



# Competencies for Advancing Transformations Towards Sustainability

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Advancing transformations towards sustainability calls for change agents equipped with a new set of competencies. Such sustainability competencies have been articulated with multiplicity and ambiguity, which is counterproductive to joint and accelerated progress. A unified framework of sustainability learning objectives would provide guidance to students, educators, and administrators of sustainability programs. To this end, we carried out a systematic review of the relevant literature. After scanning thousands of publications, we identified over 270 peer-reviewed articles of highest relevance, spanning two decades. Despite appearance otherwise, we found that there is a high level of agreement among scholars over the sustainability competencies that students should be trained in. Expanding on the five key competencies, namely, systems-thinking, anticipatory, normative, strategic, and interpersonal competence, that have gained widespread use, this article synthesizes the new suggestions made over the past decade into a unified framework. It centers on 8 key competencies in sustainability (the 5 established and 3 emerging—intrapersonal, implementation, and integration competence), which are complemented by separate disciplinary, general, and other professional competencies. This comprehensive framework of key competencies in sustainability is applicable across disciplines and can guide faculty, students, and practitioners in their joint efforts to advance transformations towards sustainability.

**Keywords:** learning objectives, sustainability education, transformations, change agents, key competencies in sustainability

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## INTRODUCTION

To achieve the Sustainable Development Goals (SDGs) by addressing persistent sustainability challenges such as climate change, biodiversity loss, and socio-economic injustices requires ambitious and whole-scale transformations of societies worldwide (UNESCO, 2017; Scoones et al., 2020). Facilitating these transformations will require novel approaches (Linnér and Wibeck, 2019) that ought to be carried out by change agents who are educated in sustainability and sustainable development (Franco et al., 2019; Redman et al., 2021). In response, the number of sustainability programs at universities and colleges has substantially increased worldwide—to over 1,500 in the United States alone over the past decade (Weiss and Barth, 2019). Yet, critics have long noted that most of this education hews too close to the status quo (Orr, 2003) and graduates of these programs are equipped only to make incremental improvements, instead of being the change agents

capable of advancing transformations (Gordon et al., 2019). The characteristics of such *transformational* change agents should be reflected in the learning objectives of sustainability programs.

Yet, there still remains a lack of clarity and coordination regarding a unified framework of sustainability learning objectives (O'Byrne et al., 2015), which undermines effectiveness, innovation, and legitimacy of such programs (Vincent and Focht, 2009). Guidance is unlikely to come via high-level policy (Mochizuki, 2016), as neither the UNDES, nor the more recent SDG 4.7, which calls for Education for Sustainable Development (ESD) globally (Giangrande et al., 2019), provide any explicit learning objectives, let alone a coherent framework for advancing transformations. In contrast, UNESCO has articulated how key competencies in sustainability can be utilized to develop educational programming around all seventeen of the SDGs (UNESCO, 2017).

Scholarly reviews of university sustainability programs (Trencher et al., 2018; Salovaara et al., 2020) and expert surveys (Rieckmann, 2012; Demssie et al., 2019; Brundiers et al., 2021) have brought those perspectives into the scholarly literature. At the same time, the growing number of scholarly works on sustainability learning objectives in diverse disciplines, from science and engineering to teacher education, has remained dispersed and thus does not offer coherent direction. Some literature reviews have been published, but these have either been large and systematic, yet, without a thorough synthesis (Hallinger and Chatpinyakoo, 2019), or synthesizing, yet, small and non-systematic (Lozano et al., 2017). In summary, there is a need for a comprehensive, systematic review which goes beyond description. This study offers such a review and synthesizes a unified framework of sustainability learning objectives to provide guidance to sustainability educators and accelerate transformations towards sustainability.

## METHODS

Synthesizing a growing body of research such as that on sustainability learning objectives is best done through a systematic literature review (Snyder, 2019). We followed the procedures laid out by Fink (2014) to be systematic, explicit, comprehensive and reproducible. One of the goals of this study was to be as thorough as possible and identify almost everything that has been published on sustainability learning objectives. In order to be sure that definitional differences did not accidentally exclude relevant articles, we searched for synonyms of learning objectives. We sought to draw from as broad a pool of publications as possible; thus, we conducted our search on Web of Science, SCOPUS, ERIC, and Google Scholar. Based on other sustainability education literature reviews, we expected these databases to provide comprehensive coverage.

The exact search strings can be found in the supplementary materials, but in brief, we were looking for publications through the end of 2020, in English which described specific learning objectives (e.g., competencies, capabilities, and attributes) for sustainability education programs (degrees, courses, etc.). In

line with the transformational framing of this review, education focused exclusively on incremental behavior changes (e.g., how to sort recycling material) were excluded. The identified publications went through an iterative screening process (Figure 1) to create a final collection of articles for review. At each stage, publications were only excluded when they clearly did not fit the above characteristics. For final inclusion, descriptions of specific sustainability learning objectives had to be identified in the text. In addition, each of the databases was screened for articles published or in press until August 2021, and the most relevant were included in the overall qualitative analysis.

For the analysis, bibliographic information as well as any information coded or extracted from the publications was imported into R (R Core Team, 2020) for analysis. A variety of analyses were performed such as text mining of the titles, keywords, and abstracts, citation analysis, and others. The learning objectives and their descriptions were extracted from each publication for both quantitative and qualitative analysis. The overall collection was also reviewed and synthesized qualitatively. Specifics and more details on the methods used for analysis can be found in the **Supplementary Materials**.

## RESULTS

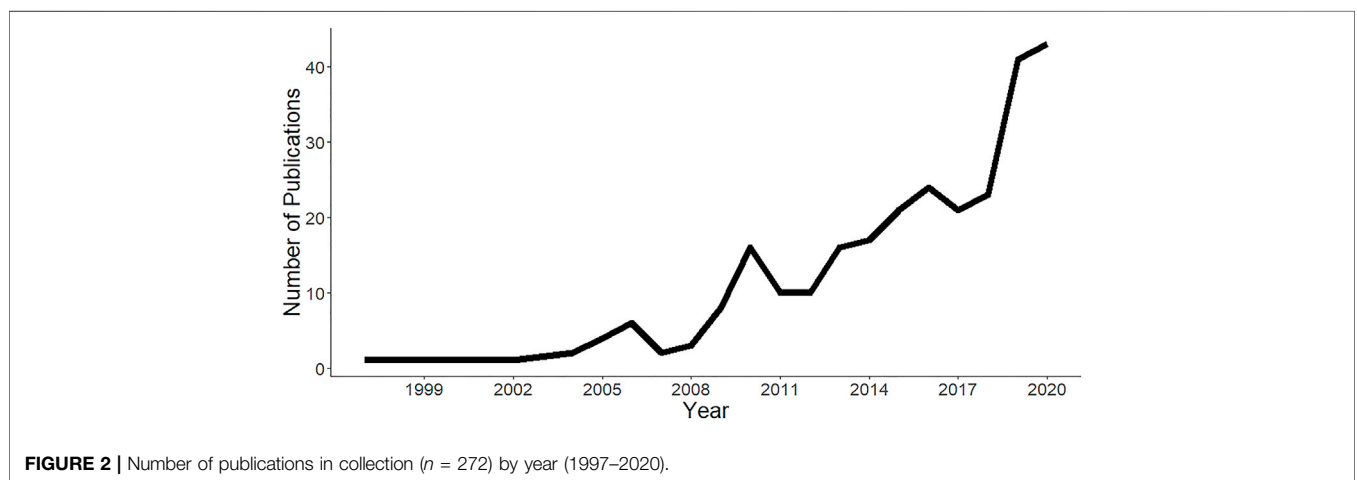
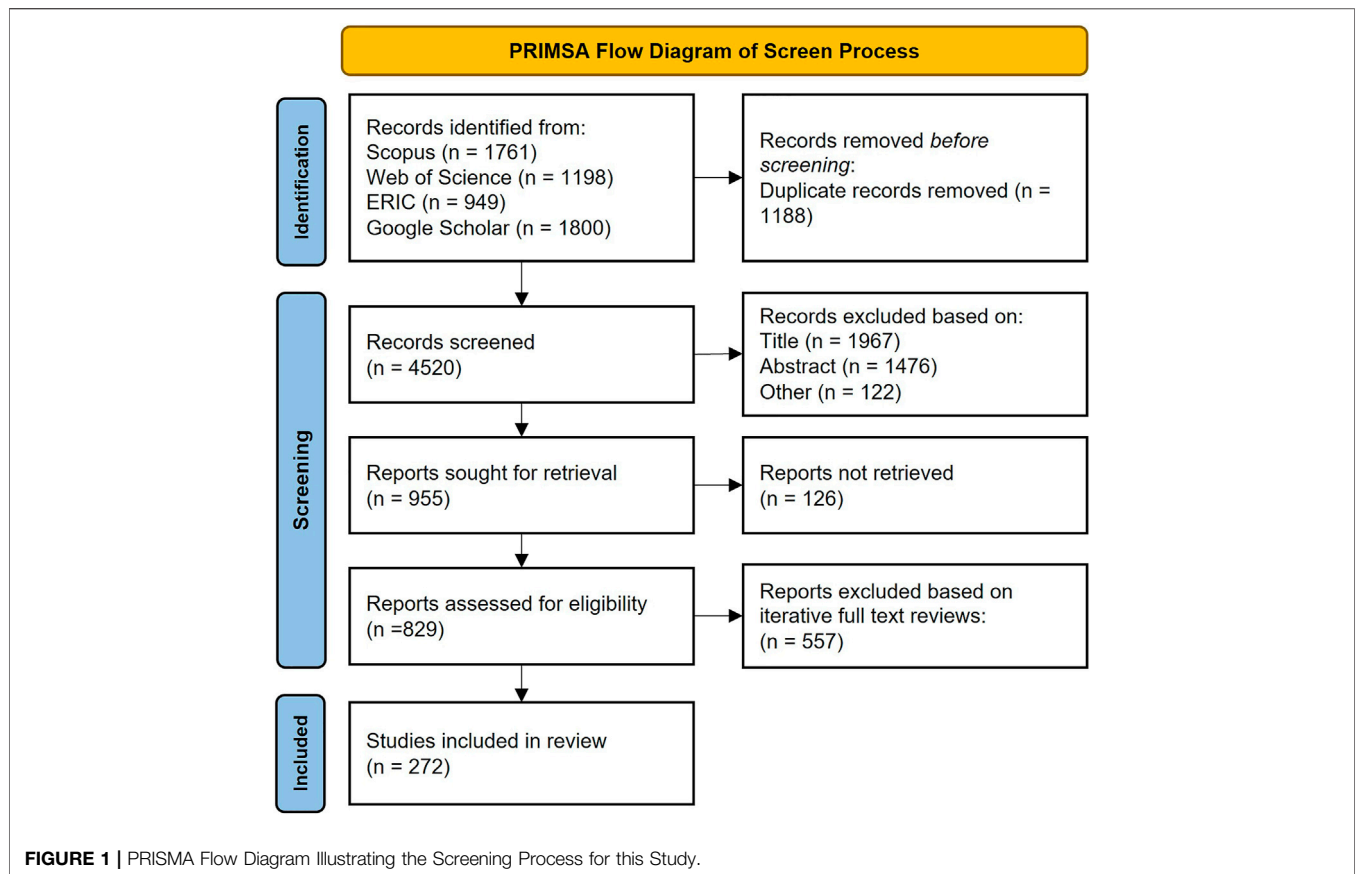
### Study Selection

After duplicates were removed, we were left with 4,520 bibliographic entries to review. The iterative process is described in more detail in the PRISMA diagram (Figure 1), but essentially, we first made several passes to exclude those publications which were clearly irrelevant before reviewing the remaining ones. The collection ultimately contained 272 publications used for complete analysis plus 5 more from 2021 which were qualitatively reviewed only (see **Supplementary Materials** for a full list).

### Increasing Publication Efforts and the Challenge of Convergence

Publishing on sustainability learning objectives only began in earnest this millennium and has grown continuously between 1997 and 2020 (Figure 2). Across the most relevant publications ( $n = 272$ ), many perspectives are being represented among diverse scientific journals (more than 100), with the top 3 journals accounting for about one third (32%). Over half of the sampled articles ( $n = 143$ ) were written for a particular discipline including teacher education ( $n = 32$ ), business/entrepreneurship ( $n = 29$ ), engineering ( $n = 29$ ), and many more such as design, computer science, health, tourism, facility management, agriculture/food, and construction. Geographically, the sample is far less diverse with only 9% of publications coming from outside of the OECD member countries.

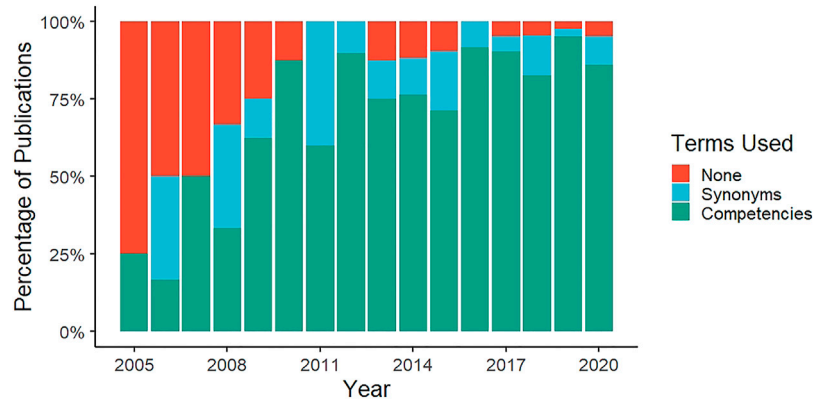
This varied body of literature converges in the intention to prepare students for contributing to sustainability transformations. Publication abstracts and titles typically include phrases explicitly referring to sustainability challenges



(77%) and pointing to the need to address them (76%). This is grounded, to some extent, in the literature, with *Our Common Future* and the *UN Decade of Education for Sustainable Development* being the two most cited background references (by 23% of articles for each).

The conducted literature search included common synonyms for learning objectives, e.g., “literacy” (Dawe et al., 2005) and “attributes” (Barrie, 2006), with “competencies” emerging as the

most widely used term (Figure 3). A competence is defined as “a complex combination of knowledge, skills, understanding, values, attitudes and desire which lead to effective, embodied human action in the world, in a particular domain (Crick, 2008).” Competencies are most often specified as independent of domain-specific content knowledge, which allows for articulating competencies across disciplines and professions. The competencies approach to education was broadly



**FIGURE 3 |** Percentage of publications mentioning competencies versus all other synonyms (“literacy” etc.) in title, keywords, or abstract by year (2005–2020) (publications prior to 2005 ( $n = 10$ ) were excluded for better presentability).

popularized beginning more than two decades ago through efforts such as the OECD-led initiative on “Definition and Selection of Competencies (DeSeCo)” (Rychen and Salganik, 2000). Yet, as late as in 2008, it was not seen as commonly used in sustainability education (Van Dam-Mieras et al., 2008), though with increased adoption since (Barth, 2015).

A common theme in the literature is that “no consensus has been reached within ESD discourses as to the process of how to identify essential abilities and as to a list of abilities seen as important” (Wolbring and Burke, 2013). Even as recently as 2021, scholars (and presumably practitioners) continue to operate as though there is “no agreement on exactly what these key competencies are” (McCarthy and Eagle, 2021). This position lends legitimacy to the current practice of continuously re-inventing sustainability competencies in the literature. At the same time, there is little explicit connectivity in the literature, with 40% of the articles (prior to 2019) not being cited by any others (in the whole sample).

## Convergence on Key Competencies in Sustainability

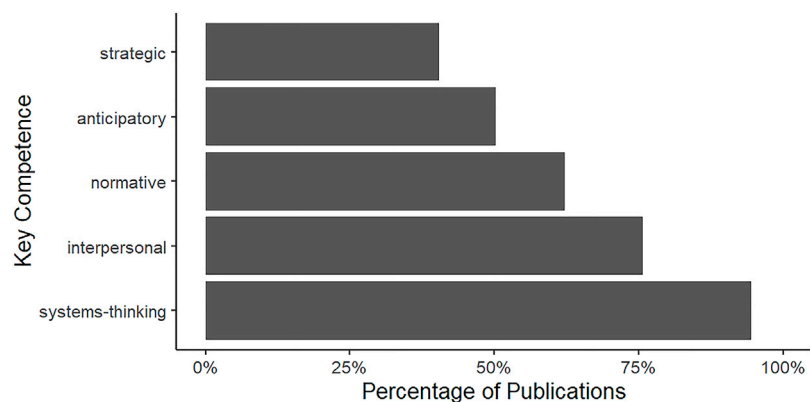
Yet, when looking beyond terminological differences, we find convergence in the literature on what graduates and professionals need to be capable of to advance social transformations to sustainability. The 2011 review article “Key competencies in sustainability—a reference framework for academic program development” (Wiek et al., 2011) was the first articulation of this convergence. The authors synthesized from the literature a framework of sustainability-problem solving competence, integrating five key competencies, namely, systems-thinking, anticipatory, normative, strategic, and interpersonal competence. This article has been received as a unifying framework and identified as “the most influential paper” in ESD (Grosbeck et al., 2019, 26). Over the past decade, it has been cited by over 63% ( $n = 141$ ) of the sampled articles published in 2011 or after ( $n = 225$ ). The second most cited publication (Rieckmann, 2012) (by 25%) distills expert opinions into a list of

competencies, without synthesizing a framework, while the third most cited publication (Barth et al., 2007) (by 21%) focuses on how competencies may be developed rather than offering a framework. Beyond citations, the 2011 key competencies framework has facilitated explicit convergence, being used as the full foundation in 32 articles (14% of the sampled articles published 2011 and after) and as a partial foundation in 78 articles (35%). Mapping this framework over the entire sample ( $n = 272$ ) between 1997 and 2020 demonstrates convergence on these competencies (Figure 4). Interviews with sustainability professionals have found these competencies to be well recognized (Salovaara et al., 2020). In addition, this framework has been applied in many real-world contexts from university programs (Boone, 2015; Richard et al., 2017; Jarchow et al., 2018) to K-12 teacher training (Archambault et al., 2013; Kieu et al., 2016; Redman et al., 2018), K-12 education directly (Wiek et al., 2016; Rodríguez-Aboytes and Nieto-Caraveo, 2018), and training for in-service professionals (Thomas and Millar, 2016; Withycombe Keeler et al., 2017).

## Updating the 2011 Key Competencies Framework

In the ten years since the publication of the 2011 key competencies framework (2011–2020), 110 articles were published that substantively engaged with the framework (beyond just citing it). Analysis of this body of literature identifies both insufficient receptions and productive suggestions relevant to an update (Wiek and Redman, 2021).

Indicative of the deficient, yet prevailing *list*-approach to competencies, scholars often acknowledge the relevance of the five competencies and then add a competence or two without offering how those might integrate into the framework and specifically contribute to sustainability problem solving (Heiskanen et al., 2016). Beyond the lack of adopting the *framework*-approach, many articles lack concise definitions and clear conceptual development of new competencies, a flaw called out by several other reviews (Sterling et al., 2017;



**FIGURE 4 |** Percentage of sampled publications ( $n = 272$ ) on competencies that can be mapped onto the 2011 framework (1997–2020).

Galleli et al., 2019; Shephard et al., 2019; Wilhelm et al., 2019; Brundiers et al., 2021). One example is “action competence” (Mogensen and Schnack, 2010), which is frequently added to the 2011 framework, but often confounded with strategic competence (Lans et al., 2014). Another common reception is to emphasize general and disciplinary competencies such as creativity (Steiner and Scherr, 2013; Lozano et al., 2017) or critical thinking (Rieckmann, 2012; Fukushima et al., 2017). As explained in the 2011 framework (p. 211), while these are necessary competencies for solving sustainability problems, they are not *key* competencies, as they are not distinct to *sustainability* but considered learning objectives of education in *general* (Voogt and Roblin, 2012).

Yet, there have also been a number of productive suggestions to expand the framework. Most relevant are three emerging competencies (for definitions, see **Table 1**), which have been proposed with varying frequencies (**Figure 5**). *Intrapersonal* competence has been called out in several conceptual (Anderson, 2013; Frank, 2021) and empirical (Giangrande et al., 2019; Brundiers et al., 2021) studies; yet, there remains some disagreement on whether this is a competence (Gómez-Olmedo et al., 2020) or an underlying disposition (Brundiers et al., 2021). *Integration* competence has already been mentioned in the original framework (p. 212) and elaborated in an early update of the framework (Wiek et al., 2016); it has been mentioned frequently thereafter (Evans, 2019). The least frequent explicit proposal is for an implementation competence (see **Figure 5**). The 2011 framework focuses on the competence to *plan* sustainability problem solving, and only touches on competence to *implement* sustainability interventions and solutions. Some authors have argued that implementation competence deserves the status of a *key* competence in sustainability (Perez Salgado et al., 2018), which is in line with other more vague descriptions of strategic action competence (Frisk and Larson, 2012). There is emerging agreement that sustainability education ought to prepare students for *taking action* (Mogensen and Schnack, 2010; Frisk and Larson, 2012); more specifically, for “collective

interventions” (Clark, 2016; Perez Salgado et al., 2018) towards “transformative social change” (Glasser, 2016). As indicated in the original version of the framework (p. 214), this is a call for *collective* sustainability problem-solving competence that goes beyond the capacity of individuals (Barth, 2015).

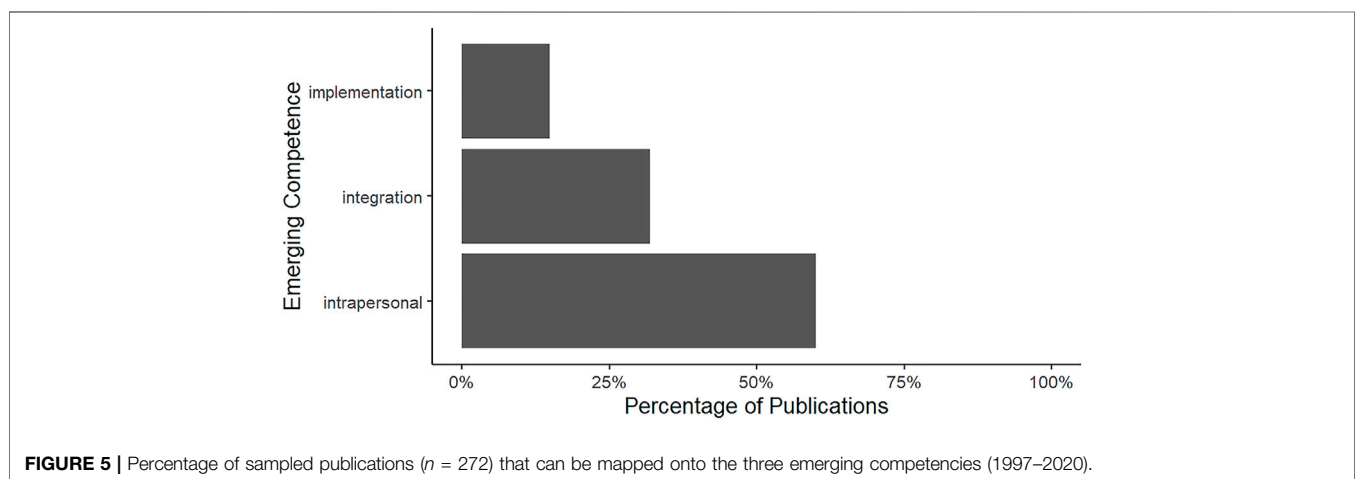
## Framework of Competencies for Advancing Sustainability Transformations

The unified framework of competencies for advancing sustainability transformations centers on 8 key competencies in sustainability (with 5 established and 3 emerging), and is complemented by disciplinary, general, and other professional competencies (**Figure 6; Table 1**). As a framework, the key competencies are *not* compiled as a *list* to select from; instead, *all* key competencies need to be integrated for advancing sustainability transformations. Systems-thinking, futures-thinking, values-thinking, and strategies-thinking enable crafting sustainability action plans that yield sustainability outcomes if successfully implemented (which requires implementation competence). Inter- and intra-personal competencies (key professional competencies) enable that planning and implementation is undertaken in collaborative and self-caring ways—key factors for success (Sipos et al., 2008; Frisk and Larson, 2012). Finally, integration competence enables a coherent combination of collaborative and self-caring planning and implementation efforts, using established procedures for sustainability problem solving (Angelstam et al., 2013; Polk, 2014; Wiek and Lang, 2016; Henry, 2018). Complementary competencies are organized on two axes: disciplinary competencies complement the (content-independent) key competencies through content-dependent expertise; general competencies such as critical thinking and creativity as well as other professional competencies such as responsive project management are generic competencies (used in many different fields) that complement the sustainability-specific key competencies in efforts to advance sustainability transformations.

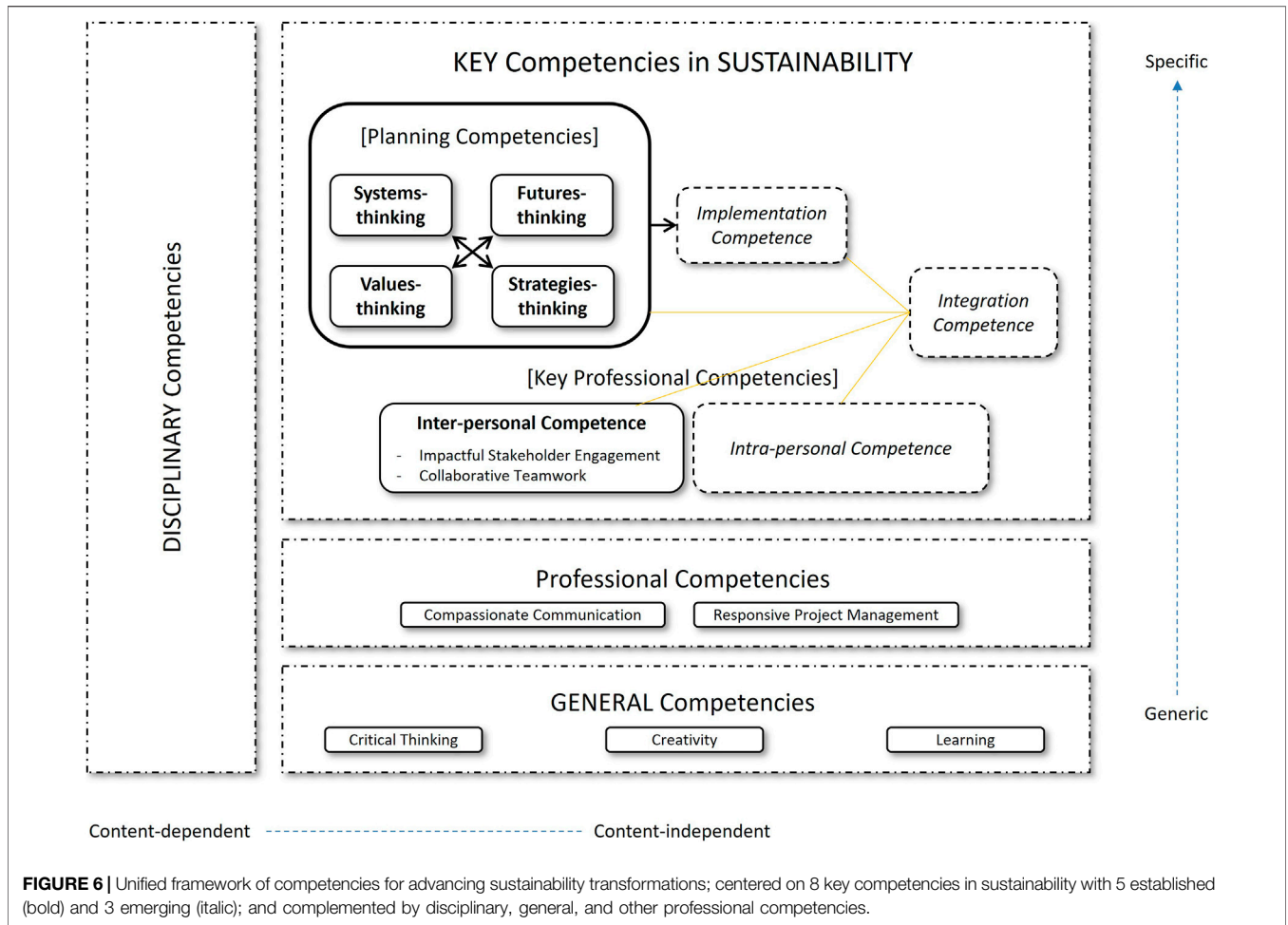
Competencies that fulfill important functions complementary to the key competencies in sustainability can be differentiated into disciplinary, general, and other professional competencies.

**TABLE 1 |** Definition and most common descriptors from the literature for each key competence in sustainability.

Competence	Definition	Descriptors from the literature
Systems-Thinking Competence	Ability to apply modeling and complex analytical approaches: 1) to analyze complex systems and sustainability problems across different domains (environmental, social, economic) and across different scales (local to global), including cascading effects, inertia, feedback loops, and other system dynamics; 2) to analyze the impacts of sustainability action plans (strategies) and interventions (how they change systems and problems)	Understand, identify, describe, analyze sustainability challenges and problems, complex issues, effects, relationships, impacts, patterns, structures, unintended consequences, feedback loops, context, interactions, etc. across different domains (environmental, social, economic), scales (local to global), and perspectives (interdisciplinary), etc.(Connell et al., 2012; Sandri, 2013; Gray, 2018; Levy et al., 2018; Schuler et al., 2018; Mahaffy et al., 2019)
Futures-Thinking Competence	Ability to carry out or construct simulations, forecasts, scenarios, and visions: 1) to anticipate future states and dynamics of complex systems and sustainability problems; 2) to anticipate how sustainability action plans (strategies) might play out in the future (if implemented).	Anticipate, foresight, envision, craft, analyze, and evaluate long-term future consequences, scenarios (multiple futures), and visions regarding intergenerational equity, future generations, uncertainty, etc.(Withycombe, 2010; Gardiner and Rieckmann, 2015; Ojala, 2017)
Values-Thinking Competence	Ability to identify, map, specify, negotiate, and apply sustainability values, principles, and goals: 1) to assess the sustainability of current and/or future states of complex systems; and 2) to construct sustainability visions for these systems; (3) to assess the sustainability of action plans (strategies) and interventions.	Identify, assess, negotiate, reconcile, reflect on, map, apply sustainability principles, morals, norms, ethics, goals, integrity, justice, conflicts, trade-offs, etc.(Remington-Doucette et al., 2014; Verma et al., 2016; Komasinkski and Ishimura, 2017)
Strategies-Thinking Competence	Ability to construct and test viable strategies (action plans) for interventions, transitions, and transformations toward sustainability.	Design, create, develop, test transformative, innovative, viable, feasible interventions, transitions, strategies, action plans, solutions, etc. considering barriers, inertia, path dependence, carriers, assets, etc.(de Haan, 2006; Wesselink et al., 2015; Fukushima et al., 2017)
Implementation Competence	Ability to put sustainability strategies (action plans) into action, including implementation, adaptation, transfer and scaling, in effective and efficient ways.	Implement, enact, adapt, manage, transfer, scale action plans, strategies, change plans, intervention plans, governance initiatives, etc.(de Haan, 2006; Perez Salgado et al., 2018; Schank and Rieckmann, 2019)
Inter-personal Competence	Ability 1) to collaborate successfully in inter-disciplinary and -professional teams; and 2) to involve diverse stakeholders, in meaningful and effective ways, in advancing sustainability transformations.	Enable, motivate, facilitate interdisciplinary, transdisciplinary, cross-cultural collaboration in teams and among stakeholders through listening, compassionate communication, negotiation, conflict resolution, empathic leadership, etc.(Ulrich, 2016; Brundiers and Wiek, 2017; Sarpin et al., 2018)
Intra-personal Competence	Ability to avoid personal health challenges and burnout in advancing sustainability transformations through resilience-oriented self-care (awareness and self-regulation)	Reflect, motivate, have respect for, be responsible, be empathetic, self-care for identity, commitment, feelings, burnout, personal boundaries, limits of capacity, etc.(Glasser, 2016; Lozano et al., 2017; Giangrande et al., 2019)
Integration Competence	Ability to apply collective problem-solving procedures to complex sustainability problems: 1) to develop viable sustainability strategies (action plans); and 2) successfully implement them, in collaborative and self-caring ways.	Develop, apply, promote, make decisions to advance sustainability by using viable, equitable, and inclusive solution processes, procedures, frameworks, schemes, etc.(Jegstad and Sinnes, 2015; Hull et al., 2016; Wiek et al., 2016)



**FIGURE 5 |** Percentage of sampled publications (n = 272) that can be mapped onto the three emerging competencies (1997–2020).



**FIGURE 6 |** Unified framework of competencies for advancing sustainability transformations; centered on 8 key competencies in sustainability with 5 established (bold) and 3 emerging (italic); and complemented by disciplinary, general, and other professional competencies.

**Disciplinary competence:** There is broad agreement that advancing sustainability transformations requires content-dependent competencies, e.g., on climate, water, energy, food, and international development (Dale and Newman, 2005; Demssie et al., 2019). Disciplinary specialties will be critical complements to the content-independent sustainability competencies, resulting in “t-”, “pi” or “shield” shaped professional profiles (Uhlenbrook and de Jong, 2012; Conley et al., 2017; Pennington et al., 2020).

**General:** Although there are no universally agreed-upon general competencies, Binkley et al. (2012) distilled a broad sample of literature into a set of ten so-called “21<sup>st</sup> century skills”. Three of these general competencies were also frequently mentioned in the literature reviewed in the present study and can therefore be considered important complementary general competencies for advancing sustainability transformations, namely, the abilities of critical thinking, creativity, and learning.

**Professional Competencies:** As indicated above, inter- and intra-personal competencies are considered key competencies in sustainability, shared mostly with other caring professions, e.g., medicine, nursing, social work. In addition, two other, more “regular”, professional competencies, namely (advanced)

compassionate communication and responsive project management, are important for advancing sustainability transformations on a more basic level (MacDonald and Shriberg, 2016; Brundiers and Wiek, 2017; Lozano et al., 2017).

## DISCUSSION

This systematic review of the growing body of literature found, despite appearance to the contrary, a convergence on learning objectives in sustainability education around a discrete set of key competencies. In particular, the five key competencies described through a framework in 2011 (Wiek et al., 2011), namely, systems-thinking, anticipatory, normative, strategic, and interpersonal competence, have gained widespread use. Several productive propositions have emerged as well. Integrating the advances of the last decade, a framework of eight key competencies in sustainability is described, along with three classes of complementary competencies which form the best published scholarly knowledge of how to equip sustainability change agents to advance sustainability transformations. While this study focused on the

perspectives captured in the literature, reviews of university sustainability programs (Trencher et al., 2018; Salovaara et al., 2020) and expert surveys (Rieckmann, 2012; Demssie et al., 2019; Brundiars et al., 2021) largely align with the findings presented here.

Zooming into the review results, systems thinking is the most established of the planning competencies, followed by interpersonal competence, which is addressed in many project-based sustainability courses (Konrad et al., 2020) (Figure 4). However, these are the less transformative of the key competencies. Futures-, values-, and strategies-thinking competencies, so far established to a lesser extent, are critical for change that disrupts the status quo (Hsu, 2020). These competencies enable graduates and professionals to envision sustainable futures, based on the SDGs, and develop effective and efficient strategies (action plans) to achieve them.

Beyond this, the three emerging competencies are much more unconventional, if not controversial. First, the aspects included as intrapersonal competence (self-awareness and self-care) are not part of typical learning objectives (Shephard, 2008; Frank, 2021), and do not fit well with how competencies are generally defined (Shephard et al., 2019; Gómez-Olmedo et al., 2020). Yet, this points more to a broader issue in education: medical schools, for example, having long realized they need to address emotional, and not just intellectual development in students (Coombs and Virshup, 1994). Second, while addressing sustainability problems is a common theme in sustainability education at the university level (Brundiars et al., 2010), this does not usually mean fully preparing graduates for *doing* sustainability (Alvarez and Rogers, 2006). Implementation competence calls for that to change, yet, this is a largely unexplored space for university programs. Finally, this review showed that like other scientists, those in sustainability continue to dissect holistic processes (i.e., problem-solving), into constituent parts (i.e., lists of competencies, as in (Lozano et al., 2017)). Integration competence pushes against this tendency and urges an emphasis on educating for the connections between competencies.

Sustainability science has developed and adopted a variety of approaches to solving problems (Angelstam et al., 2013; Polk, 2014; Wiek and Lang, 2016; Henry, 2018), with initial attempts to explore how that can shape education (Wei et al., 2020). The unified framework centers on how professionals can best collectively engage in sustainability problem solving and advancing sustainability transformations. Through this foundation, the framework is explicitly *not* intended to serve any specific discipline but should be adoptable by *all* disciplines and fields (with some relevance to sustainability). The framework offers a base from which to build off and specify learning objectives in life science, engineering, business, or teacher's education, to name a few. To this end, the language of the unified framework has been further universalized (e.g., "normative" is often mistranslated), and disciplinary competencies are now situated within this more extended framework.

The reviewed literature focused on publications in English, which underrepresents large regions of the world; a problem confirmed in other studies (Weiss and Barth, 2019). Indeed, there is, for example, a growing discourse in Latin America (in Spanish) around how to develop sustainability education (Dieleman and Juarez-Najera, 2008). We found that

specifically with regards to learning objectives in sustainability little has been published (in English) by researchers from outside the OECD. After many early calls for it (Mochizuki and Fadeeva, 2010), publications from underrepresented countries have recently increased (23 of 25 identified were published in the last 5 years), but more comprehensive inclusion of these perspectives is needed.

## CONCLUSIONS

The results of this study show that, despite terminological differences, there is substantive convergence in the literature on what change agents need to be capable of to advance social transformations to sustainability. On this basis, the article describes a framework of eight key competencies in sustainability, broadly applicable to sustainability education in all disciplines. The unified framework of key competencies in sustainability links science, education, and society in the joint effort of broadening and accelerating transformations towards the Sustainable Development Goals. This does not mark the endpoint of needed research, rather an opportunity to make much needed advances. Three immediate needs include: 1) research and development of the emerging competencies; 2) operationalization of the framework across disciplines, learning settings, and global contexts; and 3) testing the framework in real-world problem-solving settings. Even more fundamental though is the need for the community of scholars to come together and better coordinate their efforts. Complementary and comparative studies would overcome the current fractured structure of the field and allow for more robust and accelerated advances.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

## AUTHOR CONTRIBUTIONS

AR and AW designed the research project together and structured the article and wrote the article together. AW secured the funding, and AR did the data collection and full literature review. Both authors approved the submitted version.

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## REFERENCES

- Alvarez, A., and Rogers, J. (2006). Going “Out There”: Learning about Sustainability in Place. *Int. J. Sus. Higher Ed.* 7, 176–188. doi:10.1108/14676370610655940
- Anderson, M. D. (2013). Higher education revisited: Sustainability science and teaching for sustainable food systems. *Future of food: State of the art, challenges and options for action*. Editors S. Albrecht and R. Braun (Cambridge: UIT), 179–188.
- Angelstam, P., Andersson, K., Annerstedt, M., Axelsson, R., Elbakidze, M., Garrido, P., et al. (2013). Solving Problems in Social-Ecological Systems: Definition, Practice and Barriers of Transdisciplinary Research. *Ambio* 42, 254–265. doi:10.1007/s13280-012-0372-4
- Archambault, L., Warren, A., and Hartwell, L. (2013). Preparing Future Educators: Sustainability Education Framework for Teachers (SEFT). *Society for Information Technology & Teacher Education International Conference*, 174–179.
- Barrie, S. C. (2006). Understanding what We Mean by the Generic Attributes of Graduates. *High. Educ.* 51, 215–241. doi:10.1007/s10734-004-6384-7
- Barth, M. (2015). *Implementing Sustainability in Higher Education: Learning in an Age of Transformation*. London: Routledge.
- Barth, M., Godemann, J., Rieckmann, M., and Stoltenberg, U. (2007). Developing Key Competencies for Sustainable Development in Higher Education. *Int. J. Sus. Higher Ed.* 8, 416–430. doi:10.1108/14676370710823582
- Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., et al. (2012). “Defining Twenty-First Century Skills,” in *Assessment and Teaching of 21st Century Skills* (Dordrecht: Springer Netherlands), 17–66. doi:10.1007/978-94-007-2324-5\_2
- Boone, C. (2015). On Hope and Agency in Sustainability: Lessons from Arizona State University. *J. Sustain. Educ.*, 10.
- Brundiers, K., Barth, M., Cebrián, G., Cohen, M., Diaz, L., Doucette-Remington, S., et al. (2021). Key Competencies in Sustainability in Higher Education—Toward an Agreed-Upon Reference Framework. *Sustain. Sci.* 16, 13–29. doi:10.1007/s11625-020-00838-2
- Brundiers, K., and Wiek, A. (2017). Beyond Interpersonal Competence: Teaching and Learning Professional Skills in Sustainability. *Edu. Sci.* 7, 39. doi:10.3390/educsci7010039
- Brundiers, K., Wiek, A., and Redman, C. L. (2010). Real-world Learning Opportunities in Sustainability: from Classroom into the Real World. *Int. J. Sus. Higher Ed.* 11, 308–324. doi:10.1108/14676371011077540
- Clark, C. R. (2016). Collective Action Competence: an Asset to Campus Sustainability. *Int. J. Sus. Higher Ed.* 17, 559–578. doi:10.1108/IJSHE-04-2015-0073
- Conley, S. N., Foley, R. W., Gorman, M. E., Denham, J., and Coleman, K. (2017). Acquisition of T-Shaped Expertise: an Exploratory Study. *Social Epistemology* 31, 165–183. doi:10.1080/02691728.2016.1249435
- Connell, K. H., Remington, S., and Armstrong, C. (2012). Assessing Systems Thinking Skills in Two Undergraduate Sustainability Courses: A Comparison of Teaching Strategies. *J. Sustain. Educ.*, 3.
- Coombs, R. H., and Virshup, B. B. (1994). Enhancing the Psychological Health of Medical Students: the Student Well-Being Committee. *Med. Educ.* 28, 47–7. doi:10.1111/j.1365-2923.1994.tb02684.x
- Crick, R. D. (2008). Key Competencies for Education in a European Context: Narratives of Accountability or Care. *Eur. Educ. Res. J.* 7, 311–318. doi:10.2304/eej.2008.7.3.311
- Dale, A., and Newman, L. (2005). Sustainable Development, Education and Literacy. *Int. J. Sus. Higher Ed.* 6, 351–362. doi:10.1108/14676370510623847
- Dawe, G., Jucker, R., and Martin, S. (2005). *Sustainable Development in Higher Education: Current Practice and Future Developments*. York, United Kingdom: A Rep. High. Educ. Acad.

## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2021.785163/full#supplementary-material>

- de Haan, G. (2006). The BLK ‘21’ Programme in Germany: a ‘Gestaltungskompetenz’-based Model for Education for Sustainable Development. *Environ. Edu. Res.* 12, 19–32. doi:10.1080/13504620500526362
- Demssie, Y. N., Wesselink, R., Biemans, H. J. A., and Mulder, M. (2019). Think outside the European Box: Identifying Sustainability Competencies for a Base of the Pyramid Context. *J. Clean. Prod.* 221, 828–838. doi:10.1016/j.jclepro.2019.02.255
- Dieleman, H., and Juarez-Najera, M. (2008). Cómo se puede diseñar educación para la sustentabilidad. *Rev. Int. Contam. Ambient.* 24, 131–147.
- Evans, T. L. (2019). Competencies and Pedagogies for Sustainability Education: A Roadmap for Sustainability Studies Program Development in Colleges and Universities. *Sustainability* 11, 5526. doi:10.3390/su11195526
- Fink, A. (2014). *Conducting Research Literature Reviews: From the Internet to Paper*. 4th ed. Available at: <http://orbis.uottawa.ca/record=b4571892~S0>.
- Franco, I., Saito, O., Vaughter, P., Whereat, J., Kanie, N., and Takemoto, K. (2019). Higher Education for Sustainable Development: Actioning the Global Goals in Policy, Curriculum and Practice. *Sustain. Sci.* 14, 1621–1642. doi:10.1007/s11625-018-0628-4
- Frank, P. (2021). A Proposal of Personal Competencies for Sustainable Consumption. *Int. J. Sustain. High. Educ.* 22, 1225–1245. doi:10.1108/IJSHE-01-2020-0027
- Frisk, E., and Larson, K. L. (2011). Educating for Sustainability: Competencies & Practices for Transformative Action. *J. Sustain. Educ.*, 2.
- Fukushima, Y., Ishimura, G., Komazinski, A. J., Omoto, R., and Managi, S. (2017). Education and Capacity Building with Research: a Possible Case for Future Earth. *Int. J. Sus. Higher Ed.* 18, 263–276. doi:10.1108/IJSHE-10-2015-0170
- Galleli, B., Hourneaux Jr, F., Jr, and Munck, L. (2019). Sustainability and Human Competences: a Systematic Literature Review. *Bij* 27, 1981–2004. doi:10.1108/BIJ-12-2018-0433
- Gardiner, S., and Rieckmann, M. (2015). Pedagogies of Preparedness: Use of Reflective Journals in the Operationalisation and Development of Anticipatory Competence. *Sustainability* 7, 10554–10575. doi:10.3390/su70810554
- Giangrande, N., White, R. M., East, M., Jackson, R., Clarke, T., Saloff Coste, M., et al. (2019). A Competency Framework to Assess and Activate Education for Sustainable Development: Addressing the UN Sustainable Development Goals 4.7 Challenge. *Sustainability* 11, 2832. doi:10.3390/su11102832
- Glasser, H. (2016). Toward the Development of Robust Learning for Sustainability Core Competencies. *Sustainability: J. Rec.* 9, 121–134. doi:10.1089/su.2016.29054.hg
- Gómez-Olmedo, A. M., Valor, C., and Carrero, I. (2020). Mindfulness in Education for Sustainable Development to Nurture Socioemotional Competencies: a Systematic Review and Meta-Analysis. *Environ. Edu. Res.* 26, 1527–1555. doi:10.1080/13504622.2020.1777264
- Gordon, I. J., Bawa, K., Bammer, G., Boone, C., Dunne, J., Hart, D., et al. (2019). Forging Future Organizational Leaders for Sustainability Science. *Nat. Sustain.* 2, 647–649. doi:10.1038/s41893-019-0357-4
- Gray, S. (2018). Measuring Systems Thinking. *Nat. Sustain.* 1, 388–389. doi:10.1038/s41893-018-0121-1
- Grosbeck, G., Țiru, L. G., and Bran, R. A. (2019). Education for Sustainable Development: Evolution and Perspectives: A Bibliometric Review of Research, 1992–2018. *Sustainability* 11, 6136. doi:10.3390/su11216136
- Hallinger, P., and Chatpinyakoo, C. (2019). A Bibliometric Review of Research on Higher Education for Sustainable Development, 1998–2018. *Sustainability* 11, 2401. doi:10.3390/su11082401
- Heiskanen, E., Thidell, A., and Rodhe, H. (2016). Educating Sustainability Change Agents: the Importance of Practical Skills and Experience. *J. Clean. Prod.* 123, 218–226. doi:10.1016/j.jclepro.2015.11.063
- Henry, A. D. (2018). Learning Sustainability Innovations. *Nat. Sustain.* 1, 164–165. doi:10.1038/s41893-018-0053-9

- Hsu, L. P. (2020). Visioning the Future: Evaluating Learning Outcomes and Impacts of Futures-Oriented Education. *J. Futur. Stud.* 24, 103–116. doi:10.6531/JFS.202006\_24(4).0011
- Hull, R. B., Kimmel, C., Robertson, D. P., and Mortimer, M. (2016). International Field Experiences Promote Professional Development for Sustainability Leaders. *Int. J. Sustain. High. Educ.* 17, 86–104. doi:10.1108/IJSHE-07-2014-0105
- Jarchow, M. E., Formisano, P., Nordyke, S., and Sayre, M. (2018). Measuring Longitudinal Student Performance on Student Learning Outcomes in Sustainability Education. *Int. J. Sustain. High. Educ.* 19, 547–565. doi:10.1108/IJSHE-11-2016-0200
- Jegstad, K. M., and Sinnes, A. T. (2015). Chemistry Teaching for the Future: A Model for Secondary Chemistry Education for Sustainable Development. *Int. J. Sci. Edu.* 37, 655–683. doi:10.1080/09500693.2014.1003988
- Kieu, T. K., Singer, J., and Gannon, T. J. (2016). Education for Sustainable Development in Vietnam: Lessons Learned from Teacher Education. *Int. J. Sus. Higher Ed.* 17, 853–874. doi:10.1108/ijsh-05-2015-0098
- Komasinkski, A., and Ishimura, G. (2017). Critical Thinking and Normative Competencies for Sustainability Science Education. *J. High. Educ. Lifelong Learn.* 24, 21–37. doi:10.14943/J.HighEdu.24.21
- Konrad, T., Wiek, A., and Barth, M. (2020). Embracing Conflicts for Interpersonal Competence Development in Project-Based Sustainability Courses. *Int. J. Sus. Higher Ed.* 21, 76–96. doi:10.1108/IJSHE-06-2019-0190
- Lans, T., Blok, V., and Wesselink, R. (2014). Learning Apart and Together: towards an Integrated Competence Framework for Sustainable Entrepreneurship in Higher Education. *J. Clean. Prod.* 62, 37–47. doi:10.1016/j.jclepro.2013.03.036
- Levy, M. A., Lubell, M. N., and McRoberts, N. (2018). The Structure of Mental Models of Sustainable Agriculture. *Nat. Sustain.* 1, 413–420. doi:10.1038/s41893-018-0116-y
- Linnér, B.-O., and Wibeck, V. (2019). *Sustainability Transformations: Agents and Drivers across Societies*. Cambridge University Press. doi:10.1017/9781108766975
- Lozano, R., Merrill, M., Sammalisto, K., Ceulemans, K., and Lozano, F. (2017). Connecting Competences and Pedagogical Approaches for Sustainable Development in Higher Education: A Literature Review and Framework Proposal. *Sustainability* 9, 1889. doi:10.3390/su9101889
- MacDonald, L., and Shriberg, M. (2016). Sustainability Leadership Programs in Higher Education: Alumni Outcomes and Impacts. *J. Environ. Stud. Sci.* 6, 360–370. doi:10.1007/s13412-015-0344-7
- Mahaffy, P. G., Matlin, S. A., Holme, T. A., and MacKellar, J. (2019). Systems Thinking for Education about the Molecular Basis of Sustainability. *Nat. Sustain.* 2, 362–370. doi:10.1038/s41893-019-0285-3
- McCarthy, B., and Eagle, L. (2021). Are the Sustainability-Oriented Skills and Competencies of Business Graduates Meeting or Missing Employers' Needs? Perspectives of Regional Employers. *Aust. J. Environ. Educ.*
- Mochizuki, Y. (2016). Educating for Transforming Our World: Revisiting International Debates Surrounding Education for Sustainable Development. *Curr. Issues Comp. Educ.* 19, 109–125.
- Mochizuki, Y., and Fadeeva, Z. (2010). Competences for Sustainable Development and Sustainability. *Int. J. Sus. Higher Ed.* 11, 391–403. doi:10.1108/14676371011077603
- Mogensen, F., and Schnack, K. (2010). The Action Competence Approach and the 'new' Discourses of Education for Sustainable Development, Competence and Quality Criteria. *Environ. Edu. Res.* 16, 59–74. doi:10.1080/13504620903504032
- O'Byrne, D., Dripps, W., and Nicholas, K. A. (2015). Teaching and Learning Sustainability: An Assessment of the Curriculum Content and Structure of Sustainability Degree Programs in Higher Education. *Sustain. Sci.* 10, 43–59. doi:10.1007/s11625-014-0251-y
- Ojala, M. (2017). Hope and Anticipation in Education for a Sustainable Future. *Futures* 94, 76–84. doi:10.1016/j.futures.2016.10.004
- Orr, D. (2003). Four Challenges of Sustainability. *Conserv. Biol.* 16, 1457–1460.
- Pennington, D., Ebert-Uphoff, I., Freed, N., Martin, J., and Pierce, S. A. (2020). Bridging Sustainability Science, Earth Science, and Data Science through Interdisciplinary Education. *Sustain. Sci.* 15, 647–661. doi:10.1007/s11625-019-00735-3
- Perez Salgado, F., Abbott, D., and Wilson, G. (2018). Dimensions of Professional Competences for Interventions towards Sustainability. *Sustain. Sci.* 13, 163–177. doi:10.1007/s11625-017-0439-z
- Polk, M. (2014). Achieving the Promise of Transdisciplinarity: a Critical Exploration of the Relationship between Transdisciplinary Research and Societal Problem Solving. *Sustain. Sci.* 9, 439–451. doi:10.1007/s11625-014-0247-7
- R Core Team (2020). R: A Language and Environment for Statistical Computing. Redman, A., Rowe, D., Brundiers, K., and Brock, A. (2021). What Motivates Students to Be Sustainability Change Agents in the Face of Adversity. *Sustainability Clim. Change* 14, 313–322. doi:10.1089/scc.2021.0024
- Redman, E., Wiek, A., and Redman, A. (2018). Continuing Professional Development in Sustainability Education for K-12 Teachers: Principles, Programme, Applications, Outlook. *J. Edu. Sust. Dev.* 12, 59–80. doi:10.1177/2455133318777182
- Remington-Doucette, S. M., Hiller Connell, K. Y., Armstrong, C. M., and Musgrove, S. L. (2013). Assessing Sustainability Education in a Transdisciplinary Undergraduate Course Focused on Real-world Problem Solving. *Int. J. Sus. Higher Ed.* 14, 404–433. doi:10.1108/IJSHE-01-2012-0001
- Richard, V., Forget, D., and Gonzalez-Bautista, N. (2017). "Implementing Sustainability in the Classroom at Université Laval," in *Handbook of Theory and Practice of Sustainable Development in Higher Education* (Cham, Switzerland), 133–147. doi:10.1007/978-3-319-47895-1\_9
- Rieckmann, M. (2012). Future-oriented Higher Education: Which Key Competencies Should Be Fostered through university Teaching and Learning. *Futures* 44, 127–135. doi:10.1016/j.futures.2011.09.005
- Rodríguez-Aboytes, J. G., and Nieto-Caraveo, L. M. (2018). "Assessment of Competencies for Sustainability in Secondary Education in México," in *ambiental.uaslp.mx*.
- Rychen, D. S., and Salganik, L. H. (2000). "Definition and Selection of Key Competencies," in *Fourth General Assembly of the OECD Education Indicators Programme* (Tokyo, Japan), 61–73.
- Salovaara, J. J., Soini, K., and Pietikäinen, J. (2020). Sustainability Science in Education: Analysis of Master's Programmes' Curricula. *Sustain. Sci.* 15, 901–915. doi:10.1007/s11625-019-00745-1
- Sandri, O. J. (2013). Threshold Concepts, Systems and Learning for Sustainability. *Environ. Edu. Res.* 19, 810–822. doi:10.1080/13504622.2012.753413
- Sarpin, N., Kasim, N., Zainal, R., and Noh, H. M. (2018). "A Guideline for Interpersonal Capabilities Enhancement to Support Sustainable Facility Management Practice," in *IOP Conference Series: Earth and Environmental Science* (Institute of Physics Publishing), Langkawi, Malaysia, 4–5 December 2017 (OP Publishing Ltd), 012116. doi:10.1088/1755-1315/140/1/012116
- Schank, C., and Rieckmann, M. (2019). Socio-economically Substantiated Education for Sustainable Development: Development of Competencies and Value Orientations between Individual Responsibility and Structural Transformation. *J. Edu. Sust. Dev.* 13, 67–91. doi:10.1177/0973408219844849
- Schuler, S., Fanta, D., Rosenkraenzler, F., and Riess, W. (2018). Systems Thinking within the Scope of Education for Sustainable Development (ESD) - a Heuristic Competence Model as a Basis for (Science) Teacher Education. *J. Geogr. Higher Edu.* 42, 192–204. doi:10.1080/03098265.2017.1339264
- Scoones, I., Stirling, A., Abrol, D., Atela, J., Charli-Joseph, L., Eakin, H., et al. (2020). Transformations to Sustainability: Combining Structural, Systemic and Enabling Approaches. *Curr. Opin. Environ. Sustainability* 42, 65–75. doi:10.1016/j.cosust.2019.12.004
- Shephard, K. (2008). Higher Education for Sustainability: Seeking Affective Learning Outcomes. *Int. J. Sus. Higher Ed.* 9, 87–98. doi:10.1108/14676370810842201
- Shephard, K., Rieckmann, M., and Barth, M. (2019). Seeking Sustainability Competence and Capability in the ESD and HESD Literature: an International Philosophical Hermeneutic Analysis. *Environ. Edu. Res.* 25, 532–547. doi:10.1080/13504622.2018.1490947
- Sipos, Y., Battisti, B., and Grimm, K. (2008). Achieving Transformative Sustainability Learning: Engaging Head, Hands and Heart. *Int. J. Sustain. High. Educ.* 9, 68–86. doi:10.1108/14676370810842193
- Snyder, H. (2019). Literature Review as a Research Methodology: An Overview and Guidelines. *J. Business Res.* 104, 333–339. doi:10.1016/j.jbusres.2019.07.039
- Steiner, G., and Scherr, J. (2013). Higher Education for Complex Real-World Problems and Innovation: A Tribute to Heufler's Industrial Design Approach. *Ce* 04, 130–136. doi:10.4236/ce.2013.47A2016

- Sterling, S., Glasser, H., Rieckmann, M., and Warwick, P. (2017). Envisioning futures for environmental and sustainability education. *Envisioning futures for environmental and sustainability education*. Editors P. B. Corcoran, J. P. Weakland, and A. E. J. Wals (The Netherlands: Wageningen Academic Publishers), 153–168. doi:10.3920/978-90-8686-846-9\_10
- Thomas, I., and Millar, S. (2016). Sustainability, Education and Local Government: Insights from the Australian State of Victoria. *Local Environ.* 21, 1482–1499. doi:10.1080/13549839.2016.1140131
- Trencher, G., Vincent, S., Bahr, K., Kudo, S., Markham, K., and Yamanaka, Y. (2018). Evaluating Core Competencies Development in Sustainability and Environmental Master's Programs: An Empirical Analysis. *J. Clean. Prod.* 181, 829–841. doi:10.1016/j.jclepro.2018.01.164
- Uhlenbrook, S., and de Jong, E. (2012). T-shaped Competency Profile for Water Professionals of the Future. *Hydrol. Earth Syst. Sci.* 16, 3475–3483. doi:10.5194/hess-16-3475-2012
- Ulrich, M. E. (2016). Learning Relational Ways of Being: What Globally Engaged Scholars Have Learned about Global Engagement and Sustainable Community Development.
- UNESCO (2017). *Education for Sustainable Development Goals: Learning Objectives*. Paris: France.
- Van Dam-Mieras, R., Lansu, A., Rieckmann, M., and Michelsen, G. (2008). Development of an Interdisciplinary, Intercultural Master's Program on Sustainability: Learning from the Richness of Diversity. *Innov. High. Educ.* 32, 251–264. doi:10.1007/s10755-007-9055-7
- Verma, P., Vaughan, K., Martin, K., Pulitano, E., Garrett, J., and Piirto, D. D. (2016). Integrating Indigenous Knowledge and Western Science into Forestry, Natural Resources, and Environmental Programs. *J. For.* 114, 648–655. doi:10.5849/jof.15-090
- Vincent, S., and Focht, W. (2009). US Higher Education Environmental Program Managers' Perspectives on Curriculum Design and Core Competencies. *Int. J. Sus. Higher Ed.* 10, 164–183. doi:10.1108/14676370910945963
- Voogt, J., and Roblin, N. P. (2012). A Comparative Analysis of International Frameworks for 21st century Competences: Implications for National Curriculum Policies. *J. Curriculum Stud.* 44, 299–321. doi:10.1080/00220272.2012.668938
- Wei, C. A., Deaton, M. L., Shume, T. J., Berardo, R., and Burnside, W. R. (2020). A Framework for Teaching Socio-Environmental Problem-Solving. *J. Environ. Stud. Sci.* 10, 467–477. doi:10.1007/s13412-020-00603-y
- Weiss, M., and Barth, M. (2019). Global Research Landscape of Sustainability Curricula Implementation in Higher Education. *Int. J. Sus. Higher Ed.* 20, 570–589. doi:10.1108/IJSHE-10-2018-0190
- Wesselink, R., Blok, V., van Leur, S., Lans, T., and Dentoni, D. (2015). Individual Competencies for Managers Engaged in Corporate Sustainable Management Practices. *J. Clean. Prod.* 106, 497–506. doi:10.1016/j.jclepro.2014.10.093
- Wiek, A., Bernstein, M. J., Rider, W. F., Cohen, M., Forrest, N., Kuzdas, C., et al. (2016). "Operationalising Competencies in Higher Education for Sustainable Development," in *Handbook of Higher Education for Sustainable Development*. Editors M. Barth, G. Michelsen, M. Rieckmann, and I. Thomas (London: Routledge), 297–317.
- Wiek, A., and Lang, D. J. (2016). "Transformational Sustainability Research Methodology," in *Sustainability Science: An Introduction*. Editors H. Heinrichs, P. Martens, G. Michelsen, and A. Wiek (New York, Berlin: Springer), 31–41. doi:10.1007/978-94-017-7242-6
- Wiek, A., and Redman, A. (2021). "What Do Key Competencies in Sustainability Offer and How to Use Them," in *Competencies in Education for Sustainable Development – Critical Perspectives*. Editors P. Vare, N. Lausset, and M. Rieckmann (New York, Berlin: Springer).
- Wiek, A., Withycombe, L., and Redman, C. L. (2011). Key Competencies in Sustainability: a Reference Framework for Academic Program Development. *Sustain. Sci.* 6, 203–218. doi:10.1007/s11625-011-0132-6
- Wilhelm, S., Förster, R., and Zimmermann, A. (2019). Implementing Competence Orientation: Towards Constructively Aligned Education for Sustainable Development in University-Level Teaching-And-Learning. *Sustainability* 11, 1891. doi:10.3390/su11071891
- Withycombe, L. K. (2010). Anticipatory Competence as a Key Competence in Sustainability Education. Master Thesis, School of Sustainability, Arizona State University.
- Withycombe Keeler, L., Gabriele, A., Kay, B. R., and Wiek, A. (2017). Future Shocks and City Resilience: Building Organizational Capacity for Resilience and Sustainability through Game Play and Ways of Thinking. *Sustain. J. Rec.* 10, 282. doi:10.1089/sus.2017.0011
- Wolbring, G., and Burke, B. (2013). Reflecting on Education for Sustainable Development through Two Lenses: Ability Studies and Disability Studies. *Sustainability* 5, 2327–2342. doi:10.3390/su5062327

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