be established and developed (Blok *et al.*, 2016).

Complex real-world problems emerge from human actions, which re-define the context of responsibility of the problem and exposing the consequences to a wide range of actors and people concerned. These problems arise together with challenging dilemmas, which demand individuals to possess a well-grounded domain-specific expertise, an ethical understanding to act in a normative context and the ability to negotiate successfully between actors. However, tackling complex real-world problems cannot be solved by individuals, but require collective and cross-boundary approaches. Hence, each of the four competences for complex real-world problems builds and reflects the other three competences enhancing the probability of successfully addressing complex real-world problems as illustrated by Figure 3. The four meta-competences support developing expertise grounded in an understanding of the complex real-world problem, the ethical and self-awareness within a normative context and the ability to navigate between actors and stakeholders.

However, complex real-world problems are often subject of dynamic, non-transparent and multidimensional processes, which therefore require creativity with regard to both the process and the outcome (Steiner, 2013; Dörner and Funke, 2017). The ability to interconnect and look beyond the own expertise as well as to deal with a vast number of elements and dynamic of change supports individuals to stimulate a process of action or advance methodological competence. Hence, individuals require an understanding of interdependences raising systems thinking competency to one of the key sustainability competencies described by the most quoted authors in this field (Wiek *et al.*, 2011; Rieckmann, 2012; Lozano *et al.*, 2017; Brundiers *et al.*, 2020).

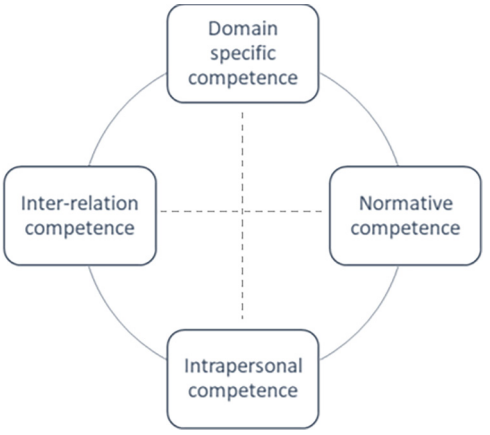

Figure 3.
Meta-competences across disciplines

Some authors raise the valuable question whether individuals need to have a better understanding about the state of the planet and grand sustainability challenges (Glasser and Hirsh, 2016; Levesque and Blackstone, 2020). Accordingly, Levesque and Blackstone (2020) bring up the topic of which type of knowledge is needed to address these challenges. They argue for a more univocal knowledge of the grand challenges such as climate change within the sustainability competences discussion. They also ask whether we need to be clearer about the specific knowledge, skill and action needed for each individual competence that seeks to address complex sustainability problems. While domain-specific competence focuses on the understanding about sustainability related to one's field, nature and life competence includes knowledge and skills in respect to social, political and ecological issues linked to the SDGs specifically or wider context. However, this separation needs further investigation to identify whether nature and life competence builds and reflects on other competences and confirms its stand-alone role.

6. Conclusions

Although the results of this study confirm our common understanding that complex real-world problems can be more sustainably solved in cross-disciplinary collaborations by developing common meta-competences, they also raise the questions about the need for one or the other competence in relation to SDGs. In particular, the extent to which each competence is needed in relation to a specific complex real-world problem and the problem's complexity.

Furthermore, higher education curricula shall specifically focus on meta-competences including domain-specific competence, inter-relation competence and intrapersonal and normative competence to develop abilities and skills in addressing and solving complex real-world problems.

Besides our findings, further research is needed to cover a full and well-balanced range of scientific disciplines and comparison of the SDGs addressed across disciplines. Hence, a comprehensive study in a survey design could contribute to a more consolidated and common understanding of the meta-competences as well as reconciled approach acknowledging needs and demand of actors and stakeholders in higher education.

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