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Development of Sustainability Competencies in Secondary School Education: A Scoping Literature Review

Kate Sposab * and Marco Rieckmann

Department of Education, Faculty I, University of Vechta, 49377 Vechta, Germany; marco.rieckmann@uni-vechta.de
* Correspondence: kate.sposab@mail.uni-vechta.de

Abstract: This scoping review examines the development and application of sustainability competence frameworks in secondary education worldwide, identifying key trends and challenges in the field. An initial pool of 2659 peer-reviewed publications from 2003 to 2023 were subjected to a rigorous, multi-stage screening process, resulting in a refined selection for in-depth analysis. Through qualitative clustering, the review identifies two primary perspectives on sustainability competencies. The first perspective emphasizes transversal competencies, applicable across diverse educational contexts, including national policies, global educational guidelines, various subject areas, and innovative teaching and learning approaches. The second perspective focuses on specific frameworks that address the cognitive, affective, and behavioral dimensions of sustainability. The review highlights a global consensus on the importance of key competencies such as critical thinking, systems thinking, and action competence, which are essential for preparing secondary students to address sustainability challenges. Additionally, it underscores the need for a holistic approach to competence development that integrates cognitive, affective, and behavioral components. Despite this consensus, the review identifies a research bias, with a predominance of studies from Europe, particularly Germany and Sweden, and calls for increased regional diversity and collaboration in future research.

Keywords: sustainability competencies; education for sustainable development; secondary school education; literature review; scoping review

Citation: Sposab, K.; Rieckmann, M. Development of Sustainability Competencies in Secondary School Education: A Scoping Literature Review. *Sustainability* **2024**, *16*, 10228. https://doi.org/10.3390/su162310228

Academic Editor: David González-Gómez

Received: 26 September 2024
Revised: 8 November 2024
Accepted: 19 November 2024
Published: 22 November 2024

1. Introduction

The global recognition of sustainability is increasing across various sectors, including urban planning, healthcare, culture, and others. Education is widely recognized as a crucial instrument for achieving sustainable development goals, as it empowers individuals to contribute effectively to societal well-being [1,2]. Many researchers worldwide emphasize the importance of a competence-based approach in Education for Sustainable Development (ESD), highlighting the need to integrate sustainability competencies into secondary education [3–6].

1.1. Education for Sustainable Development

Sustainability has become a prominent concept across diverse areas of human existence. Worldwide authorities, international organizations, and community groups are increasingly recognizing the need to shift current trends in natural resource use. They are prepared to adopt innovative economic, social, cultural, and political approaches to achieve sustainable solutions at both societal and individual levels.

These changes are intended to impact all individuals; therefore, the tools and methods for implementation should be universally applicable, regardless of geographical, cultural, or political differences. Education empowers individuals, fostering both personal growth and the capacity to contribute to the collective well-being and prosperity of global society [1].

Since the early 1990s, decision-makers, educators, and academics at various levels have recognized education as essential for achieving sustainable development goals. This involves empowering learners to make well-informed choices and take responsible actions to protect the environment, promote economic sustainability, advance social justice, and preserve cultural diversity for current and future generations [2]. Education for Sustainability, also known as Education for Sustainable Development (ESD), has gained increasing recognition and importance at global sustainability summits and in key agreements, including the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa; the 2012 UN Conference on Sustainable Development (UNCSD) in Rio de Janeiro, Brazil; and the 2015 UN Sustainable Summit in New York, USA.

Unlike conventional input-focused education, early ESD program documents and research articles emphasized learning outcomes and an output-oriented approach [3,7–9]. Among educational researchers and policymakers, the concept of competencies as intended learning outcomes has gained popularity. This concept has gradually incorporated various emerging ESD initiatives and programs focused on both student and teacher education, emphasizing competence-based approaches.

1.2. Competence-Based Approach in ESD

Interest in sustainability and ESD competencies among researchers and practitioners grew consistently from 2005 to 2008, as noted by Redman, Wiek and Barth [10]. Notable differences exist between sustainability competencies for learners and ESD competencies for teachers and educators, as highlighted by Cebrián, Junyent, and Mulà [11]. This study focuses exclusively on sustainability competencies, aiming to establish their definition and classification.

Scholars are increasingly focused on sustainability competencies for several reasons. A growing number of sustainability science programs have been developed to meet the demand for skilled professionals who can facilitate societal transitions toward sustainability. Learning objectives in various programs are increasingly framed in terms of sustainability competencies, as discussed by Redman, Wiek, and Barth [10]. The interest in developing and assessing sustainability competencies in higher education has emerged from the need to prepare students to address sustainability issues [12]. Developing sustainability research competencies through undergraduate research experiences is essential, given the complex nature of global challenges such as climate change and biodiversity loss, which require researchers with specialized sustainability research skills [13].

In addition to specialized frameworks and models of sustainability competencies, numerous practitioners and researchers in the field of ESD within school education worldwide have drawn on the concept of 21st Century Skills [14]. This concept, however, has a broader application, extending beyond sustainability to encompass various educational paradigms, including citizenship education, democratic education, and more.

Educators from various countries have adhered to international policy guidelines on ESD by adapting programs and learning environments to focus on developing the essential knowledge, skills, attitudes, and values needed to address sustainability challenges. They have sought suitable competence frameworks and models, validating them through extensive programs, national curriculum frameworks, and school networking initiatives for ESD implementation. Since the late 1990s, numerous comprehensive programs have been launched to implement ESD in schools. Examples include the German initiatives BLK "21" Programme (1999–2004) and Transfer-21 (2004–2008), as well as the German National Action Plan to support sustainability initiatives, the Danish National ESD Strategy (2009), the National ESD Strategy in Ireland (2014), and others.

Some prominent researchers in ESD have used the OECD's concept of 'key competencies' as a reference framework for evaluating the outcomes of both large and small-scale projects, as well as networking activities [4,5,15]. Others have referred to definitions of learning outcomes from UNESCO and UN education policy documents [16–18]. Regardless of the type of educational system—be it secondary school, higher education, or vocational

education—most researchers agree that key competencies encompass cognitive and practical skills, creative abilities, and psychosocial resources such as attitudes, motivation, and values [19]. However, there is disagreement on the definition of "sustainability competence" and which framework of sustainability competencies is appropriate for specific educational levels.

This situation is partially attributed to the contextual nature of sustainability content: to effectively influence actions as intended, knowledge, values, and skills related to sustainability issues must be deeply embedded in local social, economic, cultural, and environmental contexts [20]. Consequently, a variety of academic approaches are emerging regarding the form and content of sustainability competencies. While some approaches are more closely aligned with local cultural and educational contexts, others focus on covering the necessary knowledge, skills, and attitudes related to the concept of sustainability and its challenges, as described in UNESCO and UN program documents or derived from specific conceptual research, such as competence frameworks developed by de Haan, Rieckmann, and Wiek [3,6,15,21].

"We understand the term 'sustainability competency' as the combination of cognitive skills, practical abilities, and ethical values and attitudes mobilized in a real situation or context related to sustainability" [22] (p. 2769). This definition is a crucial aspect that many researchers emphasize when shaping the concept of sustainability competencies. It highlights the importance of encouraging students to develop these competencies beyond the classroom, through community-based research projects, service-learning initiatives, or other experiential learning settings where they engage with contemporary ecological, social, and economic issues.

Although this scoping literature review presents a variety of approaches to sustainability competencies, it is important to note that many of them are based on F.E. Weinert's conceptual clarifications of key competencies, which are described as "combinations of those cognitive, motivational, moral, and social skills available to (or potentially learnable by) a person or a social group [. . .] through appropriate understanding and actions of a range of demands, tasks, problems, and goals" [23] (p. 2433). National educational frameworks and global education policy documents [24,25], as well as research addressing recognized and elaborated competence approaches [3–5], have adopted Weinert's definition when developing ESD learning outcomes. Waltner, Riess, and Mischo define sustainability competencies as "the entirety of cognitive abilities and skills as well as related motivational, volitional, and social readiness in order to solve sustainability-related problems and to shape sustainable development in private, social, and institutional contexts." [26] (p. 299). Researchers from the United States propose the following definition of sustainability competencies, which can also serve as a foundation for this study: "complexes of knowledge, skills, and attitudes that enable successful task performance and problem solving with respect to real-world sustainability problems, challenges, and opportunities" [6] (p. 204).

1.3. ESD in Secondary School Education

A significant number of publications in recent years discuss competencies or learning outcomes in ESD in the context of higher education or vocational training. This is understandable given the pressing need for more professionals with diverse backgrounds, a sense of social and environmental responsibility, and the ability to support the growth of green economies [6,10,11,27–31]. In particular, it is important to highlight the considerable amount of research literature on sustainability competencies in teacher education and practice, including systematic literature reviews [32–41]. Research on teachers' ESD competencies in specific subject areas has also made a noteworthy contribution [42–45]. A growing body of literature reveals a broad geographical extent and diversity of applied approaches concerning the integration of ESD content and methodology in school practice, as well as the cultivation of related competencies among students. Numerous ecological school certification programs and networks have engaged hundreds of schools worldwide [46]. Several reports and collections of school practices at the national and international levels

document their work, which is carried out as multi-stakeholder or small-scale local projects, as whole-school approaches, or as particular interdisciplinary activities [47–50]. Since the start of the UN Decade for ESD (2005–2014), there have been numerous conference proceedings, research papers, and related project outcomes published on the development of sustainability competencies in school contexts worldwide [51–58].

However, although there is a recent literature review on sustainability competencies in primary school education [59], there is currently no up-to-date study on the frameworks or models of sustainability competencies suitable for secondary education.

This scoping review aims to address this gap by defining a body of literature focused on sustainability competencies and approaches within secondary school education across different social, cultural, and geographical contexts. This research focuses on the secondary school age group (11–18 years) because individuals in this stage of personality development are capable of informed decision-making and intentional actions in new situations and contexts [60]. However, there are obstacles associated with adolescence, such as a decline in enthusiasm and willingness to participate in civic campaigns or school projects, a phenomenon known as the "adolescence dip" [61]. These issues motivate scholars to explore teaching methods that incorporate psychosocial factors related to the developmental characteristics of adolescents, such as holistic and pluralistic teaching techniques [62].

1.4. Research Aim

This article aims to address the gaps in existing research by identifying and assessing ideas, models, and frameworks related to sustainability competencies in the literature on secondary school education. This study reviews worldwide research conducted in the educational field and outlines procedures to evaluate the current state of approaches to sustainability competencies that can be fostered among secondary school learners. The assessment provides comprehensive data to identify overarching patterns and assumptions in the sector, as well as specific methodologies, discrepancies, and deficiencies.

This paper addresses the following research questions:

- Which types of competencies are discussed and evaluated in the selected articles?
- What settings or backgrounds influence the emergence of competence frameworks?
- How do competence frameworks for secondary schools differ from those in other areas, such as higher education?

The findings from this study will contribute to evaluating the existing knowledge in this field of research, providing a comprehensive summary of current studies on sustainability competencies at the secondary school level, and identifying areas for future research.

2. Materials and Methods

2.1. Procedure of the Scoping Literature Review

In order to address these research questions, we conducted a scoping review [63]. A scoping review is a type of literature review that explores literature to find knowledge gaps, clarify concepts, or investigate research trends and its characteristics [64,65]. The overarching purpose is to determine "the coverage of a body of literature on a given topic" [63] (p. 2). As Armstrong et al. [66] point out, scoping reviews are especially useful if the questions under investigation are broad because it is still unclear what more specific questions can be posed. In contrast to systematic literature reviews, scoping reviews do not require specific quality standards from the identified literature for inclusion (e.g., a minimum number of participants in empirical studies) [64].

To ensure that the scoping review is conducted in a rigorous and transparent manner, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines [64]. These guidelines provide a standardized approach for conducting and reporting on scoping reviews, ensuring that the study is transparent, systematic, and replicable.

To identify relevant studies for this review, we systematically searched the following databases from January 1995 to March 2024: Web of Science, ERIC, and Google Scholar. The search was performed using the following terms:

Web of Science: sustainability competencies OR sustainability skills OR sustainability capabilities OR sustainability abilities OR ESD competencies AND education for sustainable development OR sustainability education OR education for sustainability OR ESD AND secondary school OR secondary education OR secondary students OR basic school. The first sample included 1277 publications.

ERIC: ("secondary education" OR "secondary school" students) AND ("sustainability competencies" OR "competencies for sustainable development" OR "ESD competencies" OR "sustainability skills" OR "skills for sustainable development" OR "sustainability abilities" OR "sustainability capabilities" OR "abilities for sustainable development" AND "education for sustainable development"). The first sample was composed of 271 publications.

Google Scholar: "secondary education" OR "secondary school" students AND "sustainability competencies" OR "competencies for sustainable development" OR "ESD competencies" OR "sustainability skills" OR "skills for sustainable development" OR sustainability abilities" OR "sustainability capabilities" AND "education for sustainable development". The first sample included 1111 publications.

To conduct the initial screening of the literature, specific inclusion criteria were employed. These criteria were chosen to encompass a comprehensive range of synonyms associated with the concept of "competence" within the scientific literature, particularly those relevant to the education domain. Additionally, they aimed to narrow the focus of the search specifically to the field of secondary education. The selected criteria and filters are as follows:

1. Content or appropriate search terms: The chosen terms were intended to encompass a broad spectrum of synonyms commonly used in scientific literature to denote the concept of "competence". This includes terms such as skills, abilities, and capabilities within the context of education. Furthermore, these terms were specifically tailored to refine the search to the field of secondary education.

2. Publication date: To align with the study's objective of investigating sustainability competence frameworks within secondary education, a temporal parameter was set from January 1995 to March 2024. This timeframe was selected considering the global impetus for sustainability policies and plans following the Earth Summit in Rio in 1992, which subsequently led to the emergence of the first publications referencing learning outcomes in ESD.

3. Language of publication: English and German were selected as the primary languages for the search. English was chosen due to its dominance in academic discourse, while German was selected as the original language of many foundational works and authors in ESD competence research studies. Consequently, publications not available in English or German were excluded from consideration.

4. Type of publication: To ensure the reliability of the sources, the inclusion criteria stipulated that the selected papers must be peer-reviewed publications. Therefore, documents such as working papers, conference proceedings, or doctoral theses that did not meet the criteria of peer-reviewed publications were excluded from the sample. However, it is acknowledged that certain search engines may not consistently distinguish between various types of publications, necessitating a final manual review to ensure adherence to this criterion.

The initial sample, comprising 2659 academic publications, was subjected to an initial selection process to refine its scope. In this first round of selection, all duplicate entries (n = 120), non-peer-reviewed papers (including book chapters, master's and doctoral theses, and research reports) (n = 424), literature, scoping or bibliometric reviews (n = 47), and papers unrelated to pedagogy or education (n = 519) were systematically removed from

the initial sample. Following this refinement, the remaining set of 1549 papers underwent a preliminary screening based on their titles (Figure 1).

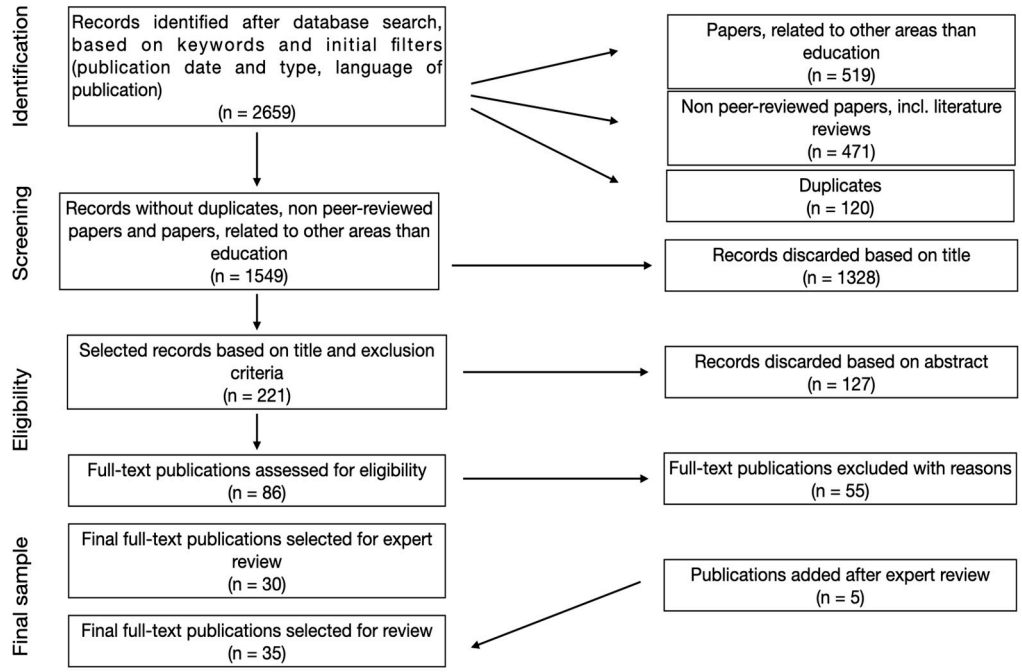

Figure 1. The steps of the review process.

During this stage of screening, additional inclusion and exclusion criteria were employed to further refine the selection. The criteria applied were as follows:

1. Educational area: Articles addressing competence development within the domains of ESD, Education for Sustainability, or closely related concepts such as Global Citizenship Education or Democracy Education (Politische Bildung in Germany) were considered for inclusion. This criterion is aligned with Target 4.7 of Sustainable Development Goal 4—Education for sustainable development and global citizenship.

2. Level of education system: Given the specific focus of the current research on the development of sustainability competencies among secondary school students, articles dealing with sustainability competencies in higher education, teacher education, vocational education, or primary/elementary schools were excluded from the sample.

3. Type of sustainability competencies: Academic papers focusing on a singular competence, considered critical for addressing sustainability issues (such as creativity, ethical competence, emotional intelligence, futures literacy, or adaptive capacity), were excluded due to their specialized nature. Conversely, papers that discussed models or frameworks of sustainability competencies, specifically designed for secondary schools, were selected for inclusion in the sample.

This multi-step screening process aimed to systematically refine the initial sample, ensuring that the selected academic publications align with the research's targeted focus on sustainability competencies within the context of secondary school education.

Following the completion of the initial practical screening based on the examination of scientific paper titles, a substantial reduction occurred, with 1328 papers being excluded. Subsequently, a second practical screening was conducted, involving the scrutiny of keywords and abstracts for the remaining 221 publications. This stage further narrowed down the selection, leaving 86 papers for the conclusive round of screening, involving a thorough examination of the full text. The exclusion criteria applied at this stage were as follows:

1. Teacher-learner approach: Academic papers primarily concerned with conceptual considerations or experimental results related to knowledge, skills, and values in teaching Education for Sustainable Development (ESD)-related issues—specifically, teachers' com-

petencies in teaching sustainability issues (ESD competencies)—were excluded from the final sample. The focus was on papers addressing students' sustainability competencies as learning outcomes rather than teacher competencies.

2. Focus on competencies: Publications exploring the development of sustainability competencies within specific school subjects, such as Science, Geography, or Life Skills, and across entire curricula or national education systems at the secondary level were considered for inclusion. However, papers primarily centered on ESD methods, topics, or approaches for integrating sustainability into the school environment, where sustainability competencies were only mentioned as part of the ESD approach, were not included in the final sample.

3. Students' perceptions or perspectives: Papers that predominantly explore the opinions or perspectives of secondary school students on ESD/sustainability issues or topics without a primary focus on students' sustainability competencies as learning outcomes were excluded from the final sample.

As a result of two rounds of selection, 30 papers remained for expert review. The compilation of these selected papers, along with their abstracts, was shared with two ESD experts. Through productive dialogue with these experts, five additional articles were included in the final selection to ensure its comprehensiveness and relevance. The final set for evaluation consisted of thirty papers in English and five in German (refer to the List of Papers Selected for Review in the Supplementary Materials File S1).

2.2. Analysis Framework

This review study employs a methodological approach that combines a qualitative method with various quantitative approaches to categorize articles and discern patterns and trends in the field of sustainability competencies. The qualitative aspect endeavors to map the diverse concepts, sets, and frameworks of competencies mentioned in the selected articles. Most studies exploring sustainability competencies delineate various sets of key sustainability competencies/skills, often drawing from frameworks proposed in global/European, as well as national and regional education policies and program documents or the works of renowned ESD researchers, including de Haan, Wiek and Redman, and Rieckmann. Additionally, these studies incorporate concepts from the current discourse on sustainability competencies such as action competence [4,67], sustainability consciousness [61,62,68], and green skills [31,69] into their conceptualizations.

In outlining the articles for review, the narrative encompasses the interpretation of secondary characteristics of the studies. These include the year of publication, geographical distribution of research, the field of the journal, affiliation of the authors with specific institutions, and the type of research. These secondary characteristics are considered in relation to the main category, specifically the types of sustainability competencies.

It is noteworthy that not all selected papers concentrate exclusively on sustainability competencies for the secondary school level. Some propose competence frameworks that encompass both secondary school, vocational and higher education levels [5,31,70], while others research the indicators of sustainability in various learning environments [71–73] or evaluation tools for learning outcomes assessment [26,69,70] applicable to various target groups, including students from primary and secondary schools, teachers, and parents. Consequently, the competence frameworks and approaches used as guidelines in these studies extend beyond the secondary school level to encompass other educational levels.

3. Results

The information presented in this results section is organized according to several criteria, including the temporal distribution of articles, their geographic origins, the key journals contributing to the field, and the affiliations of the authors. It includes descriptive statistics of the sets or types of sustainability competencies. Furthermore, the keywords, paper types, and a summary of the teaching-learning methodologies define the content of the publications.

3.1. Methodological Qualitative Approach: Type of Sustainability Competencies

The study utilizes a qualitative methodology to categorize, explain, and analyze various methods and frameworks of sustainability competencies in secondary school as provided in the chosen publications. By thoroughly examining the selected full-text papers for this scoping review, certain characteristics were identified. These characteristics were utilized for the purpose of clustering, categorizing, and describing the sustainability competencies that researchers referred to in their respective papers. The sustainability competencies identified in the sample were studied from two perspectives:

1. as a set of transversal competencies for curricula or a certain education area;
2. as a structured framework model for development and assessment of sustainability-related knowledge, skills, attitudes and behavior in the educational process.

Both perspectives will be thoroughly discussed in the later sections of the results part.

3.1.1. The Prevailing Conceptual Approaches

Among the aforementioned shared perspectives, the five most widely used conceptual approaches to sustainability competencies for secondary school education were identified (Table 1). Not only do the authors of the selected publications examine these conceptual approaches, but other academics also refer to them as exemplary frameworks for sustainability competencies.

Table 1. List of prevailing sustainability competencies frameworks for secondary education.

Sustainability Competencies Concept	Definition	Related Educational Areas/Frameworks	Papers Exploring the Concept/Citing the Concept
Action competence	The concept of action competence includes the capacity to be able to act, now and in the future, and to be responsible for one's actions [67].	Environmental Education	5/9
Gestaltungskompetenz (shaping competence)	Gestaltungskompetenz is a specific capacity to act and solve problems [3].	Environmental Education; OECD's DeSeCo project (2005)	1/7
Sustainability consciousness	The concept of sustainability consciousness taps into students' knowingness, attitudes, and behavior in relation to the sub-themes to the environmental, social and economic dimensions of SD [62].	Environmental Education, Democracy Education	3/3
Green skills	Green skills are the technical skills, knowledge, values and attitudes needed in the workforce to develop and support sustainable social, economic and environmental outcomes in business, industry and the community [69].	TVET frameworks of CEDEFOP (2009) [74], OECD (2011) [75], Australian Green Skills Agreement	3/3
Competencies for transformative action	Sustainability "competencies" embody the concepts and skills that will enable students to understand and resolve complex sustainability problems by equipping them with the ability to become change agents [76].	Theory of behavioral change	1/2

Table 1 includes these five approaches, each accompanied by a concise definition, the associated educational area or policy framework relevant to its development, and the number of papers that directly address and cite each concept. This table encapsulates more than a third of the selected papers (n = 13) that directly investigate these concepts, along with references to these conceptual approaches in other selected papers (n = 25).

3.1.2. Clustering Based on Shared Perspectives

The aforementioned categorization, based on two main shared perspectives of the researchers in the sample, reflects common views on incorporating sustainability competencies into secondary school curricula (Table 2).

Table 2. List of shared researchers' approaches, clustered around two key perspectives.

	Shared Perspectives on Sustainability Competencies Frameworks	Countries to Which the Studies Pertain	Number of Papers, Dealing with This Approach
1.	Set of transversal competencies for curricula or a certain education area		
1a.	Aligned with the priorities of national or regional education curricula/policies	South Korea, Maldives, Indonesia, Germany, Serbia, Croatia, Montenegro, Malaysia, Spain	10
1b.	Derived from global education guidelines (UN, UNESCO, OECD, Earth Charter)	Germany, Spain, South Korea, Chile, Guatemala	6
1c.	Domain-specific competencies (through the lens of school subjects or education domain)	Spain, South Korea, Malaysia, Maldives, Israel, Germany, Chile	12
1d.	Domain-specific competencies (through the lens of teaching-learning approach)	Germany, Sweden, Maldives, Belgium, Spain, Israel, UK, India, Guatemala	11
1e.	Frameworks originated from relevant conceptual research	Sweden, Belgium, Ukraine, Germany, USA, UK, Spain, India	10
2.	Structural model for the relevant cognitive abilities, skills and attitudes	Germany, Sweden, Taiwan, Denmark, Indonesia, Malaysia	11

The first perspective focuses mostly on various sets of cross-cutting sustainability competencies, for various education domains. These sets of competencies might be (1a) aligned with the priorities of national or regional education policies and curriculum frameworks or (1b) derived from global education guidelines from organizations such as the UN, UNESCO, OECD, or an Earth Charter initiative. Furthermore, the cross-cutting competencies sets were identified by authors of the publications for the specific purposes of their research, such as (1c) inclusion of sustainability contents into specific subjects (i.e., Geography or Economics) or into broader educational domains like Climate Change education; (1d) use of specific teaching-learning approaches for better understanding of sustainability issues; or (1e) development of sustainability competencies frameworks, originated from authors' specific conceptual research. The latter viewpoint has mostly emerged from, and been established within, concrete educational traditions, such as action competence [67] in Denmark, shaping competence (Gestaltungskompetenz) [15] in Germany, and transition skills [77] in Sweden. The researchers, who presented a second key perspective, concentrated mostly on educational tools for identification and measurement of cognitive abilities, skills, and attitudes necessary for engagement with sustainability issues, such as the concept of sustainability consciousness [61,62,68] from Sweden, or the structured framework model for sustainability sub-competencies [26,70] from German researchers.

The local context also influences the clustering process to some degree. The German national competencies framework, aligns with the approach of "Politische Bildung" (citizenship education) significant to the German educational heritage as outlined by Asbrand [78]. The case study from Maldives [79] demonstrates the significance of incorporating sustainability competencies into the National Curriculum Framework and implementing a community-based approach in local environments to address the disaster risks resulting from climate change within the economic and ecological context.

It should be noted that there were only a few publications in which only one viewpoint or perspective was utilized. The majority of researchers, for instance, from South Korea, Malaysia, and the Maldives have examined sustainability competencies from various view-

points simultaneously in their studies [17,31,79] (Table 2). The table presented above is a simplified version; the complete version can be found in Table S1 in Supplementary Materials.

3.1.3. List of the Most Cited Sources

During the article clustering process, it became evident that multiple researchers reference concepts and approaches related to sustainability competencies that are widely recognized across all educational fields, particularly in higher education. Although these approaches were not included in the scoping review due to their broad applicability beyond our specific focus, it was clear that they played a crucial role in developing specific competence frameworks for the secondary education sector. To provide a comprehensive overview, we have compiled a list of the most frequently cited sources that have influenced the research articles selected for our scoping review (Table 3).

Table 3. List of the most cited frameworks of sustainability competencies.

Name of the Source	Competencies Framework	Number of Papers, Citing the Framework
UNESCO. Education for Sustainable Development Goals. Learning Objectives. 2017 [25]	Systems thinking competency Anticipatory competency Normative competency Strategic competency Collaboration competency Critical thinking competency Self-awareness competency Integrated problem-solving competency	9
Wiek, A.; Withycombe, L.; Redman, C.L. Key competencies in sustainability: a reference framework for academic program development. 2011 [6]	Systems-thinking competence Anticipatory competence Normative competence Strategic competence Interpersonal competence Problem-solving competence	8
OECD. Definition and selection of key competencies. Executive summary. 2005 [19]	Interactive use of media and methods Interacting in socially heterogeneous groups Acting autonomously	5
UNESCO. Roadmap for Implementing the Global Action Programme on ESD. 2014 [80]	Critical and systemic thinking, Collaborative decision-making, Taking responsibility for present and future generations.	7
CEDEFOP. Future skill needs for the green economy. 2009 [74]	Green skills supporting: resource efficiency, the low carbon industry, climate resilience, and skills to protect manage natural assets	4

Recognizing common conceptual approaches, shared perspectives on integrating sustainability competencies into secondary school curricula, and key sources that have shaped the design of competence frameworks in various countries offers valuable insights into the trends and issues influencing researchers' perspectives on sustainability competencies in secondary education. These insights highlight the interconnectedness of educational research across different levels and the importance of established frameworks in guiding the development of competencies in the context of secondary education.

3.1.4. Word Cloud of All Mentioned Sustainability Competencies

To conclude the clustering process, a word cloud was generated from all sustainability competencies identified in the selected papers using the website www.wordclouds.com (accessed on 15 August 2024) (Figure 2).

Figure 2. Word cloud for sustainability competencies.

The objective of compiling all mentioned sustainability competencies into a single list was to gain a preliminary understanding of the most common competencies related to secondary education worldwide. In certain cases, we modified the authors' wording and utilized synonyms to create a comprehensive list. This approach may have resulted in the loss of some contextual nuances that researchers implied in their competence frameworks. For example, competencies such as "the competency to plan, implement, and evaluate consumption-related activities" and "the competency to critically take on one's role as an active stakeholder in the market" in the concept "Key Competencies Framework for and Beyond Sustainable Consumption" [5] were transformed into "planning and implementing competency" and "critical thinking competency", respectively.

Through the mapping and clustering of sustainability competencies, we generated a list of competencies and categories of competencies for secondary education, grounded in diverse views and approaches from researchers in twenty different countries worldwide. This list, consisting of 56 unique items and a total of 178 items, may serve as a foundation for further exploration, potentially through an international Delphi study.

The initial list of competencies and categories, extracted from the word cloud, highlights 15 of the most commonly mentioned sustainability competencies, skills, or abilities applicable to secondary education worldwide. These competencies, which were mentioned five or more times, include critical thinking (critical reflection), foresighted thinking, system thinking, reflection, action competence, communication, creative thinking, planning and implementation, collaborative decision making (participatory skills), interdisciplinary work, cooperation, evaluating skills, empathy (compassion), problem solving and dealing with complexity. This list will be further utilized to assess compatibility with identified teaching-learning approaches and types of research presented in the publications.

3.2. Quantitative Analysis

3.2.1. Relevant Journals and Time Range of the Selected Articles

All publications included in the review have undergone peer review processes. A significant proportion of the articles in the sample, accounting for over a quarter (26%), were published in the journal *Sustainability*, followed by *Environmental Education Research* (9%), *GAIA—Ecological Perspectives on Science and Society* (6%), and the *International Journal of Academic Research in Business and Social Sciences* (6%). The remaining 50% of publications

were distributed across various other journals. The studies presented in this scoping review span from 2003 to 2023, depicting a steady increase in the number of publications over the years (Figure 3).

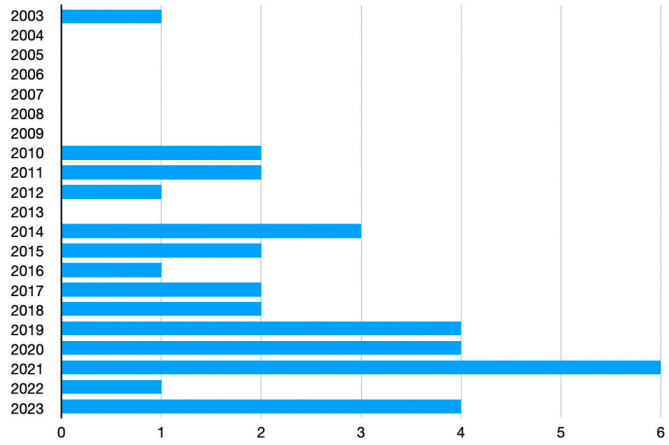

Figure 3. Time range of the sample.

The earliest research papers in the sample date back to 2003 and 2010, coinciding with initial attempts to describe sustainability competencies into three areas: Recognizing, Assessing, Acting (Erkennen, Bewerten, Handeln) [81], as well as the introduction of the concept of action competence by Danish researchers [4]. This period also saw the emergence of the concept of "shaping competence" (Gestaltungskompetenz) in the German educational discourse [3]. Notably, in 2005, the OECD published "Key Competencies for Personal, Social, and Economic Well-Being" [19], laying the groundwork for subsequent research in various educational domains. The figure above clearly illustrates the growing interest among scholars in competencies research, particularly since 2010. This period coincides with the global spread of the UN Decade for ESD, which mobilized significant educational resources and emphasized the importance of conceptualizing accumulated experiences. Additionally, in 2011, Wiek and his colleagues presented a set of key sustainability competencies, justifying their significance for ESD [6].

The last nine years (2014–2023) have witnessed substantial growth in scientific literature exploring and measuring sustainability competencies at the secondary school level, with publications (in English and German) increasing from 2 to 6 per year.

3.2.2. Geographical Distribution by Countries and Academic Institutions

The academic papers reviewed present a remarkably diverse geographical panorama. They encompass theoretical frameworks, models, experimental results, analyses of national curricula, and case studies in the realm of "sustainability competencies in secondary school education", sourced from sixteen different countries. This range emphasizes the growing global interest in the conceptualization, research, validation, and assessment of sustainability competencies, covering regions from Ukraine to Taiwan and the Maldives (Figure 4).

Germany and Sweden emerge as the most frequently researched countries, followed by Spain and Malaysia, each with more than two publications. The rest of the sample comprises countries represented by a single article. This distribution not only highlights the locations where theoretical foundations of sustainability competencies at the secondary education level are being more thoroughly explored and academically supported but also affirms the broad geographical interest in this area of research.

Overall, the majority of articles, exceeding 60%, originate from European countries, while around 30% come from Asia, and less than 10% are from America. (Figure 5).

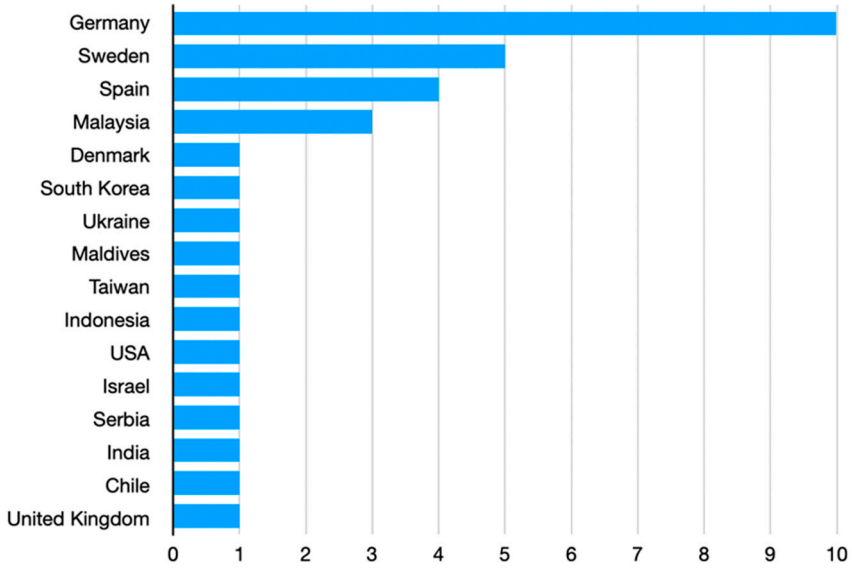

Figure 4. Geographical distribution of papers (countries).

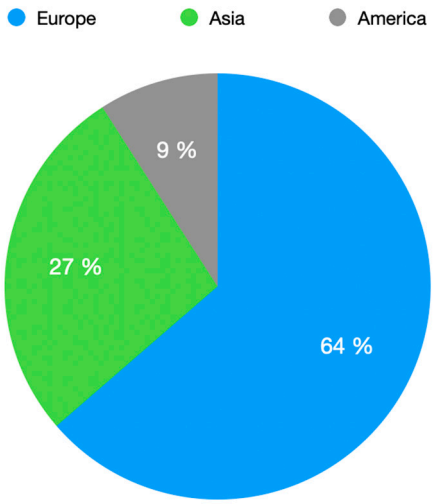

Figure 5. Geographical distribution of papers (continents).

It is noteworthy to mention that, in this categorization, a country of the selected paper was considered the geographical location where the research was conducted. For instance, in cases of experiments or case studies, the countries where these activities took place were considered. In purely conceptual papers, the country was determined based on the geographical affiliation of the researchers.

Furthermore, the publications in the sample were analyzed based on the total number of institutions presented by authors and the geographical distribution of these institutions.

This analysis revealed a similar trend in the geographical distribution of the research.

The majority of participating institutions, 28 out of 42 (60%), are located in Europe. Sweden, Germany, and Spain lead with seven institutions each. In total, there are 17 countries represented among the research institutions, along with one international network, the Global University Network for Innovation.

In terms of leading academic institutions mentioned more than twice as affiliations of the researchers, Universiti Pendidikan Sultan Idris from Malaysia, with eight researchers, is followed by Karlstad University from Sweden and the University of Education Freiburg from Germany, each with five researchers, at the forefront. Among the fourteen universities and academies with the highest number of researchers, four different German universities,

as well as two universities from Sweden and two from Spain, are involved in research on various aspects of sustainability competencies.

The listed academic institutions primarily include universities, institutes, schools, and academies of postgraduate education. In total, there are 43 academic institutions, with Swedish and German universities leading in numbers.

However, interpreting the number of academic institutions represented by participating researchers, combined with the types of sustainability competencies researched, reveals a slightly different picture (Table 4).

Table 4. Relationship of countries and researchers to identified competence frameworks.

Country	Number of Affiliated Researchers	Type of Researched Frameworks of Sustainability Competencies
Germany	17	1. structural model of relevant knowledge/skills/attitudes (sustainability subcompetencies [26,70,82]); 2. transversal key sustainability competencies (a) based on national curricula/education policy [78]; (b) through the lens of teaching-learning approach [83,84]; (c) through the lens of subject domains [5,84]; (d) framework originated from conceptual research (shaping competence (Gestaltungskompetenz [15])
Sweden (Taiwan)	15	1. structural model of relevant knowledge/skills/attitudes (sustainability consciousness [61,62], action competence [4,72,77,85], sustainability commitment [86]); 2. transversal key sustainability competencies: (a) through the lens of teaching-learning approach [62,77,85]; (b) framework originated from conceptual research [85] (transition skills, knowledge capabilities [77])
Spain	13	1. transversal key sustainability competencies: (a) based on national curricula/education policy [87,88]; (b) based on global/European education guidelines [16,18]; (c) through the lens of teaching-learning approach [16,18]; (d) through the lens of subject domains [18,87,88]; (e) framework originated from conceptual research [87]
Malaysia	10	1. transversal key sustainability competencies (Green skills) [31,69]: (a) based on national curricula/education policy; (b) based on global/European education guidelines; (c) through the lens of subject domains
Ukraine	5	framework originated from conceptual research [71]
Belgium	4	structural model for relevant knowledge/skills/attitudes (sustainability consciousness, action competence) [72];
Indonesia	4	1. structural model for relevant knowledge/skills/attitudes [89]; 2. transversal key sustainability competencies: (a) abased on national curricula/education policy
Chile (Spain/India)	4	1. transversal key sustainability competencies [90]: (a) through the lens of subject domains; (b) based on global/European education guidelines

Table 4. *Cont.*

Country	Number of Affiliated Researchers	Type of Researched Frameworks of Sustainability Competencies
USA	3	framework originated from conceptual research (key competencies for transformative action) [76]
Serbia	3	transversal key sustainability competencies based on national curricula/education policy [91]
Denmark	2	structural model for relevant knowledge/skills/attitudes (action competence) [4]
South Korea	2	1. transversal key sustainability competencies [17]: (a) based on national curricula/education policy; (b) through the lens of subject domains; (c) based on global/European education guidelines
India	2	1. transversal key sustainability competencies [73]: (a) through the lens of teaching-learning approach; (b) framework, originated from conceptual research
Maldives (Australia/ Italy)	2	1. transversal key sustainability competencies [78]: (a) based on national curricula/education policy; (b) through the lens of subject domains

The table indicates that the largest number of affiliated researchers, representing more than half of all authors in the sample (n = 45), are based in Germany, Sweden, and Spain, showcasing a broad variety of approaches to sustainability competencies in secondary school education. Researchers from these countries are suggesting, exploring, and validating various approaches to sustainability competencies [5,18,26,61,82], within school curricula [15,68,88] and at the classroom level [77,83,85,87]. In contrast, Malaysian researchers, who follow the first three countries in Table 5 with ten researchers, predominantly engage with one competency approach, namely, Green Skills. The works of Malaysian researchers frequently refer to international policies designed to promote green growth and vocational training [74,75] and the Australian Green Skills Agreement as guidance for educators at the secondary school level [31,69]. This focused engagement with a specific competence approach contrasts with the broader spectrum of methodologies observed in European research, highlighting regional differences in the application and development of sustainability competencies. Similar trends are also observed in other Asian countries. Four out of six Asian countries in the survey tend to align sustainability competencies with the requirements of national curricula or global education guidelines.

It is noteworthy that the concepts of sustainability consciousness and action competence have gained popularity beyond the educational traditions of Denmark and Sweden, where they originated, and have been applied in countries such as Taiwan and South Korea [17,61].

In comparing the geographical distribution by research location and academic affiliation of the researchers, it was observed that those who have established authority as experts in certain areas were invited for co-authorship to assess quantitative experiments or case studies conducted in other countries [16,61,90]. Therefore, we observe more researchers and research institutions from Sweden and Spain in the distribution by authors' affiliation than by geographical distribution regarding the location of research mentioned in the papers.

Table 5. Type of research paper.

Type of Research Paper	Research Methods Used	Number of Papers	Countries	Number of Researchers in Co-Authorship
Conceptual and quantitative research	Description of a frame model + close-ended questionnaires	6	Sweden, Germany, India	2 to 3 researchers
Conceptual research	Description of a frame model, teaching approach, critical reflection, evaluation tool	10	Spain, Sweden, Malaysia, Germany, USA, Denmark	1 to 4 researchers
Qualitative research	Analysis of curriculum, interviews, case-studies, documentary study, modified Delphi study	12	Spain, Malaysia, Maldives, Sweden/Taiwan, Belgium, UK, Serbia, Guatemala Germany, South Korea	1 to 6 researchers
Conceptual and qualitative research	Description of a frame model + case study, literature review, longitudinal study	3	Germany, Ukraine, Belgium	2 to 5 researchers
Quantitative research	SEM, cluster sampling method, close-ended questionnaires, cross-sectional study	6	Sweden, Malaysia, Sweden/Taiwan, India, Indonesia, Germany	4 to 5 researchers
Qualitative and quantitative research (mixed-method design)	Class observations and semi-structured interviews, longitudinal study, experiment, analysis of teaching materials	2	Israel, Chile	1 to 4 researchers

3.2.3. Analysis of Authorship

In total, the sample includes contributions from 87 different authors, with the majority of articles (52%) being co-authored by three and four researchers. One-third of the selected articles (n = 13) were written by one researcher and in co-authorship of two researchers. Publications authored by five authors accounted for four, and only one article involved six authors (Table 5).

Nearly two-thirds of all contributors (65%) are affiliated with European academic institutions, one-fourth (25%) are connected to Asian institutions, and a few researchers work at institutions in America (9%) or with international organizations such as the Global University Network for Innovation.

It is worth noting that the number of authors contributing to each publication is somewhat connected to the type of research, particularly regarding quantitative experiments. The majority of the six quantitative surveys in the sample (4 out of 6) were conducted with co-authorship of five authors, while two were co-authored by four authors. In addition to the observation that a larger number of researchers is often needed to select appropriate measuring and assessment instruments or to interpret results, it was noted that groups of authors for quantitative experiments were sometimes international. This indicates attempts to test the validity and applicability of competence approaches and measurement instruments derived from European contexts, such as "action competence", in other cultural contexts, for example, in Taiwan [61]. More details on the type of research and its relation to the number of authors in co-authorship and their countries of affiliation are provided in Table 5.

3.2.4. Type of Research

The academic papers in this sample were categorized according to the type of research applied to describe, interpret, assess or validate the chosen set or concept of competencies. All papers were distributed across five categories of pure and mixed research approaches (Figure 6).

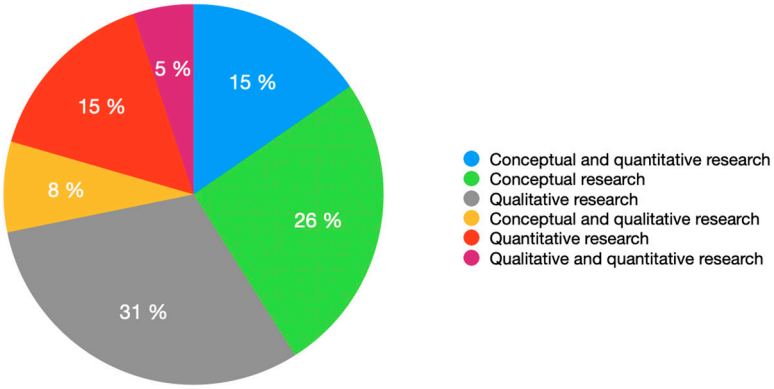

Figure 6. Distribution of conceptual and experimental works.

Each research type was combined with the research methods used, the names of the countries the researchers represented, and the number of researchers who collaborated on specific studies (see Table 5 above). In total, qualitative and conceptual research predominated in this sample, with 31% of articles focused on qualitative research design and 26% on conceptual considerations, respectively. About 15% of all publications combined theoretical considerations with quantitative research. Among purely experimental articles, qualitative works outnumbered quantitative studies, accounting for 31% and 15% of all publications, respectively. A significant number of articles (35%) in the sample included quantitative research, whereas 44% of all authors employed qualitative research methods.

3.2.5. Teaching-Learning Methods

While the primary goal of this scoping review does not directly involve the assessment of learning outcomes in Education for Sustainable Development (ESD) at the secondary school level, the selection of teaching-learning methods and the design of learning environments significantly influence the efficacy of sustainability competencies set as reference values for specific education systems or areas. Hence, the teaching-learning methods referenced in the articles of the sample were compiled, presented as a word cloud, and analyzed using the website www.wordclouds.com (accessed on 15 August 2024).

The analysis of the word cloud indicates that educators and researchers highly value active learning methods aimed at fostering reflective, self-directed learning in the integration of ESD principles at the secondary school level. Notably, problem-based learning, project-based approaches, interdisciplinary inquiry, participatory learning, real-world explorations, place-based learning, and holistic and pluralistic approaches were among the most appreciated methods, mentioned more than three times in the publications (Figure 7).

Comparing this with the word cloud of the most cited sustainability competencies frameworks (Figure 2), it becomes evident that these teaching methods align well with desired competencies such as critical thinking, dealing with complexity, and participatory skills. Situated and place-based learning, real-world explorations, community-based learning, and community service learning—mentioned around 10 times in the selected papers—highlight the considerable awareness among researchers regarding the need to establish connections between classroom activities and local sustainability issues. Communication ability, cooperation, foresighted thinking, and planning and implementation skills emerge as crucial sustainability competencies for secondary school students in this context.

Holistic and pluralistic learning approaches stand out as some of the most cited teaching methods. Nearly one-fifth of the papers in the sample emphasize holistic interdisciplinary perspectives on content and learner-centered teaching strategies [4,61,62,72,77,83,84]. The consistent implementation of these strategies in ESD at the whole-school level may strengthen the development of sustainability competencies in secondary school students, potentially overcoming barriers that influence pro-social behavior during adolescence, often referred to as the "adolescence dip" [61,62].

Figure 7. Wordcloud of researched methods.

3.2.6. Keywords Approach

The keyword analysis, visualized as a word cloud, reaffirms the effectiveness of the search strategy and selection process, emphasizing that the majority of keywords in the sample are related to ESD in terms of learning outcomes or competencies (Figure 8).

In line with expectations, "education for sustainable development" was the most frequently used term, appearing in more than half of the papers as a keyword (n = 20), followed by "sustainable development" (n = 6), "sustainability competencies" (n = 5), "action competence" (n = 4), and "sustainable development goals" (n = 4). Notably, the authors of the publications employed a range of synonymous keywords, including competency/competence; education for sustainable development/ESD/education for sustainability; sustainability awareness/sustainability commitment/sustainability consciousness/environmental awareness/sustainability thinking; and environmental behavior/pro-environmental behavior. This observation underscores the constantly emerging concepts and ideas in the field and highlights the diversity of terminology used to describe these concepts.

Table 6 provides insights into clusters of keywords in the sample. All 196 keywords were clustered into eight groups and analyzed afterward. Despite each item in the sample focusing on developing sustainability competencies at the secondary school level, only 11 keywords directly referenced this level of education, including terms like "secondary education" and "secondary school students". These keywords also encompassed expressions from the field of educational psychology, such as "adolescence dip", signifying the age group under consideration. In instances where the abstracts explicitly discussed qualitative or quantitative studies involving adolescents, the authors did not emphasize this aspect within the assigned keywords. This factor may have contributed to the comparatively smaller sample size for this scoping review, despite a substantial number of records identified through database searches.

Figure 8. Keywords word cloud.

Table 6. List of clustered keywords.

Nr.	Groups of Clustered Keywords	Number of Keywords	%
1.	Learning outcomes, competencies aspects	48	27%
2.	Education areas, related to sustainability	35	19%
3.	Education standards, curricula	29	17%
4.	Teaching methods and didactical tools	25	13%
5.	Research methods and tools	20	10%
6.	Sustainability	17	9%
7.	Countries	8	4%
8.	Educational psychology	4	2%

In other respects, the identified keywords primarily belonged to the category of competencies and their aspects (27%), encompassing terms such as attitudes, skills, and behavior. This was followed by keywords associated with ESD areas (19%), as well as topic fields related to curricula, education standards, and the teaching process (17%). Approximately one-fourth of the keywords pertained to teaching (13%), while research methods and tools constituted 10% of the keywords (Table 6).

4. Discussion

The results of the scoping review provide insights into general trends in sustainability competencies research at the secondary school level globally. They also help identify achievements, gaps, and inconsistencies in research within this educational field.

4.1. Overview of Sustainability Competencies Research in Secondary Education

In addressing the first and second research questions—specifically, "Which types of competencies are discussed and evaluated in the selected articles?" and "What settings or backgrounds influence the emergence of competence frameworks?"—Tables 1 and 2 in the results section present a comprehensive overview of the five most widely used

concepts and two key perspectives, including five shared approaches within the first perspective, employed by researchers to describe and cluster sustainability competencies at the secondary school level.

The five most widely used concepts revealed in the scoping review—action competence, sustainability consciousness, Gestaltungskompetenz (shaping competence), green skills, and key competencies for transformative action—have been highlighted due to their extensive coverage across a substantial number of papers that directly address these concepts (n = 13) and cite them in additional papers (25 citations). This underscores the relevance of these concepts for researchers worldwide, as evidenced by various research types in recent years, including systematic literature reviews [92–94], comparative studies [73,95,96], and the operationalization of sustainability competencies within school curricula [26,61,62,70,82].

The total number of articles in the sample that simultaneously cite more than one of the five concepts of sustainability competencies as influential research contexts is only six, which is not very significant. The impact of several concepts—such as sustainability consciousness and action competence, action competence and Gestaltungskompetenz, and sustainability consciousness, action competence, and key competencies for transformative action—can be found in about 18% of the papers, with some of these concepts mentioned by authors as important background for the research.

Two critical perspectives on interpreting sustainability competencies for secondary school education were identified. The first perspective involves tendencies that associate sustainability competencies with a set of transversal competencies, which were categorized into five groups based on the researchers' priorities:

1. originated from the relevant conceptual research (e.g., Gestaltungskompetenz [15], transition skills [77], competencies for transformative action [76]);
2. specified for a specific subject area (Science, Geography or Climate Change) [5,17,31,79,84,88,90];
3. aligned with the priorities of national or regional curricula/educational policies [17,31,79,91] or
4. with the guidelines, developed by esteemed European and global education agencies as UNESCO, OECD, etc. [5,16–18,31,83,90];
5. achievable with assistance of certain teaching-learning approaches, such as holistic and pluralistic approach [62,72], project-based approach [77,79,97], authentic learning [73], inverted classroom and self-assessment [87,97], etc.

The second perspective, on the other hand, characterizes sustainability competencies as a framework model that emphasizes the development of cognitive, affective-motivational, and behavioral aspects [68,70], or highlights specific issues such as agency [97] and collective decision-making and action readiness [4].

It is important to note that the first perspective, outlined by five different viewpoints (Table 2 and Table S1 in the Supplementary Materials), is found in over two-thirds of the papers in the sample (n = 26), including contributions from researchers in 19 different countries. Conversely, the second perspective is primarily presented by researchers from three countries: Sweden, Germany, and Denmark, with one exception where researchers from Indonesia are also included. In one instance, researchers from Sweden, Belgium, and Taiwan collaborated on a paper presenting this perspective.

The importance of sustainability competencies in relation to national and global education policies, as well as their relevance to specific educational areas and school subjects, is increasing across different continents and within various educational fields. However, the focus on designing, measuring, and assessing sustainability competencies, along with the empirical outcomes of ESD initiatives, is particularly prominent in European countries, specifically Germany and Sweden. These countries possess the necessary institutional resources and experienced research teams dedicated to these endeavors.

These perspectives were highlighted as a result of the observed patterns in the chosen papers regarding how academics strive to articulate sustainability competencies and incor-

porate them into local settings, such as national or regional curricula, specialized courses, or teaching methods.

As previously articulated, a notable portion of the selected papers (n = 15) draws upon the guidelines outlined in national curriculum frameworks or global/European education program documents to substantiate their approaches to sustainability competencies at the secondary school level. It is noteworthy that these perspectives are predominantly adopted by authors from Asian countries, Eastern Europe, or Latin America (Table 2). In contrast, approaches grounded in the synthesis of conceptual works by other researchers or scientific theories are more prevalent in European and American studies (Tables 1 and 2).

Turning to the types of research prevalent in the sample, two key takeaways emerge. Firstly, the abundance of conceptual publications reflects the ongoing growth in educational studies on sustainability competencies in secondary school education. The continual emergence of new framework models, evaluation tools, and teaching methods calls for thorough descriptions and validations. Secondly, the significant presence of experimental studies, comprising 69% of the papers, signals a positive development. This suggests a diminishing gap in the use of tools to measure and validate progress in fostering sustainability competencies in secondary schools [26,62,69,82,89].

In concluding this observation, it is important to consider several factors that might influence this situation. Firstly, most of the selected works come from European countries, where well-established academic research traditions and robust support for educational studies exist. Secondly, the language barrier could affect the quality of English-language research papers selected for this review. We do not have a clear picture of how extensive the body of academic literature is, including experimental works in researchers' native languages within the sample or those excluded due to language criteria. Lastly, it may not be straightforward to transfer competence approaches developed in different cultural and educational settings into national education systems, although there are some collaborative publications attempting this [16,61,90].

4.2. Consensus on Sustainability Competencies

It is worth mentioning that the literature reviews on sustainability competencies at various educational levels, which have emerged in recent years, predominantly consider one specific sustainability competencies framework. For example, the widely used conceptual framework model by Wiek, Withycombe, and Redman [6] is referenced in relation to higher [10], secondary [73], and primary education [59]; or action competence is discussed across all school levels [92]; or green competencies/green skills in the context of professional (engineering) education [94]. This scoping review, however, focuses on the particular lenses or perspectives that various scholars of sustainability competencies use to prioritize and address the needs of education for sustainable development in their own countries.

Despite the diverse concepts and "shared perspectives" regarding sustainability competencies at the secondary school level, authors largely converge on core key competencies. This alignment mirrors the sustainability competencies frameworks proposed by highly cited authors and globally recognized policy documents (Table 3), even when competencies and skills are occasionally formulated differently. The findings of this scoping review highlight a list of the most valued competencies at the secondary school level (mentioned five times or more in the selected publications), including critical thinking (or critical reflection), systems thinking, foresighted thinking, action competence, reflection, communication, planning and implementation, creative thinking, participatory skills (or collaborative decision-making), empathy (compassion), cooperation, dealing with complexity, interdisciplinary work, problem solving, and evaluating alternatives (Figure 2). These competencies, identified in the analyzed publications, are deemed essential for secondary school students to navigate present and future situations characterized by uncertainty and sustainability challenges.

These key competencies for sustainability share a common structural and functional framework, as emphasized by the majority of authors when referring to competencies as desirable learning outcomes across various social and geographical contexts:

1. The structure of sustainability competence is delineated into three main components: cognitive, emotional-motivational, and behavioral. It is also recognized as a cluster of cognitive and non-cognitive dimensions: knowledge, skills, values, emotions and attitudes [19]. In particular, these different dimensions are presented, e.g., in the concept of sustainability consciousness, which encompasses students' knowingness, attitudes, and behavior in relation to the sub-themes to the environmental, social, and economic dimensions of sustainable development [61]. Researchers from South Korea categorize sustainability competencies into three domains based on this structure: intellect-oriented, personality-oriented, and relationship-oriented domains [17]. The methods mentioned in the selected papers, especially holistic and pluralistic learning, are also designed to foster all significant components of sustainability competencies simultaneously.
2. The functional features of sustainability competence/competencies, particularly the potential ability of learners to contribute to the well-functioning society based on principles of human rights, social, economic, and ecological responsibility, and their capacity to "cope successfully with complex demands and challenges across a wide spectrum of relevant contexts and domains" [96] (p. 321), also find common understanding among the majority of researchers. Notably, the concept of shaping competence (Gestaltungskompetenz) is considered a "specific capacity to act and solve problems" [15] (p. 320) or "to change in future the social relationships, to empower the learners to contribute to the social development processes" [78] (p. 11). The concept of action competence includes the "capacity to be able to act, now and in the future, and to be responsible for one's actions" [67] (p. 175). These concepts exemplify the inclusion of functional dimensions into the subsets of sustainability competencies. In essence, the functionality of sustainability competence lies in the disposition of knowledge, skills, values, and attitudes that empower learners to make informed decisions and take meaningful actions. This empowerment aims to shape the future of societies towards a fairer way of life for people and nature, aligning with the UNESCO Roadmap for the Global Action Programme on ESD [1].
3. Another shared feature about sustainability competencies among the majority of researchers is their transversality or cross-cutting dimension, signifying the applicability of sustainability competencies across various education areas and subject domains starting from classroom level and up to the level of national education policies. Researchers are expanding the scope of sustainability competencies beyond the school curriculum and into the domain of engagement with school administrators, local partners, and the community by choosing and experimenting with different teaching-learning methodologies [73,79,86,90,98]. For secondary school education, this feature is crucial in preparing learners to consider and act effectively in various areas of life, where they may encounter challenges related to sustainability.

4.3. Gaps and Inconsistencies in Research Within This Educational Field

The clustering method applied to various perspectives and approaches to sustainability competencies in the sample uncovered notable insights in this research field. A substantial number of papers cite or derive support from sources such as global/European policy documents or guidelines applicable to all education areas [1,8,25] or from research works, initially designed for higher education [6] rather than from papers, being directly tied to secondary education. Notably, some researchers underpin their educational constructs on 21st-century skills, OECD, and CEDEFOP skills frameworks, which, although not explicitly addressing sustainability competencies, are oriented towards lifelong skills or competencies pertinent to vocational training [74,75]. Authors often build upon these global contexts to

formulate context-based sustainability competencies approaches, which are intended for secondary education purposes in the relevant learning environments.

Another noticeable trend that stands out is the predominance of European authors in developing and applying sustainability competencies concepts and assessment tools specifically tailored for secondary school education. Key frameworks such as those by de Haan [15] and Mogensen, Jensen and Schnack [4,67], along with operationalization and assessment tools from Swedish [62,68] and German researchers [26,82], were predominantly cited or elaborated upon in papers by European researchers. Sweden and Germany, in particular, lead with innovative conceptual approaches that can be implemented in school environments and measured with practical assessment tools. This trend partly explains why researchers from Asian countries, Eastern Europe, and Latin America often draw on global or European education policies.

However, recent research on sustainability competencies in primary school education [59] highlights the growing interest of researchers from Eastern and Central Europe (Ukraine, Poland, Czech Republic) in exploring and assessing sustainability competencies at this educational level. Furthermore, a literature review on research regarding action competence since 2010 [92] suggests an increasing number of publications from America, though these findings encompass papers covering all educational levels, from primary school to higher education. In this regard, collaborative international publications should be mentioned, that explore and validate competence frameworks and concepts for secondary school education, e.g., researchers' groups from Taiwan, Sweden, Belgium [61], Spain, Guatemala [16] and Chile, Spain [90]. These opportunities could influence the predominant focus on sustainability competencies frameworks in Western European studies.

It is notable that Latin America (two contributions), Eastern and Central Europe (two contributions), and Africa (no contributions) are either underrepresented in the sample or have very little representation. Other obstacles to fruitful academic exchanges are rising, even as language constraints that formerly prevented academics from these locations from fully participating in academic exchanges are gradually being overcome thanks to AI translation technologies and growing worldwide networks. Publications from the former Soviet Russian-speaking region (Russia, Belarus) are completely absent from the sample. Academic research on ESD and sustainability competencies is extremely rare in this region, despite the large number of school sustainability initiatives and local networks started by grassroots organizations and primarily funded by non-formal education institutions. Local educators and researchers have been further deprived of the advantages of worldwide academic and educational interactions by recent political trends in these countries toward isolation and indoctrination, notably in education and research.

It should also be noted that, apart from sustainability competencies, researchers in the field refer to other competence frameworks, such as 21st Century Competencies [14] or Global Citizenship competencies [99]. However, exploring this area lies beyond the scope and research objectives of this article, which focuses primarily on sustainability competencies within the secondary school sector.

5. Conclusions

The objective of this scoping review is to provide academic communities with the current status of sustainability competencies frameworks and concepts in the realm of secondary school education. An analysis of the selected papers, encompassing key characteristics, revealed several findings. Firstly, there has been an increase in the number of papers since 2010, with contributions coming from nearly all continents. Secondly, a more detailed exploration of the data considers the affiliations of researchers with academic institutions. Notably, the leading academic institutions in this field are located in Sweden and Germany, followed by Spain. The prominence of Germany and Sweden is evident across various research types, including conceptual, quantitative, qualitative, and mixed approaches (Table 6). Additionally, researchers from these countries are prevalent in joint international research teams (Table 5) and are prominently cited in this review (Table 1).

However, it should be noted that the considerable number of German authors in the sample arose due to the inclusion of both German and English in the initial search criteria. While this may introduce a certain bias in the scoping review, it does not diminish the significance of German researchers' contributions to the field.

Since the aim of the article is to provide an overview of the existing models and frameworks specifically designed for secondary education and to explore the approaches of various researchers in defining and designing sustainability competencies frameworks in different contexts, it could not focus in detail on the definitions of certain competencies, such as critical thinking or systems thinking. Within the diverse competence frameworks emerging in various geographical and educational contexts, these competencies are inevitably understood within different scopes of meaning. Some researchers in the sample refer to these competencies as sub-competencies within broader frameworks, without specifying their meaning [73,76,79], while others regard systems thinking and critical thinking as particular sets of tools and techniques for developing, for example, higher-order skills [84,90,98].

The qualitative clustering method applied to various approaches to sustainability competencies, as presented in this review, has revealed insights into two main shared perspectives on addressing sustainability competencies at the secondary school level. Notably, the first perspective, which centers around a set of transversal sustainability competencies, is represented in more than two-thirds of the papers in the sample (n = 26), involving researchers from 19 different countries. In contrast, the second perspective is primarily represented by researchers mostly from three countries: Sweden, Germany, and Denmark. Researchers presenting both perspectives demonstrate a tendency toward conceptual work and thorough elaboration regarding learning outcomes assessment and the development of measurement tools for the introduced sustainability competencies frameworks.

The main findings from the clustering approach include:

- broad diversity of approaches to conceptualization of sustainability competencies for the secondary school level worldwide;
- identification of shared perspectives among the researchers, despite their geographical and cultural backgrounds;
- categorization of main approaches within shared perspectives based on priorities and research interests of various researchers;
- focus on certain foundational sustainability competencies that are considered relevant across various educational domains of sustainability education at secondary school level;
- emphasis on cognitive, affective, and behavioral aspects among almost all identified approaches, which indicated a worldwide acknowledged holistic approach to competence development.

The findings underscore the significance of fostering agency, collective decision-making, and readiness for action among students, which are crucial for their active participation in sustainable practices.

Based on these findings, we propose that further international research is necessary to support region-based researchers in developing their theoretical frameworks or refining their approaches. This collaborative effort can contribute to the diversity of theoretically and methodologically grounded approaches on a global scale.

The analysis indicates that within the field of ESD for secondary schools, the diversity of approaches resulting from context-dependent objectives and priorities of researchers is likely to remain heterogeneous in the foreseeable future. In other words, a one-size-fits-all solution is not applicable to sustainability competencies at the secondary school level. Instead, formulating these competencies in various contexts requires careful consideration at both macro and micro levels. At the macro level, attention to the teaching and learning of local social, cultural, and even political backgrounds is crucial. Simultaneously, at the micro level, employing appropriate pedagogical approaches—such as cooperative

and participatory learning, a place-based approach, and holistic and pluralistic learning—becomes essential. These considerations will empower researchers and teachers to establish suitable sustainability competencies or sets of competencies as their goals.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su162310228/s1, File S1: List of Papers Selected for Review; Table S1: Detailed list of shared researchers' approaches, clustered around two key perspectives [11–16,19,24,25,30,60,61,67–72,74–78,80–90,95,96,99–110].

Author Contributions: Conceptualization, K.S. and M.R.; Methodology, K.S. and M.R.; Investigation, K.S.; Writing—original draft, K.S.; Writing—review & editing, K.S. and M.R.; Supervision, M.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Deutscher Akademischer Austauschdienst (DAAD) (German Academic Exchange Service) in the form of a PhD scholarship (Hilde Domin-Program) granted to Kate Sposab.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

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