

Action competencies for sustainability and its implications to environmental education for prospective science teachers: A systematic literature review

H. Husamah^{1,2*} , Hadi Suwono¹ , Hadi Nur^{1,3} , Agus Dharmawan¹ 

¹ Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, INDONESIA

² Department of Biology Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Malang, INDONESIA

³ Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, MALAYSIA

Received 13 April 2022 ▪ Accepted 13 July 2022

Abstract

Students' action competence must be taught and developed, particularly for prospective science teachers, to have a pedagogical perspective as environmental educators. As indicated by publications in respected journals, researchers' focus and alignment on the issue of action competence are highly expected. This systematic literature review aims to compare the findings of research articles published by Web of Science-indexed journals. The keyword used to find the articles on the Web of Science's database was "action competence," which discovered 193 publications. Furthermore, 25 articles met the criteria to be analyzed. Preferred reporting items for systematic reviews and meta-analysis was the inclusion and exclusion model used. In the last three years, research focused on action competence has increased. The research employed several methods, i.e., qualitative, quantitative, mixed-methods, and development research. Jelle Boevende Pauw and Wanda Sass were the authors who frequently published research that focused on action competence. The keyword action competence was directly associated with environmental education, sustainable development, education-based learning for sustainable development, and evaluation. The authors who published their research with this focus were from 16 countries, mainly from Europe, i.e., Sweden, Belgium, and Denmark. The continent diversity of authors who contributed articles indicated that the action competence issue had become a global concern. Furthermore, it was found that the number of non-collaborating publications (universities or countries) was higher than those collaborating, even though single authors rarely wrote the articles. The recent trend shows that publications are authored by scientists with various backgrounds such as fields, universities, and even countries. The authors of this paper developed and proposed eight ideas to be reflected by prospective science teachers or science teacher education providers in educating future science teachers concerned about action competence about sustainable development.

Keywords: action competence, sustainable development, environmental education, science teacher

INTRODUCTION

Action competence is the development of understanding competence and skills that enable a person to take critical action (Carlsson & Simovska, 2012; Jensen & Schnack, 2006; Mogensen & Schnack, 2010; Nielsen et al., 2012; Robertson, 2017). The concept of action competence was mentioned by Jensen and

Schnack in 1997, as a form of critical thinking toward traditional environmental education patterns that have been running for decades (Chen & Liu, 2020). Action competence illustrates an ability to critically assess alternative solutions in action to achieve sustainable future targets (Hedefalk et al., 2014; Sass et al., 2020). Action competence has various competence to guide proper actions, abilities, attitudes, and values, as well as

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✉ usya_bio@umm.ac.id (*Correspondence) ✉ hadi.suwono.fmipa@um.ac.id ✉ hadinur@utm.my

✉ agus.dharmawan.fmipa@um.ac.id

Contribution to the literature

- The researchers focus on the original publication about action competence for sustainable themes and its implications for environmental education for prospective science teachers, something that no other academics have done so that a study baseline may be provided.
- The review of the scope of material we utilize only contains research/original publications, offering an overview of the researchers' focus and alignments on this theme. The scope of information that the researcher use is limited to research/original articles; thus, it provides an illustration or description of the focus and partisanship of researchers regarding this theme.
- The researchers formulate various author contributions emphasized in their articles so that it can be a complete formulation of how to develop the "action competence for sustainable" theme in the future.

the willingness and opportunity to act. The focus of action competence is centered on an intentional act of doing something to improve environmental and sustainability outcomes (Teaching and Learning Research Initiative, 2010).

The issues students choose for their actions must be meaningful and relevant to their lives, current circumstances, and prospects (Hurst et al., 2013; Mpungose, 2020). The issues can be raised from the themes or contexts studied by students (Darling-Hammond et al., 2020). Sustainable development is a theme directly tied to action competence (Chen & Liu, 2020; Mogensen & Schnack, 2010) because this field is progressively gaining traction in tandem with the more mature and bustling discussion concerning the concept of sustainability (Chen & Liu, 2020).

Sustainable development has been a famous slogan in contemporary development discourse (Mensah, 2019). Wise development for communities is sustainable development, in which it aims to improve the quality of life of people around the world, both from present and future generations (Bubriski et al., 2008; Husamah et al., 2022; Fonseca et al., 2020; Messerli & Murniningtyas, 2019). Sustainable development means not exploiting natural resources that exceed the capacity and carrying capacity of the earth (Bao et al., 2020; Ribeiro, 2012). Sustainable development is a development that ensures the continuous improvement of the community's economic welfare, the sustainability of the community's social life, the quality of the environment, and the implementation of governance in order to maintain an increase in the quality of life from one generation to the next (Kusakabe, 2013; Purvis et al., 2019).

Learning purposes in the 21st century should refer to sustainable development goals (SDGs) (García et al., 2020; Jumrodah et al., 2021; Keller, 2020; Wibowo & Sadikin, 2019), including education to produce science teacher candidates (Burbules et al., 2020; Chankseliani & McCowan, 2021; Chisingui & Costa, 2020; García et al., 2020). Therefore, science teacher candidates' perceptions and understanding of sustainable development are crucial (Aulia, 2020; Bezeljak et al., 2020; Burmeister & Eilks, 2013; Kwee, 2021; Novidsa et al., 2020). When they become real scientific teachers, they must have a strong

and precise understanding of the subject, be able to produce creative and appropriate learning plans, and be skilled in implementing education-based learning for sustainable development (ESD) (Erlina, 2021) in order to realize students' action competence.

One way to understand learning in ESD is by developing action competence (Eames, 2010; van Poeck & Vandenabeele, 2012). Action competence should be taught and developed to students (Hedefalk et al., 2014), specifically for science teacher candidates so that they have a pedagogical perspective as an environmental educators (Nielsen et al., 2012). In the context of action competence, it is emphasized that the challenge today is that science educators need to continuously develop their competence and abilities to develop their students' potential. The teachers who continuously develop self-action competence will be able to adapt to dynamic changes so that it is not awkward to be actively involved in efforts to achieve SDGs (Ardhi, 2018). Teachers who have action competence will design learning material, learning implementation strategies, learning methods, learning media, and evaluation models based on sustainable development (Firdaus et al., 2016). These stages, if followed consistently and systematically, will actively promote the spirit of collective change to motivate large-scale community action (Nugroho et al., 2021), at least in realizing environmental health issues in their school (Silo & Mswela, 2016).

Several studies try to link action competence for sustainability with education. For instance, it is by linking the focus of action competence with environmental education as a part of education and a contribution to democracy (Breiting et al., 1999). In other reviews, critical thinking is considered a central element in developing action competence, particularly in environmental education (Mogensen, 1997). In a study by Pedro and Pedro (2010), one possible cause for the gap between attitudes and behavior is a general interest in the environment combined with action competence.

Meantime, the researchers examine about affordability and limitations of textbooks to promote the action competence for sustainability in school. The researchers argue that the existing textbooks are substantially still limited in promoting action

competence for sustainability. It uses a cross-curricular approach and critically assesses problem-oriented action at the collective and individual levels (Biström & Lundström, 2021b). Furthermore, in another publication, Biström and Lundström (2021a) discover that sustainable development and gender equality are regulated as a topic that is not integrated into the school's textbook. They also discover that the social dimension in sustainable development is not well described. Recently, Sass et al. (2022a) investigated action competence in sustainable development (ACiSD) in students and discovered that grade levels enhance improvements in ACiSD students. They recommend investigating how and to what extent the educational approach for science teacher candidates can affect student changes in ACiSD.

So far, three systematic literature reviews (SLRs) on action competence have been discovered. The first is a study of two research journals with the most decisive influence on environmental education from 2008 to 2013 to analyze how they contribute to developing action competence (van Poeck & Vandenabeele, 2012). The second is a study conducted by Chen and Liu (2020). Their study is only focused on developing students' action competence for a sustainable future. Finally, another SLR is conducted by Lohmann et al. (2021), which is focused on teachers' professional action competence in education for sustainable development. Hence, it can be stated that SLR has not been found that focuses on action competence for sustainability, which is related to environmental education in higher education, especially from the perspective of prospective science teachers (prospective and pre-service teachers). Consequently, the SLR aimed to examine and compare numerous studies on journal articles connected to the issue of action competence for sustainable development and its implications for environmental education for prospective science teachers.

METHOD

Research Framework

This review was an SLR, and the review included techniques for identifying, evaluating, and analyzing various current and relevant information in the literature/references in order to answer research questions and examine them thoroughly (Snyder, 2019; Xiao & Watson, 2019). The SLR "was helpful to summarize the latest knowledge on a particular topic with a systematic and transparent method of answering research questions" (Kurniati et al., 2022).

Research Question

Determination of research question (RQ) was used to define the scope to develop a clear focus for the study.

This RQ was developed in response to the needs of the chosen issue, namely:

"What are the implications of action competence research for potential science teachers in terms of environmental education?"

Search Article and Inclusion Criteria

The researchers used the "action competence" term in the searching menu of the Web of Science (WoS) database. We use the "Search" menu on the WoS. We only use the keyword "action competence" to focus the search. Search engines will find all articles that contain the word "action competence" in the title, abstract, content, or references. WoS is the most famous and trusted global citation database in the world. WoS provides best-in-class publications, easily accessible citation data, the first broad scope international bibliographic (world's oldest), the world's leading scientific citation search, and the most widely used and authoritative database of research publications and citations (Birkle et al., 2020; Li et al., 2018; Pranckute, 2021). This comprehensive platform allows authors to track articles from nearly 1.9 billion references cited from more than 171 million records.

The obtained data were in the form of *CSV and *RIS, which were then synced into the Reference Manager (Mendeley). Software VOSviewer was used to visualize the data so that the data were more transparent and communicative. By utilizing the words, the researchers discovered 193 articles. Inclusion and exclusion models were used as preferred reporting items for systematic reviews and meta-analysis (PRISMA), referred to as Gallagher et al. (2016). In line with Booth et al. (2012), we used the scoping review method. Scoping review aims to answer questions from research topics determined by using various sources of similar research articles and then grouping and drawing conclusions.

The following points were the inclusion criteria used, namely

- (1) articles published between January 2012 and March 2022;
- (2) articles published in English;
- (3) articles that include research/original articles; and
- (4) articles that were solely connected to action competence research.

Figure 1 represents the order of inclusion and exclusion that the researchers used. According to Figure 1, the researchers discovered 193 during their initial search. Also, the researchers examined articles published between 2012 and 2022. There were 113 articles that met the criteria, which meant that 80 items were excluded. The researchers then just used the original criteria/research article. There were 73 articles that met the criteria, which meant that 40 articles were excluded.

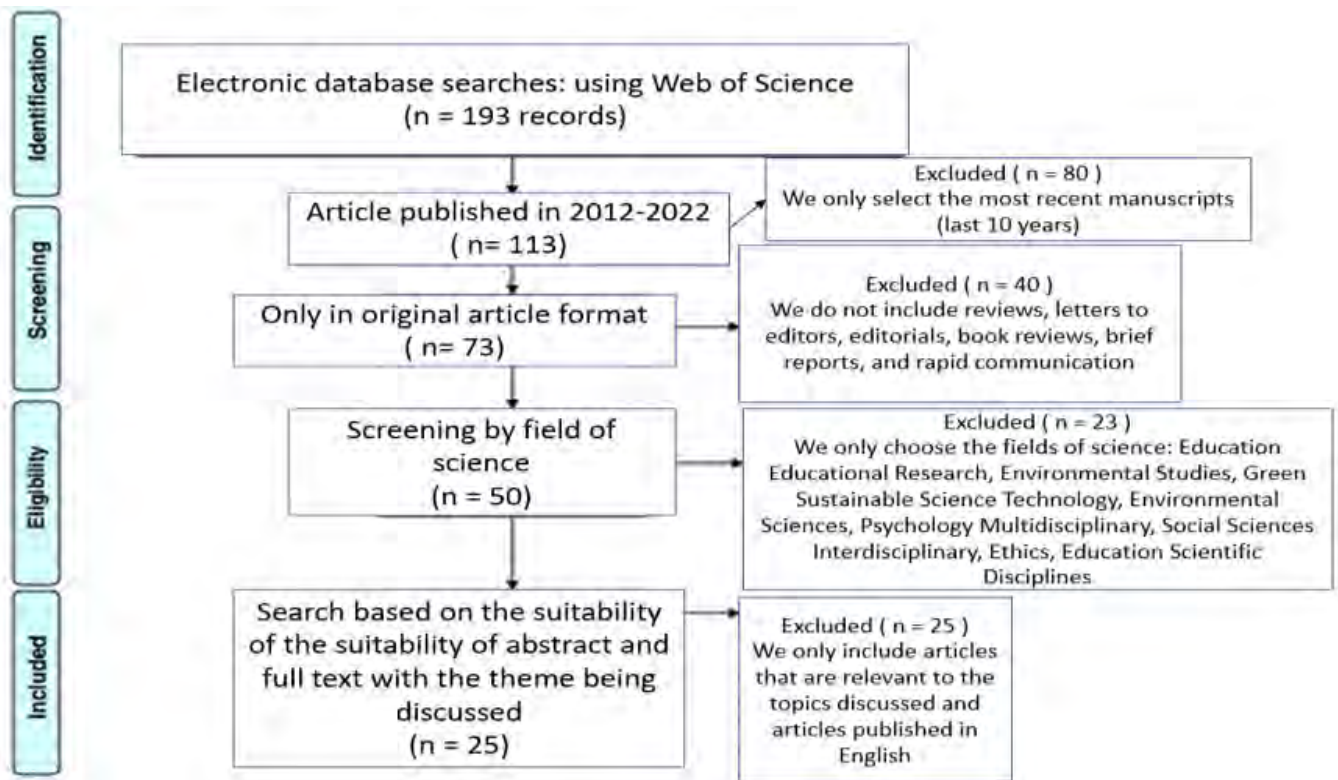


Figure 1. Systematic review flow diagram (The PRISMA flow diagram for the systematic literature review detailing the database searches, the number of abstracts screened, and the full texts retrieved)

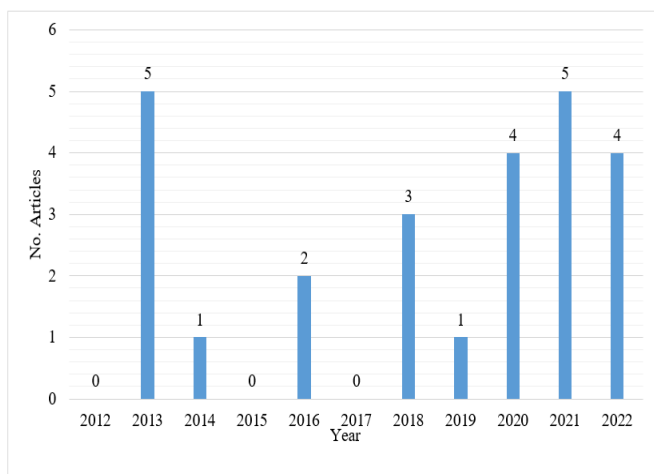


Figure 2. Distribution year of article

Furthermore, the researchers utilized inclusion criteria in the field of science to ensure that only acceptable fields of study were chosen, i.e., education educational research, environmental studies, green sustainable science technology, environmental sciences, psychology multidisciplinary, social sciences interdisciplinary, ethics, and education scientific disciplines. As a result, there were 50 articles that fit the requirements, and 23 items were excluded.

The researchers defined science fields that were not suited, such as nursing, law, linguistics, management, medical science, reproductive biology, social science biomedical, agriculture dairy animal science, area

studies, behavioral science, biotechnology applied microbiology, business finance, communication, developmental biology, emergency medicine, engineering environmental, hospitality leisure sport tourism, humanities multidisciplinary, language linguistic, medicine research experimental, microbiology, neuroscience, pediatrics, psychology applied, psychology social, regional urban planning, social work, and urban studies. Finally, the researchers re-examined the existing papers to ensure that they corresponded to the issues mentioned, that the complete text was accessible, and that the articles were published in English. As a result, the researchers received 25 articles, which indicated that 25 articles were rejected.

RESULTS

Distribution Year

Figure 2 presents several articles published from 2012 to 2022. **Figure 2** shows three years with no publications about action competence, specifically in 2012, 2015, and 2017. Following a peak in 2013, the theme of action competence has grown in popularity over the last three years (2020 to 2022). In 2021, the number will be identical to 2013. Though just four articles were identified in 2022, this subject will likely generate much attention. Thus the number will continue to climb, especially since this data is only up to March 2022, which means that there are still nine months to go for publication momentum.

Table 1. Types of research on action competence themes

No	Type of research	Amount	References
1	Qualitative	9	(Almers, 2013; Bergen & Santo, 2018; Biström, 2021; Biström & Lundström, 2021a, 2021b; Brødsgaard et al., 2013; Clark, 2016; Hedefalk et al., 2014; Sass et al., 2020)
2	Quantitative	8	(Cincera & Krajhanzl, 2013; Díaz-Noguera et al., 2020; Isac et al., 2022; Jensen, 2013; Olsson et al., 2022; Sánchez & Arias, 2021; Sass et al., 2022a, 2022b)
3	Development research	4	(Blythe & Harré, 2020; Olsson et al., 2020; Ruge et al., 2016; Sass et al., 2021)
4	Mixed-method approach	3	(Dittmer et al., 2018; Piasentin & Roberts, 2018; Zhan et al., 2019)
5	Case study	1	(Silo, 2013)



Figure 3. Authors that mostly perform publications based on the action competence theme

The year 2013 can be considered as the beginning of the revival of action competence studies, and the aggregate number is significant. However, there has been a decline in interest in this study, especially in 2014-2017. The year 2018 became the second revival point in the study of action competence, where three published articles were found. Although it declined again in 2019 (only one publication was found), the number of publications related to this theme continued to attract researchers' interest in the following years.

Research Types/Methods

The trend of research related to "action competence" themes is presented in **Table 1**. A study on action competence is more likely to be carried out utilizing a qualitative technique (nine articles). However, there are a lot of quantitative studies that only have one distinction from qualitative research (eight articles). This implies that the issue of action competence can be approached qualitatively and quantitatively. Hence, various researchers are interested in employing the mix-method (three researches). Another point of interest is the existence of a trend of action competence, which is approached through development research.

Author and Keywords

Figure 3 highlights the authors who have published the most articles on action competence. In **Figure 3**, Jelle Boeve-de Pauw and Wanda Sass from the Universiteit Antwerp published the most articles with five articles each, followed by Kris De Meyer from King's College London and University College London, and Peter Van Petegem from the University of Antwerp.

Figure 4 depicts the VOSviewer output findings for each author's relationship. Jelle Boeve-de Pauw, Wanda Sass, Kris De Meyer, and Peter Van Petegem are the most

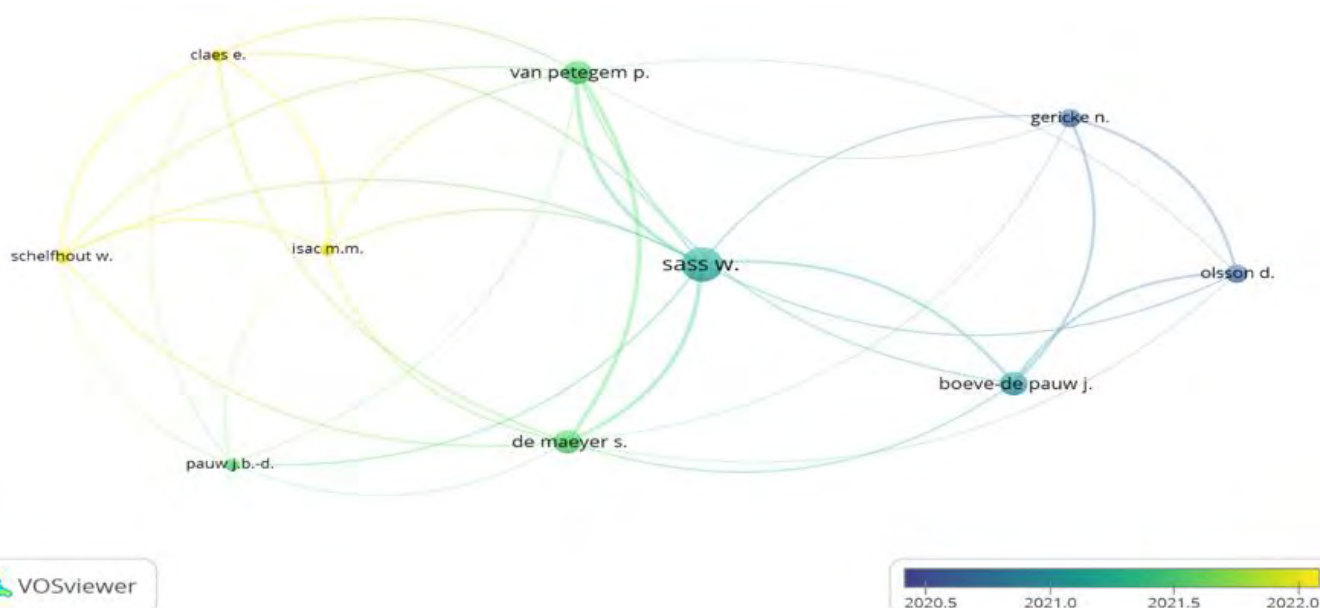


Figure 4. Dominant author and the relationship between authors in the theme of action competence

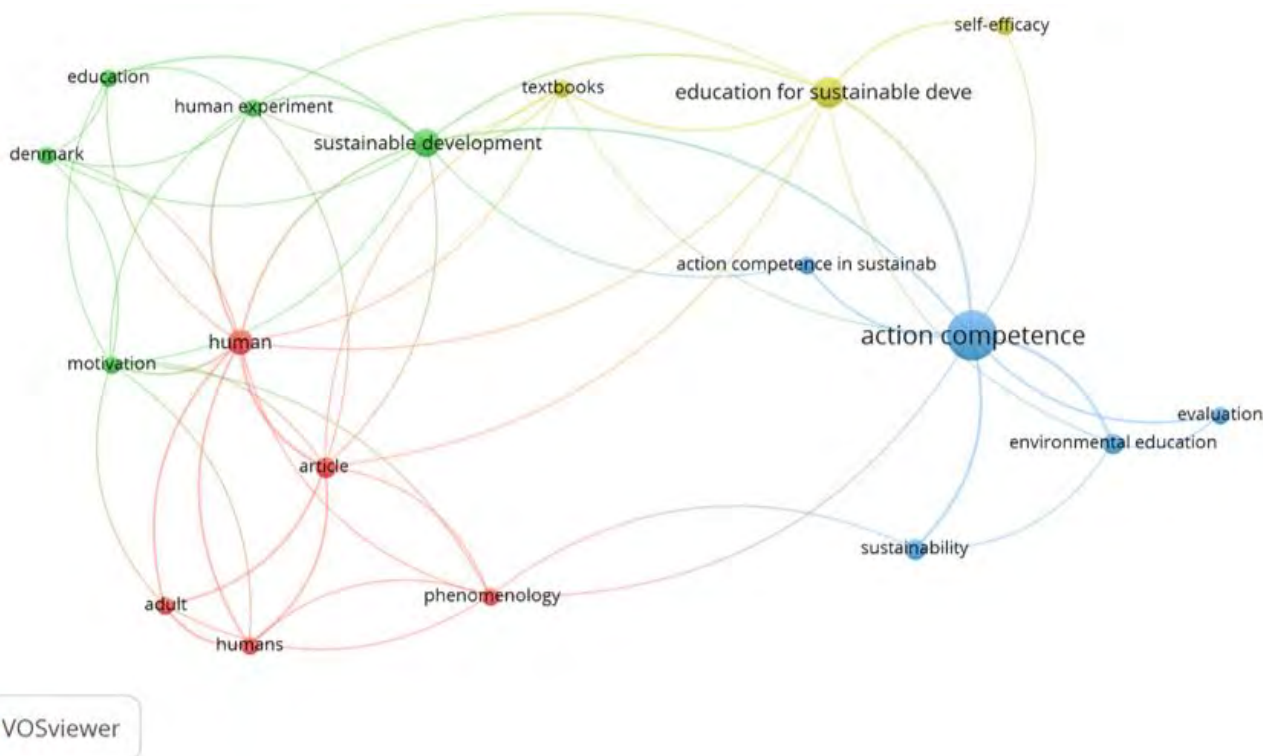


Figure 5. VOSviewer display for type of analysis “Co-occurrence □ keywords”

Table 2. Types of research on action competence themes

No	Country	Continent	Amount	%
1	Sweden	Europe	18	26.87
2	Belgium	Europe	16	23.89
3	Denmark	Europe	9	13.43
4	Spain	Europe	3	4.48
5	USA	America	3	4.48
6	New Zealand	Australia-Oceania	3	4.48
7	Italy	Europe	2	2.99
8	Czech Republic	Europe	2	2.99
9	Germany	Europe	2	2.99
10	Hong Kong	Asia	2	2.99
11	Uganda	Africa	2	2.99
12	Colombia	America	1	1.49
13	China	Asia	1	1.49
14	Brazil	America	1	1.49
15	Canada	America	1	1.49
16	Botswana	Africa	1	1.49

prominent names. Daniel Olsson, N. Gericke, Maria Magdalena Isac, Wouter Schelfhout, and Ellen Claes are among the other names that have emerged. Wanda Sass is the crucial reference in this list of names that collaborate or cite each other. What needs to be explained is that although there are Wanda Sass articles published in 2020, 2021, and 2022, VOSviewer considers that works that are related to others and are considered to be bridging between authors are articles published in 2021, entitled “Development and validation. An instrument for measuring action competence in sustainable development within early adolescence is the action competence in sustainable development questionnaire (ACiSD-Q)”.

Figure 5 reveals the keyword trend the author frequently utilized when writing about the action competence theme. According to Figure 5, the keyword of action competence is directly related to environmental education, action competence in sustainable development, ESD, and evaluation. Meanwhile, its derivatives, such as sustainable development, are linked to human experimentation and motivation.

Author’s Nationality and International Collaboration

The trends of the author’s nationality of research related to “action competence” themes are presented in Table 2.

According to Table 2, the author has only 16 countries of origin, namely Sweden, Belgium, Denmark, Spain, USA, New Zealand, Italy, Czech Republic, Germany, Hong Kong, Uganda, Colombia, China, Brazil, Canada, and Botswana. Dominant articles are written by Swedish authors (26.87%) and Belgian authors (23.89%), as well as Danish authors (13.43%). If based on continents, European contributes the most authors who publish about action competence (77.64%). America is the second-largest contributor (8.95%). Meanwhile, other continents make a relatively small contribution and the same amount, namely Australia-Oceania (4.48%), Asia (4.48%), and Africa (4.48%). It is interesting to note that publications on action competence are written by authors from all continents, indicating that action competence has become a global topic.

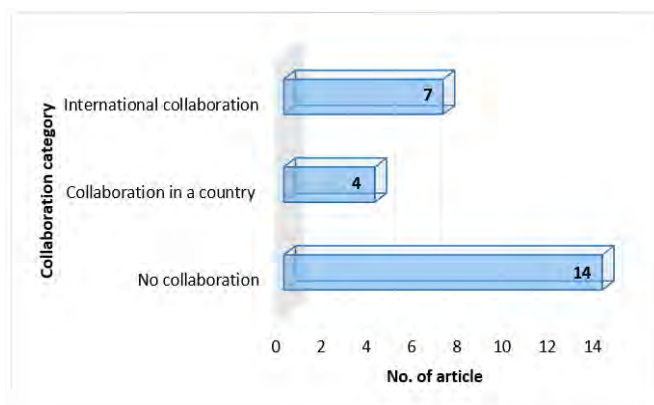


Figure 6. Authors' collaboration in writing articles

Figure 6 presents collaboration in the publication of articles by the author, including collaborations between universities across nations, collaborations inside a single country, and those that do not collaborate.

Meanwhile, Figure 7 depicts the distribution of scientist collaboration.

According to Figure 6, there are more articles published with non-collaborating status, both between universities and between countries (as many as 14 articles or 56%). However, if the researchers examine the 25 articles identified (as shown in Figure 7), the researchers may conclude that articles written separately are uncommon. Although the articles are only written by authors from one university, they appear to collaborate across scientific subjects by joining a research unit at the university. Nonetheless, the number of collaborations between universities and countries cannot be neglected since it is relatively considerable, namely 11 publications

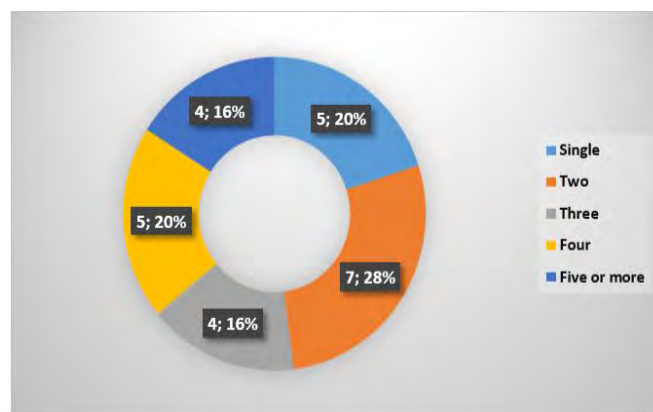


Figure 7. Distribution of scientist collaboration

or 44%. Only five articles (20%) are written independently/by a single author.

Linkage/Contribution to Action Competence and Environmental Education for Prospective Science Teachers

The vital contribution of the article to the theme of environmental education for prospective science teachers can be seen in Table 3.

Table 3 shows a contribution from two references related to environmental education for prospective teachers:

- (1) Science teachers must realize that the implementation of environmental education to realize action competence in students requires process and consistency;

Table 3. The important contribution of articles to environmental education theme for science prospective teachers

No	Aims	Method	Main results	Contribution of each reference	Links to environmental education
1	Explore children's possibilities to learn action competence	Qualitative	How do children make value judgments in situations where facts are not sufficient for solving a problem	Action competence (AC) is the ability to make critical decisions about different alternative actions toward a more sustainable future (Hedefalk et al., 2014).	Science teachers must realize that implementing environmental education to develop action competence in students necessitates a process and consistency.
2	Revisits the seminal question of the effectiveness of ESD	Quantitative	Developing action competence by implementing ESD in school takes time	Developing students' action competence in formal education takes time (Olsson et al., 2022).	These six points become the reference for science teachers implementing environmental education.
3	Analyze what drives a person's action competence	Qualitative	Six general themes based on narrative analysis.	Things that encourage action competence for sustainability include emotions that create a desire to change conditions; core values and contrasting perspectives; penetration action; confidence and competence with what can be contributed; confidence and self-confidence; outsiders, and a sense of belonging (Almers, 2013).	

Table 3 (Continued). The important contribution of articles to environmental education theme for science prospective teachers

No	Aims	Method	Main results	Contribution of each reference	Links to environmental education
4	Analyze the concept of action competence	Qualitative	The use of action competence provides the means for knowledge transfer, action accountability, self-awareness, and reflection.	The use of AC allows for knowledge transfer, accountability for actions, self-awareness, and reflection. In addition, students learn crucial problem-solving skills and the mission of sustainability as a result of this approach (Bergen & Santo, 2018).	These four aspects become the reference for science teachers implementing environmental education.
5	What factors correlate with pupils' action competence	Quantitative	The level of competence of the action is different; the most critical factor is the perception of student participation in the decision-making process.	Male and female students' level of AC is different (Cincera & Krajhanzl, 2013).	Science teachers must be aware that gender issues must be addressed while implementing environmental education.
6	We are assessing the impact of YLEC on environmental action competence in two countries.	Mixed-method	YLEC effectively built on the conditions faced in each country.	Action-oriented education is vital in advancing citizen engagement in a culture of sustainability (Dittmer et al., 2018).	Science teachers must prioritize student and parent involvement (direct practice/project) in implementing environmental education; therefore, communication must continue.
7	Analyzing the role of campus practitioners in creating sustainable campuses and communities	Qualitative	Collective action competence needs to be implemented	Two specific recommendations for campus sustainability practitioners can be made: (1) use components of social learning in conjunction with collective action, and (2) prioritize AC over cognitive outcomes (Clark, 2016).	
8	Help students develop action competence by WCEP	Mixed-method	The student's water conservation action competence in the four aspects	Students should be assisted in building action competence by participating in conservation education programs (Zhan et al., 2019).	
9	Analyzing student participation in environmental management activities	Case study	Dialogue between teachers and students is lacking; teachers tend to view student participation as minimal.	Teachers tend to regard children's participation in environmental management activities as relatively limited due to a lack of conversation between teachers and students (Silo, 2013).	
10	Interviewing parents in managing their children	Qualitative	Parents feel responsible for their children's habits but still need professional support.	A better understanding of how to approach, motivate, & support parents in using their competence to help their children is desperately needed (Brødsgaard et al., 2013).	
11	How students' participation in the school program	Development research	Students who participated in LOMA educational activities became motivated to develop a program.	Students' AC includes knowledge, insight, motivation, ownership, action experience, commitment, cooperation, & critical thinking. When students engage in hands-on work with teachers & peers, they build practical skills in AC relating to food & health (Ruge et al., 2016).	

Table 3 (Continued). The important contribution of articles to environmental education theme for science prospective teachers

No	Aims	Method	Main results	Contribution of each reference	Links to environmental education
12	How is the content of textbooks on sustainable development and gender equality about the promotion of action competence	Qualitative	Sustainable development and gender equality are not integrated into textbooks.	The content of textbooks on sustainable development and gender equality might help or hinder the growth of action competence (Biström & Lundström, 2021a).	Science teachers must guarantee that the textbooks used in environmental education implementation are acceptable (in line with the sustainability mission, are not gender biased, and the topics are integrated).
13	The affordability and limitations of textbooks for promoting action competence.	Qualitative	The relationship between the ecological, economic, and social dimensions and between different subjects is less developed.	Existing textbooks substantially limit the possibility of fostering action competence for sustainable development (Biström & Lundström, 2021b).	
14	Understand the role of textbooks in promoting action competence for sustainability	Qualitative	Sustainable development and sexuality are set as separate topics in all books.	In all textbooks, sustainable development and sexuality are considered independent issues (Biström, 2021).	
15	Discusses the benefits and limitations of MAD	Development research	MAD significantly promoted the transformation and action competence in participants.	MAD is one example of a long-term student leadership program. This curriculum emphasizes the significance of transformation and action competence in motivating change (Blythe & Harré, 2020).	The MAD program, DMGAC, and AR are some strategies that science teachers can utilize to undertake environmental education.
16	Compares the learning effects of the DMGAC with the DMDI	Quantitative	Students participating in the DMGAC achieve a higher tactical performance index than the DMDI.	DMGAC is a teaching program that teaches students how to improve their tactical performance in AC (Sánchez & Arias, 2021).	
17	Presenting students' perceptions of professional competence through the use of technology	Quantitative	We must improve our learning design by combining simplicity and flexibility to enable students' professional skills.	By combining simplicity and flexibility, we should improve the design of augmented reality-based learning (Díaz-Noguera et al., 2020).	
18	Describes sustainability courses that can contribute to promoting paradigm change and student action competence.	Mixed-method	Students demonstrate an increased aspect of their beliefs about the socio-economic aspects of sustainability and gain increased awareness of sustainability issues.	The growth of action competence and paradigm change can be examined by assessing their learning experiences and comparing pre- and post-learning questionnaires (Piasentin & Roberts, 2018).	Research-based innovations that science teachers can use and develop in environmental education are PACesd-Q, SPACS-Q, and ACiSD-Q.
19	Outlining a project on ACP	Quantitative	The article has presented the intervention model and its phases its theoretical basis and considers methodological questions, obstacles, and exciting findings.	In action competence, innovation based on research-generated knowledge and success with implementation strategies presupposes a relationship between professionals and researchers (Jensen, 2013).	
20	Introduce an integrated framework on PACesd	Quantitative	The results of the reliability analysis and hierarchical confirmatory factor analysis provide evidence of good measurement properties of the PACesd instrument.	Education practitioners can utilize the PACesd-Q instrument to monitor and identify ESD development needs (Sass et al., 2022a)	
21	Implementation of the valid PACesd measurement instrument for teachers.	Quantitative	Higher PACesd levels of primary school teachers compared to secondary education teachers.	According to PACesd, the main form of ESD professional development is continuous interaction between groups of teachers about ESD issues (Isac et al., 2022).	

Table 3 (Continued). The important contribution of articles to environmental education theme for science prospective teachers

No	Aims	Method	Main results	Contribution of each reference	Links to environmental education
22	Operationalization of the concept of action competence for sustainability through the development of SPACS-Q	Development Research	SPACS-Q is a new instrument supported by theory and is empirically reliable and valid.	SPACS-Q is a new and theory-driven instrument that is empirically reliable and valid, and researchers are encouraged to utilize it when examining people's Action Competence for Sustainability in various contexts (Olsson et al., 2020).	
23	Reports on the development of the ACiSD-Q measurement instrument.	Development Research	Rigorous statistical analysis confirmed the proposed structure, reliability, construct, and predictive validity of the ACiSD-Q instrument.	ACiSD-Q is valid and reliable, making it appropriate for monitoring students' ESD and Action Competence in sustainable development (Sass et al., 2021).	
24	It offers an updated and refined generic definition of action competence as a person's competency.	Qualitative	They connect the concept of action competence with commitment, enthusiasm, knowledge, and self-efficacy.	Action Competence involves commitment, passion, knowledge, and self-efficacy in resolving contentious matters. The specific notion of "Action Competence in Sustainable Development" (ACiSD) articulates people's ability to engage in issue solving related to sustainability (Sass et al., 2020).	
25	Analyze and determine that formal education plays a role in changing students' ACiSD	Quantitative	Grade level is essential for ACiSD change in early adolescence.	Changes in a grade level are significant for ACiSD students. However, more research is needed to determine how the teacher education approach influences these changes (Sass et al., 2022b).	

- (2) Five points serve as a reference for science teachers in implementing environmental education, namely emotions that create a desire to change conditions, core values and contrasting perspectives, penetration of action, confidence and competence with what can be contributed, trust and confidence, people outside, and a sense of belonging;
- (3) Four aspects that serve as references for science teachers in implementing environmental education, namely knowledge transfer, action accountability, self-awareness, and reflection;
- (4) Science teachers must be aware that gender factors need attention in the implementation of environmental education;
- (5) Science teachers must prioritize the involvement of students and parents (direct practice/project) in the implementation of environmental education, therefore dialogue must continue;
- (6) Science teachers must ensure that the textbooks used in the implementation of environmental education are genuinely appropriate (in line with

the sustainability mission, are not gender biased, and the topics are integrated);

- (7) Some things that science teachers can use in implementing environmental education are the make a difference (MAD), didactic model game action competences (DMGAC) program, and augmented reality (AR); and
- (8) Research-based innovations that science teachers can use in environmental education are PACesd-Q, SPACS-Q, and ACiSD-Q.

DISCUSSION

Distribution Year

The last three-year trend indicates that the study on action competence has been increasing. This means that researchers' interest in this theme is getting better. This is in line with the view of Chen and Liu (2020) that as the concept of sustainability has been growing in recent years, the issue of action competence has steadily gained researchers' attention. This coincides with a significant

increase in the interdisciplinary topic of sustainable development.

The increase in researchers' interest in action competence is in line with the improvement of the implementation of environmental education. Environmental education has become a global practice (Benítez et al., 2019; Edsand & Broich, 2020; Marpa, 2020; Nurwidodo et al., 2020; Reddy, 2021). It is confirmed that action competence is one of environmental education's primary goals (Breiting et al., 1999; Breiting & Mogensen, 1999). The concept of action competence is considered a central position, particularly in the theory of environmental education, due to its numerous issues. At the same time, action competence should be considered an alternative in environmental education (Jensen & Schnack, 1997). Action competence refers to a student's ability to act environmentally oriented as an active participant in environmental education. It includes the ability to recognize problems, make decisions about solutions, and take activities that prepare children to participate in future environmental action. Student action competence development can be viewed as a classroom practice that fosters its development through environmental education (Eames et al., 2006).

Research Types/Methods

Issue of action competence can be approached through qualitative and even quantitative or mixed-method. Action competence in environmental education can also be approached using development research. Baytak (2011) discovers that environmental issues can be approached quantitatively, depending on the case, as in Ballantyne et al.'s (2001) view. Meanwhile, Yesilyurt et al. (2020) assert that student data about environmental education, such as describing enthusiastically and reflecting on environmental awareness, as well as the results of interviews with students who gain awareness of the environment, empathize with nature, and draw very aesthetic pictures, can be approached qualitatively. On the other hand, Ikhsan et al. (2019) use quantitative and qualitative mixed methods in their research entitled "the research-based learning approach in environmental education." Furthermore, according to Ardoin et al. (2020), given the variation in research designs and data, the researchers use a mixed-methods approach to review environmental education outcomes for conservation.

In different cases, data indicates that the issue of action competence can be approached using development research. Development research is a systematic study focusing on designing, illustrating, and evaluating programs, processes, and instructional products that must meet consistency and internal effectiveness criteria. The development focus of this research is that the research is very crucial. The products, product impact, and general analysis of the design development or evaluation product are the focus of this

research. Development research has made significant contributions to the advancement of the field, frequently serving as the basis for developing models and theories (Richey, 1994). Development research is appropriate for both experienced researchers and those preparing to become researchers. This research aims to stimulate future thinking about methods, strategies, and problems related to the field (Klein & Richey, 2007)

Author and Keywords

According to the data (Figure 3 and Figure 4), the most productive authors are Jelle Boeve-de Pauw and Wanda Sass. These names are related to the names of other authors. These names collaborate or cite each other, with Wanda Sass being the most important reference.

Jelle Boeve-de Pauw is an assistant professor of science education at the Freudenthal Institute at the University of Utrecht. He is interested in environmental education and education for sustainable development and others. Measurement problems and evaluation in this field are the core of his research. In addition, he teaches courses related to the postdoctoral researcher and visiting professor dynamics of society. He is also affiliated with the researcher and visiting professor. Furthermore, he is an associate editor for Springer environment journals, development and sustainability (Universiteit Utrecht, 2022). He has 17 h-index and 42 documents based on the Scopus data (<https://www.scopus.com/authid/detail.uri?authorId=35270983100>).

Meanwhile, Wanda Sass is interested in action competence in education for sustainable development, specifically in children (aged 10 to 14) and teachers. She emphasizes that she is happy to be a part of the VALIES team (<http://www.edo-valies.be/>) and the research unit of Edubron (<https://www.uantwerpen.be/en/research-groups/edub/>). Moreover, she is also interested in what motivates people and their environmental behavior (University of Antwerp, 2022). She has four h-index and eight documents based on the Scopus data (<https://www.scopus.com/authid/detail.uri?authorId=57203062605>).

According to the data (Figure 5), it can be seen that the keyword of action competence is directly related to sustainability, environmental education, action competence in sustainable development, sustainable development, ESD, and evaluation. While its derivatives, such as sustainable development, are related to motivation. According to Olsson et al. (2022), environmental education, action competence in sustainable development, and ESD are interrelated. Therefore, we can conclude that ESD affects students' action competence for sustainability. Our longitudinal growth model implies that students' action competences can be developed and influenced by their experiences

teaching ESD in their schools. Meanwhile, Chen and Liu (2020) postulate that the purpose of ESD is to develop future citizens who can make proper decisions and take responsible action to solve sustainability problems. This research indicates that action-oriented and transformative pedagogy encourages students to be active participants, strengthens their ability to examine cause and effect, and expands on their vision to identify solutions to sustainability issues.

Regarding the evaluation, according to Hedefalk et al (2014) in ESD, action competence is an ability to make assessments critically and evaluate in several different ways as the basis for future actions to achieve a sustainable future. The results depict how children make score assessments when facts are insufficient to solve the problem. On the other hand, Kurt et al. (2013) assert that action competence should be seen as a holistic construction involving various literacy, critical thinking, responsibility, and motivation, all qualities needed to solve social problems. According to Olsson et al. (2020), in the context of action competence, it can be seen that three kinds of significant motivation underlie environmental behavior, i.e., intrinsic motivation, extrinsic motivation, and motivation.

Author's Nationality

Only 16 countries have published the author's action competence articles. Most of the articles are produced by European authors from Sweden, Belgium, and Denmark. In recent decades, ESD has become a significant factor in influencing educational policy developments in Sweden. In this context, Sweden is the most progressive country in terms of implementing ESD at various levels of education and doing ESD research (Biström & Lundström, 2021b). Based on documents issued by UNESCO, ESD and the ideals of realizing action competence have been used and even integrated into the formal context of the curriculum and educational practices implemented in Sweden (Olsson et al., 2016). Indeed, it can be emphasized that Sweden is a country that influences international interests in reviewing and implementing the ESD and the achievement of action competence (Cars & West, 2015). In its early stages of development, Sweden's education curriculum has emphasized the importance of individual responsibility in addressing larger-scale or global environmental issues (Hillbur et al., 2016). In Sweden's curriculum (i.e., 2011 curriculum), it has been emphasized that one of the goals is that the students can obtain knowledge about the condition of sustainable development and understanding of the way of lifestyle that provides an impact on health, environment, and community (Svalfors, 2017).

Meanwhile, in Belgium, the ESD is embedded compulsory education curriculum through subject-specific and cross-curricular educational goals (Isac et

al., 2022). Indeed, a more extensive project has been enforced, namely valorizing integrated and action-oriented education for sustainable development (VALIES). This project aims to study the critical success factors and barriers to bringing integrated and action-oriented education for sustainable development to schools in Belgium (Sass et al., 2022b). In Denmark, the situation is similar. Issues of action competence have become a matter of interest in Denmark. Action competence has been a critical concept in educational circles in Denmark since the 1980s (Mogensen & Schnack, 2010).

Authors in all continents have written articles on action competence. This indicates that the issues of action competence have become global concern. This demonstrates the impact of intergovernmental agreements and the resilience of the action competence from environmental education to education for sustainable development (Chen & Liu, 2020). For instance, especially in Oceania, action competence for sustainability has been recognized by the New Zealand government as a critical goal (Teaching and Learning Research Initiative, 2010). A model of action competence can be implemented in the class, which is influenced by the role of student culture in the model (Arthur, 2011).

Authors' Collaboration

More articles with non-collaborating status (university and country) are published; nonetheless, articles written by independent/single authors are uncommon. A single author writes only a few articles. The articles tend to be written and published by scientists across fields, universities, and countries. The current trend shows a tendency for articles to be published in collaboration. This is because ESD and action competence have become global issues, with increasing evidence that scientists from other continents are interested in these issues.

Good articles should be written by scientists from various areas (collaboration). Collaboration is crucial, especially when dealing with complexities necessitating integrating knowledge from various disciplines (Eberle et al., 2021). Scientific publications are the building blocks of discovery and collaboration. This pattern encourages excellent readability, comprehension, and confidence. This is a more collaborative and diverse way of communicating our scientific products (Freeling et al., 2021). Collaborative research encourages group creativity that exceed the creativity of any individual in the team, which in the publication context will have a high impact since it is a cross-disciplinary product (Uzzi et al., 2013). Consequently, collaborative publication encourages the emergence of collective creativity to maximize original and innovative research as a result of individual reflection and brainstorming during the script development process (Oliver et al., 2018).

Interdisciplinary research is generally more heavily funded than research with a limited area of knowledge (Bellotti et al., 2016). This trend shows that more research is being carried out in large teams, so it is more likely that multiple authors will write articles from different institutions, disciplines, and cultural backgrounds. At the same time, it should be acknowledged that collaborative writing with multiple authors has additional challenges, such as author involvement, fair credit, diversity of work styles, and clarity of communication (Frassl et al., 2018). Other challenges come from theoretical and methodological approaches across the team's line of work (Peffer & Renken, 2016).

Contribution to Environmental Education for Prospective Teachers

The researchers can formulate several vital points that can be described the relationship one by one. First, science teachers should know that implementing environmental education requires processes and consistency to realize student action competence. This is in line with Kimaryo (2011) that the implementation of environmental education is a complex process, so it can be a challenge for the teachers. According to Chen and Liu (2020), through the learning process and environmental education, action competence can be instilled in students so that they have visions and commitments based on critical thinking. Conde and Sánchez (2010) also postulate that this can be strengthened by developing the participation process and students' motivation. In this context, Dayagbil et al. (2021) have a particular view that administrative understanding is needed to support teaching-learning processes, students have a role as a core of the system, lecturers or science teachers carry out various academic roles, and parents share responsibility for continuous learning, communities and external partner contribute to the implementation of education as well.

Second, there are six points of reference for science teachers when implementing environmental education: emotions; contrasting values and perspectives; penetration of action; confidence, competence, and self-confidence; outsiders; and a sense of belonging. Almers (2013) proposes that the six points can be explored phenomenologically through the lives of three Swedes who have for several years reduced their ecological footprint, led activist environmental initiatives, engaged in ecosystem protection, and participated in advanced non-activism in public. A possible follow-up to all of this is the need in the future to implement the six main themes in cross-cultural studies to challenge or articulate additional themes, particularly in the context of competence for science teacher candidates. Finally, it should be memorized that based on Biesta (2009), action competence is not only about "acting" and not for education that is only considered as taking action. This

necessitates the goal of all high-quality science education and environmental education.

Third, four aspects serve as a guide for teachers when implementing environmental education: knowledge transfer, action accountability, self-awareness, and reflection. According to Bergen and Santo (2018), through these four points, the students are expected to gain continuous critical problem-solving skills, which can be applied in various conditions in the future. Action competence consists of concrete components that apply to the sustainability of the knowledge gained by students. Correspondingly, Filho et al. (2018) underline that reflection is critical to developing students' transformative potency as agents of a sustainable future. Educational institutions must transform to become models of social justice and environmental management, as well as promote sustainable learning. In the context of prospective science teachers as adults, Loeng (2020) emphasizes that independent learning is needed, which this term is often used in adult education. The tendency to self-direction is the fundamental difference between children and adults in learning situations.

Fourth, science teachers must recognize that gender issues must be addressed in the implementation of environmental education in order to attain action competence. To implement the ESD, teachers should have professionalism, specifically ESD (Lohmann et al., 2021); one of them is by paying attention to the aspect of gender equality so that it makes a significant contribution to its achievement (Yuan et al., 2022). Gender equality in the community will improve their knowledge about implementation and challenges related to sustainable development (González & Sebastián-López, 2022). ESD is an education vision that tries to balance human and economic well-being with cultural traditions and respect for natural resources, where gender equality, respect for human rights, and managing natural resources are emphasized (Wals & Kieft, 2010). We habitually use humanity as just one planet, but we have a habit of using it irresponsibly. We are still far from reaching gender equality, with a significant power asymmetry in people's abilities to acquire and develop knowledge about sustainability (UNESCO, 2021).

Fifth, science teachers must prioritize student and parent involvement (direct practice/project) in environmental education implementation, so communication must continue. Students' participation is based on scientific knowledge, environmental culture, and ethics (Shutaleva et al., 2020). Participation in the form of projects tries to change learned patterns of life and encourage people to contribute toward a more sustainable climate. Implementing learning projects based on environmental implications and human responsibility will be highly beneficial in developing competence (Thor & Karlsudd, 2020). In the context of the relationship with parents, to facilitate future

collaboration, it is recommended to communicate in collaborative curriculum development projects (Keselman et al., 2011).

Dialog between science teachers, students, and parents is essential to implementing environmental education. The use of the dialogical approach as a strategy to improve environmental awareness can support the children's will so that it is possible to be included in the permanent curriculum (Vicencio, 2012). In an emancipatory way, efforts must be made to engage people in active dialogue to establish individual goals and environmental action plans (Torkar, 2014). A process of dialogue, collaboration, review, and refinement of the teaching and learning process is required to embrace culture inclusively (Ferrante, 2012). Dialogue can be conducted across age groups, cultures, and contexts. Various studies have examined the uniqueness of dialogue as a powerful and effective learning tool since it can change cultural-social context and people's mindsets (García-Carrión et al., 2020).

Sixth, science teachers must ensure that the textbooks used in environmental education implementation are acceptable (in line with the sustainability mission, are not gender biased, and the topics are integrated). Environmental education is becoming increasingly important in the science curriculum since it provides an opportunity to study science subject matter and introduce social and cognitive skills. A textbook is necessary in this regard (Verma & Dhull, 2017). In addition, the textbook is an essential learning material to help students understand a concept (Ilma & Wijarini, 2017; Kimaryo, 2011). Unfortunately, a study shows that science textbooks on environmental issues are relatively limited information. This provides an initial understanding of science teacher perspectives in environmental education and several implications for developing the environmental textbooks that must be done in the future (Oguz et al., 2004). This can be a challenge, Biström and Lundström (2021b) explain that current textbooks substantially limit the potential to promote action competence for sustainable development, i.e., through a cross-curricular approach and critically assessing problem-oriented action at the collective and individual levels.

Seventh, teachers can use several things in implementing environmental education: The MAD program, the DMGAC, and AR. These are only several examples that can be tried. MAD is a continuing leadership program for high school students in Auckland, New Zealand, which program aims to encourage transformative learning and action competence (Blythe & Harré, 2020). The study results show that MAD affects increasing environmental knowledge, change in personal practice, and participation in environmental action and leadership (Bourassa, 2017). Additionally, "DMGAC is a new didactic model based on constructivism educational

theory. It promotes learning tactical behaviors, decision making, autonomy, and cognitive development" (Sánchez & Arias, 2021). Another exciting thing is the AR of environmental education. AR in the environmental education class effectively arouses students' interest and encourages participation for better involvement in learning activities; thus, it effectively increases students' understanding of learning materials (Huh et al., 2020). However, designing AR-based learning activities for environmental education is problematic because it can be done in informal and outdoor environments (Arvola et al., 2021), such as field trips or parks. As a result, it can be discussed further about the purpose and the form of AR, particularly in environmental education (Ducasse, 2020).

Eighth, teachers can use research-based innovations in environmental education, are PACesd-Q and ACiSD-Q. From an academic perspective, the challenge of environmental education - enhancing student action competence - cannot be considered separately. Once a problem has been agreed upon, students use critical thinking to examine it. They then use creative thinking to visualize what happened or to decide what improvements they would like to see. Next, the students analyze problems and ideas about them to determine what is possible and continue to identify what can help them achieve their goals (enablers) and what can hinder them (barriers). Finally, the students developed an action plan and applied it. After completing their action, the students evaluate the results and identify what they have learned from experience (even if their original goal has not been achieved) (Ministry for Education, 2015). Therefore, an evaluation of students' abilities in the context of action competence should be carried out, in which it can utilize PACesd-Q, SPACS-Q, and ACiSD-Q.

CONCLUSION

This SLR reveals that there has been an increase in research on action competence over the previous three years. This demonstrates that researchers' interest in this topic is increasing. The growing interest in action competence corresponds to the expansion of environmental education. Furthermore, it has been discovered that the topic of action competence can be approached using either qualitative or quantitative methods or a combination of the two (mix-method). Data from several cases suggest that development research can address the issue of action competence. In the author's context, it may be inferred that Jelle Boeve-de Pauw and Wanda Sass publish the most action competence themes. These names are related to the names of other authors. These names collaborate or cite each other, with Wanda Sass being the most prominent reference. According to the data, the action competence keyword is directly associated with sustainability, environmental education, action competence in

sustainable development, ESD, and evaluation. Meanwhile, its derivatives, such as sustainable development, are related to motivation.

We also discovered that just 16 countries publish papers on action competency based on the author's nationality. Most papers are produced by European authors, specifically from Sweden, Belgium, and Denmark. Action competence articles are authored by authors from many continents, demonstrating that the topic of action competence has become a global concern. There are also more articles published with non-collaborating status (universities and countries); however, articles written independently/a single author are rare. Only a few articles have a single author. Articles are typically authored and published by scientists from various fields, universities, and countries. The current trend indicates that publications are being published in collaboration.

We can generate several essential points:

- (1) science teachers must realize that the implementation of environmental education to achieve action competence in students requires process and consistency;
- (2) there are six points as a reference for science teachers in implementing environmental education;
- (3) there are four aspects that become a reference for teachers in implementing environmental education;
- (4) Science teachers must be aware that gender factors need attention in the implementation of environmental education to achieve action competence;
- (5) Science teachers must prioritize student and parent involvement in the implementation of environmental education, so dialogue must continue;
- (6) Science teachers must ensure that the textbooks used in implementing environmental education are truly appropriate;
- (7) Science teachers can use examples in implementing environmental education; and
- (8) PACesd-Q, SPACS-Q, and ACiSD-Q are research-based innovations that teachers can use in environmental education.

Based on the formulation of these critical points, we can recommend several things for further research, namely

- (1) In-depth research is needed on the consistency and processes carried out by science teachers or even lecturers at universities in the implementation of environmental education to realize action competence in students;

- (2) the implementation of the six main points that serve as a reference for science teachers in implementing environmental education, it is necessary to examine the pattern of implementation or how the implementation model is in the field/classroom so that it is more targeted;
- (3) There needs to be research on the impact of the four aspects that serve as a reference for teachers for the successful implementation of environmental education;
- (4) Studies or surveys on the sensitivity of science teachers to gender factors in the implementation of environmental education to achieve action competence need to be carried out;
- (5) It is necessary to develop a learning model or system that encourages the involvement of students and parents in the implementation of environmental education based on maximizing dialogue;
- (6) It is necessary to develop textbooks that are in line with the needs of implementing environmental education;
- (7) It is necessary to conduct joint research with teachers to implement several examples of learning models in environmental education; and
- (8) The application of PACesd-Q, SPACS-Q, and ACiSD-Q can be done in schools.

In addition, this instrument can be further developed according to the conditions and characteristics (demography) of the region, region, or country and the learning needs in the classroom, for example, by linking it to aspects of spirituality and religiosity (in this case, it is very suitable for countries that are closely related to the religious values like Indonesia).

Limitation

We did not arrive at the meta-analysis stage due to the limited data obtained and the limited space (pages) available in this article. Therefore, this needs to be an opportunity for further researchers to continue the study or analysis to the meta-analysis aspect.

Author contributions: All authors have sufficiently contributed to the study, and agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

- Almers, E. (2013). Pathways to action competence for sustainability-Six themes. *Journal of Environmental*

- Education*, 44(2), 116-127. <https://doi.org/10.1080/00958964.2012.719939>
- Ardhi, M. W. (2018). Integrasi green learning dalam pembelajaran biologi untuk mendukung sustainable development goals [Integration of green learning in biology learning to support sustainable development goals]. *Prosiding Seminar Nasional Sains dan Entrepreneurship [Proceedings of the National Seminar on Science and Entrepreneurship]*, V, 14-21.
- Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, 241, 108224. <https://doi.org/10.1016/j.biocon.2019.108224>
- Arthur, M. (2011). Development of action competence using education for sustainability in a New Zealand school. *University of Waikato*. <https://researchcommons.waikato.ac.nz/handle/10289/5376>
- Arvola, M., Fuchs, I. E., Nyman, I., & Szczepanski, A. (2021). Mobile augmented reality and outdoor education. *Built Environment*, 47(2), 223-242. <https://doi.org/10.2148/BENV.47.2.223>
- Aulia, R. (2020). Persepsi mahasiswa calon guru Kimia tentang pendidikan untuk pembangunan berkelanjutan [Chemistry teacher candidate student's perception about education for sustainable development]. *UIN Syarif Hidayatullah Jakarta*. <http://repository.uinjkt.ac.id/dspace/handle/123456789/49987>
- Ballantyne, R., Fien, J., & Packer, J. (2001). Intergenerational influence in environmental education: A quantitative analysis. *Australian Journal of Environmental Education*, 17(3), 1-7. <https://doi.org/10.1017/S0814062600002378>
- Bao, H., Wang, C., Han, L., Wu, S., Lou, L., Xu, B., & Liu, Y. (2020). Resources and environmental pressure, carrying capacity, and governance: A case study of Yangtze River Economic Belt. *Sustainability (Switzerland)*, 12(4), 1576. <https://doi.org/10.3390/su12041576>
- Baytak, A. (2011). Towards effective instructions in environmental education: A critical review of literature. *European Journal of Physics Education*, 2(1), 16-22.
- Bellotti, E., Kronegger, L., & Guadalupi, L. (2016). The evolution of research collaboration within and across disciplines in Italian academia. *Scientometrics*, 109(2), 783-811. <https://doi.org/10.1007/s11192-016-2068-1>
- Benítez, F. F., Paredes, M. E. R., Collado-Ruano, J., Terán, E. F. H., & Ibarra, G. D. L. (2019). Environmental education program in Ecuador: Theory, practice, and public policies to face global change in the anthropocene. *Ensaio [Rehearsal]*, 27(105), 859-880. <https://doi.org/10.1590/S0104-40362019002701950>
- Bergen, J., & Santo, L. T. (2018). Action competence: A concept analysis. *Nursing Forum*, 53(3), 358-363. <https://doi.org/10.1111/nuf.12248>
- Bezeljak, P., Scheuch, M., & Torkar, G. (2020). Understanding of sustainability and education for sustainable development among pre-service biology teachers. *Sustainability (Switzerland)*, 12(17), 6892. <https://doi.org/10.3390/SU12176892>
- Biesta, G. (2009). Good education in an age of measurement: On the need to reconnect with the question of purpose in education. *Educational Assessment, Evaluation and Accountability*, 21(1), 33-46. <https://doi.org/10.1007/s11092-008-9064-9>
- Birkle, C., Pendlebury, D. A., Schnell, J., & Adams, J. (2020). Web of Science as a data source for research on scientific and scholarly activity. *Quantitative Science Studies*, 1(1), 363-376. <https://doi.org/10.1162/qssa00018>
- Biström, E. (2021). Action competence for sustainable sexuality: An analysis of Swedish lower secondary level textbooks in biology and religious education. *Sex Education*, 00(00), 1-14. <https://doi.org/10.1080/14681811.2021.1966408>
- Biström, E., & Lundström, R. (2021a). Action competence for gender equality as sustainable development: Analyzing Swedish lower secondary level textbooks in biology, civics, and home and consumer studies. *Comparative Education Review*, 65(3), 714607. <https://doi.org/10.1086/714607>
- Biström, E., & Lundström, R. (2021b). Textbooks and action competence for sustainable development: An analysis of Swedish lower secondary level textbooks in geography and biology. *Environmental Education Research*, 27(2), 279-294. <https://doi.org/10.1080/13504622.2020.1853063>
- Blythe, C., & Harré, N. (2020). Encouraging transformation and action competence: A theory of change evaluation of a sustainability leadership program for high school students. *Journal of Environmental Education*, 51(1), 83-96. <https://doi.org/10.1080/00958964.2019.1629381>
- Booth, A., Sutton, A., & Papaioannou, D. (2012). *Systematic approaches to a successful literature review*. SAGE.
- Bourassa, L. (2017). The ripple effect: Youth leadership development and influence on environmental engagement in the community. *Wilfrid Laurier University*. <https://scholars.wlu.ca/etd/1929>
- Breiting, S., & Mogensen, F. (1999). Action competence and environmental education. *Cambridge Journal of*

- Education*, 29(3), 349-353. <https://doi.org/10.1080/0305764990290305>
- Breiting, S., Hedegaard, K., Mogensen, F., Nielsen, K., & Schnack, K. (1999). Action competence, conflicting interests and environmental education. *Research Programme for Environmental and Health Education, DPU, Aarhus University*. https://www.dpu.dk/fileadmin/www.dpu.dk/en/research/researchprogrammes/environmentalandhealtheducation/for_skning_miljoe-og-sundhedspaedagogik_20090707140335_action-competence-muvin.pdf
- Brødsgaard, A., Wagner, L., Peitersen, B., & Poulsen, I. (2013). Action competence obstacles to managing childhood overweight: In-depth interviews with mothers of 7- to 9-year-old children. *Journal of Pediatric Nursing*, 28(5), 453-463. <https://doi.org/10.1016/j.pedn.2013.02.024>
- Bubriski, K., Debebe, E., Isaac, J., Noy, F., Perret, M., Schneider, E., & Sudhakaran, P. (2008). Achieving sustainable development and promoting development cooperation. *United Nations*. https://www.un.org/en/ecosoc/docs/pdfs/fina_08-45773.pdf
- Burbules, N. C., Fan, G., & Repp, P. (2020). Five trends of education and technology in a sustainable future. *Geography and Sustainability*, 1(2), 93-97. <https://doi.org/https://doi.org/10.1016/j.geosus.2020.05.001>
- Burmeister, M., & Eilks, I. (2013). An understanding of sustainability and education for sustainable development among German student teachers and trainee teachers of chemistry. *Science Education International*, 24(2), 167-194. <https://doi.org/10.1039/C2RP20137B>
- Carlsson, M., & Simovska, V. (2012). Exploring learning outcomes of school-based health promotion—A multiple case study. *Health Education Research*, 27(3), 437-447. <https://doi.org/10.1093/her/cys011>
- Cars, M., & West, E. E. (2015). Education for sustainable society: attainments and good practices in Sweden during the United Nations Decade for Education for Sustainable Development (UNDES). *Environment, Development and Sustainability*, 17(1), 1-21. <https://doi.org/10.1007/s10668-014-9537-6>
- Chankseliani, M., & McCowan, T. (2021). Higher education and the sustainable development goals. *Higher Education*, 81(1), 1-8. <https://doi.org/10.1007/s10734-020-00652-w>
- Chen, S. Y., & Liu, S. Y. (2020). Developing students' action competence for a sustainable future: A review of educational research. *Sustainability (Switzerland)*, 12(4), 1374. <https://doi.org/10.3390/su12041374>
- Chisingui, A. V., & Costa, N. (2020). Teacher education and sustainable development goals: A case study with future biology teachers in an Angolan higher education institution. *Sustainability (Switzerland)*, 12(8), 3344. <https://doi.org/10.3390/SU12083344>
- Cincera, J., & Krajhanzl, J. (2013). Eco-schools: What factors influence pupils' action competence for pro-environmental behaviour? *Journal of Cleaner Production*, 61, 117-121. <https://doi.org/10.1016/j.jclepro.2013.06.030>
- Clark, C. R. (2016). Collective action competence: An asset to campus sustainability. *International Journal of Sustainability in Higher Education*, 17(4), 1-22. <https://doi.org/10.1108/IJSHE-04-2015-0073>
- Conde, M. del C., & Sánchez, J. S. (2010). The school curriculum and environmental education: A school environmental audit experience. *International Journal of Environmental and Science Education*, 5(4), 477-494.
- Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 24(2), 97-140. <https://doi.org/10.1080/10888691.2018.1537791>
- Dayagbil, F. T., Palompon, D. R., Garcia, L. L., & Olvido, M. M. J. (2021). Teaching and learning continuity amid and beyond the pandemic. *Frontiers in Education*, 6(July), 1-12. <https://doi.org/10.3389/educ.2021.678692>
- Díaz-Noguera, M. D., Hervás-Gómez, C., & De-La-Calle, A. M. (2020). Professional action competences through experiences with augmented reality. *Journal of Turkish Science Education*, 16(4), 554-568. <https://doi.org/10.36681/tused.2020.7>
- Dittmer, L., Mugagga, F., Metternich, A., Schweizer-Ries, P., Asiimwe, G., & Riemer, M. (2018). "We can keep the fire burning": Building action competence through environmental justice education in Uganda and Germany. *Local Environment*, 23(2), 144-157. <https://doi.org/10.1080/13549839.2017.1391188>
- Ducasse, J. (2020). Augmented reality for outdoor environmental education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 329-352). Springer International Publishing. https://doi.org/10.1007/978-3-030-42156-4_17
- Eames, C. (2010). A framework for developing action competence in education for sustainability (EfS). *Teaching & Learning Research Initiative*. http://www.tlri.org.nz/sites/default/files/projects/9245_Appendix%20F.pdf
- Eames, C., Law, B., Barker, M., Iles, H., Mckenzie, J., Patterson, R., Williams, P., & Wilson-Hill, F. (2006). Investigating teachers' pedagogical approaches in

- environmental education that promote students' action competence. *Education. Teaching & Learning Reserach Initiative*. <http://www.tlri.org.nz/tlri-research/research-completed/school-sector/investigating-teachers%E2%80%99-pedagogical-approaches>
- Eberle, J., Stegmann, K., Barrat, A., Fischer, F., & Lund, K. (2021). Initiating scientific collaborations across career levels and disciplines—A network analysis on behavioral data. *International Journal of Computer-Supported Collaborative Learning*, 16, 151-184. <https://doi.org/10.1007/s11412-021-09345-7>
- Edsand, H. E., & Broich, T. (2020). The impact of environmental education on environmental and renewable energy technology awareness: Empirical evidence from Colombia. *International Journal of Science and Mathematics Education*, 18(4), 611-634. <https://doi.org/10.1007/s10763-019-09988-x>
- Erlina, N. (2021). Kesiapan calon guru IPA dalam pengembangan rencana pembelajaran berbasis education for sustainable development [Readiness of prospective science teachers in developing learning plans based on education for sustainable development]. *Jurnal Pendidikan dan Pembelajaran Sains Indonesia [Indonesian Journal of Science Education and Learning]*, 4(2), 142-150.
- Ferrante, C. A. (2012). *A case study of inclusion and diversity: A whole school approach using the social model of disability* [PhD thesis, University of Northumbria].
- Filho, W. L., Raath, S., Lazzarini, B., Vargas, V. R., de Souza, L., Anholon, R., Quelhas, O. L. G., Haddad, R., Klavins, M., & Orlovic, V. L. (2018). The role of transformation in learning and education for sustainability. *Journal of Cleaner Production*, 199, 286-295. <https://doi.org/10.1016/j.jclepro.2018.07.017>
- Firdaus, L. N., Wulandari, S., & Ahmad, D. (2016). Desain pembelajaran berbasis pedagogi hijau bagi mahasiswa calon guru biologi FKIP Universitas Riau [Green pedagogy-based learning design for prospective biology teacher students, FKIP University of Riau]. *Jurnal Pedagogi Hayati [Journal of Life Pedagogy]*, 1(1), 11-18.
- Fonseca, L. M., Domingues, J. P., & Dima, A. M. (2020). Mapping the sustainable development goals relationships. *Sustainability (Switzerland)*, 12(8), 1-15. <https://doi.org/10.3390/SU12083359>
- Frassl, M. A., Hamilton, D. P., Denfeld, B. A., de Eyto, E., Hampton, S. E., Keller, P. S., Sharma, S., Lewis, A. S. L., Weyhenmeyer, G. A., O'Reilly, C. M., Lofton, M. E., & Catalán, N. (2018). Ten simple rules for collaboratively writing a multi-authored paper. *PLoS Computational Biology*, 14(11), 6-13. <https://doi.org/10.1371/journal.pcbi.1006508>
- Freeling, B. S., Doubleday, Z. A., Dry, M. J., Semmler, C., & Connell, S. D. (2021). Better writing in scientific publications builds reader confidence and understanding. *Frontiers in Psychology*, 12(August), 1-8. <https://doi.org/10.3389/fpsyg.2021.714321>
- Gallagher, K. E., Kadokura, E., Eckert, L. O., Miyake, S., Mounier-Jack, S., Aldea, M., Ross, D. A., & Watson-Jones, D. (2016). Factors influencing completion of multi-dose vaccine schedules in adolescents: A systematic review. *BMC Public Health*, 16(1), 172. <https://doi.org/10.1186/s12889-016-2845-z>
- García, E. G., Magaña, E. C., & Ariza, A. C. (2020). Quality education as a sustainable development goal in the context of 2030 agenda: Bibliometric approach. *Sustainability (Switzerland)*, 12(15), 1-18. <https://doi.org/10.3390/SU12155884>
- García-Carrión, R., López de Aguilera, G., Padrós, M., & Ramis-Salas, M. (2020). Implications for social impact of dialogic teaching and learning. *Frontiers in Psychology*, 11(February), 1-11. <https://doi.org/10.3389/fpsyg.2020.00140>
- González, R. de M., & Sebastián-López, M. (2022). Education on sustainable development goals: Geographical perspectives for gender equality in sustainable cities and communities. *Sustainability*, 14(4042), 1-19. <https://doi.org/10.3390/su14074042>
- Hedefalk, M., Almqvist, J., & Lidar, M. (2014). Teaching for action competence. *SAGE Open*, 4(3), 1-8. <https://doi.org/10.1177/2158244014543785>
- Hillbur, P., Ideland, M., & Malmberg, C. (2016). Response and responsibility: Fabrication of the eco-certified citizen in Swedish curricula 1962-2011. *Journal of Curriculum Studies*, 48(3), 409-426. <https://doi.org/10.1080/00220272.2015.1126358>
- Huh, J. R., Park, I. J., Sunwoo, Y., Choi, H. J., & Bhang, K. J. (2020). Augmented reality (AR)-based intervention to enhance awareness of fine dust in sustainable environments. *Sustainability (Switzerland)*, 12(23), 1-21. <https://doi.org/10.3390/su12239874>
- Hurst, B., Wallace, R., & Nixon, S. B. (2013). The impact of social interaction on student learning. *Reading Horizons: A Journal of Literacy and Language Arts*, 52(4), 375-398. <https://doi.org/10.1080/15534510601154413>
- Husamah, H., Suwono, H., Nur, H., & Dharmawan, A. (2022). Sustainable development research in Eurasia Journal of Mathematics, Science and Technology Education: A systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(5), em2103. <https://doi.org/10.29333/ejmste/11965>
- Ikhsan, F. A., Kurnianto, F. A., Apriyanto, B., Nurdin, E. A., & Puji, R. P. N. (2019). The research based

- learning approach in environmental education. *IOP Conference Series: Earth and Environmental Science*, 243(1), 012029. <https://doi.org/10.1088/1755-1315/243/1/012029>
- Ilma, S., & Wijarini, F. (2017). Developing of environmental education textbook based on local potencies. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 3(3), 194-201. <https://doi.org/10.22219/jpbi.v3i3.4540>
- Isac, M. M., Sass, W., Pauw, J. B. De, De Maeyer, S., Schelfhout, W., Van Petegem, P., & Claes, E. (2022). Differences in teachers' professional action competence in education for sustainable development: the importance of teacher co-learning. *Sustainability (Switzerland)*, 14(2), 767. <https://doi.org/10.3390/su14020767>
- Jensen, B. B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research*, 3(2), 163-178. <https://doi.org/10.1080/1350462970030205>
- Jensen, B. B., & Schnack, K. (2006). The action competence approach in environmental education: Reprinted from Environmental Education Research (1997) 3(2), pp. 163-178. *Environmental Education Research*, 12(3-4), 471-486. <https://doi.org/10.1080/13504620600943053>
- Jensen, N. R. (2013). Action competence-a new trial aimed at social innovation in residential homes? *European Journal of Social Work*, 16(1), 120-136. <https://doi.org/10.1080/13691457.2012.722980>
- Jumrodah, Liliarsari, Adisendjaja, Y. H., & Sanjaya, Y. (2021). Keterampilan berpikir kreatif mahasiswa calon guru biologi pada konsep biota laut menuju pembangunan berkelanjutan melalui pembelajaran berbasis proyek [Creative thinking skills of prospective biology teacher students on the concept of marine life towards sustainable development through project-based learning]. *Jurnal Pendidikan Sains dan Matematika [Journal of Science and Mathematics Education]*, 9(1), 98-106. <https://doi.org/10.23971/eds.v9i1.2993>
- Keller, L. (2020). Still searching for (education for) sustainable development-Reflections on the need, challenges, and chances of transforming education in the 21st century. *Jurnal Pendidikan Geografi [Journal of Geography Education]*, 25(2), 179-192. <https://doi.org/10.17977/um017v25i22020p179>
- Keselman, A., Levin, D. M., Kramer, J. F., Matzkin, K., & Dutcher, G. (2011). Educating young people about environmental health for informed social action. *Umw Gesundheit Online*, 4(December 2010), 1-8.
- Kimaryo, L. A. (2011). *Integrating environmental education in primary school education in Tanzania: Teachers' perceptions and teaching practices*. Åbo Akademi University Press.
- Klein, J. D., & Richey, R. C. (2007). *Design and development research: Methods, strategies and issues*. Routledge.
- Kurniati, E., Suwono, H., Ibrohim, I., Suryadi, A., & Saefi, M. (2022). International scientific collaboration and research Topics on STEM education: A systematic review. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(4), em2095. <https://doi.org/10.29333/ejmste/11903>
- Kurt, A. A., Akbulut, Y., Odabasi, H. F., Ceylan, B., Kuzu, E. B., Donmez, O., & Izmirli, O. S. (2013). Factors motivating and hindering information and communication technologies. *Turkish Online Journal of Qualitative Inquiry*, 4(January), 34-46.
- Kusakabe, E. (2013). Advancing sustainable development at the local level: The case of machizukuri in Japanese cities. *Progress in Planning*, 80, 1-65. <https://doi.org/10.1016/j.progress.2012.06.001>
- Kwee, C. T. T. (2021). I want to teach sustainable development in my English classroom: A case study of incorporating sustainable development goals in English teaching. *Sustainability (Switzerland)*, 13(8), 4195. <https://doi.org/10.3390/su13084195>
- Li, K., Rollins, J., & Yan, E. (2018). Web of Science use in published research and review papers 1997-2017: A selective, dynamic, cross-domain, content-based analysis. *Scientometrics*, 115(1), 1-20. <https://doi.org/10.1007/s11192-017-2622-5>
- Loeng, S. (2020). Self-directed learning: A core concept in adult education. *Education Research International*, 2020(3816132), 1-12. <https://doi.org/10.1155/2020/3816132>
- Lohmann, J., Breithecker, J., Ohl, U., Gieß-Stüber, P., & Brandl-Bredenbeck, H. P. (2021). Teachers' professional action competence in education for sustainable development: A systematic review from the perspective of physical education. *Sustainability (Switzerland)*, 13(23), 13343. <https://doi.org/10.3390/su132313343>
- Marpa, E. (2020). Navigating environmental education practices to promote environmental awareness and education. *International Journal on Studies in Education*, 2(1), 45-57. <https://doi.org/10.46328/ijonse.8>
- Mensah, J. (2019). Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. *Cogent Social Sciences*, 5(1), 1653531. <https://doi.org/10.1080/23311886.2019.1653531>
- Messerli, P., & Murniningtyas, E. (2019). Global sustainable development report 2019: The future is now-Science for achieving sustainable development. *Independent Group of Scientists. United*

- Nations. https://sustainabledevelopment.un.org/content/documents/24797GSDR_report_2019.pdf
- Ministry for Education. (2015). *Action competence learning process*. <http://health.tki.org.nz/Key-collections/Curriculum-in-action/Making-Meaning/Teaching-and-learning-approaches/Action-competence-learning-process>
- Mogensen, F. (1997). Critical thinking: A central element in developing action competence in health and environmental education. *Health Education Research*, 12(4), 429-436. <https://doi.org/10.1093/her/12.4.429>
- Mogensen, F., & Schnack, K. (2010). The action competence approach and the “new” discourses of education for sustainable development, competence and quality criteria. *Environmental Education Research*, 16(1), 59-74. <https://doi.org/10.1080/13504620903504032>
- Mpungose, C. B. (2020). Emergent transition from face-to-face to online learning in a South African University in the context of the coronavirus pandemic. *Humanities and Social Sciences Communications*, 7(1), 1-9. <https://doi.org/10.1057/s41599-020-00603-x>
- Nielsen, W., Andersen, P., Hurley, A., Sabljak, V., Petereit, A.-L., Hoskin, V., & Hoban, G. (2012). Preparing action competent environmental educators. *Australian Journal of Environmental Education*, 28(2), 92-107. <https://doi.org/10.1017/aee.2013.3>
- Novidsa, I., Purwianingsih, W., & Riandi, R. (2020). Exploring knowledge of prospective biology teacher about education for sustainable development. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 6(2), 317-326. <https://doi.org/10.22219/jpbi.v6i2.12212>
- Nugroho, O. F., Permanasari, A., & Firman, H. (2021). Persepsi dan praktik pendidikan keberlanjutan di Indonesia untuk education for sustainability development (ESD) selama pandemi COVID-19 [Perceptions and practices of sustainability education in Indonesia for education for sustainability development (ESD) during the COVID-19 pandemic]. *Eduscience: Jurnal Ilmu Pendidikan [Eduscience: Journal of Educational Science]*, 7(1), 45-51.
- Nurwidodo, N., Amin, M., Ibrohim, I., & Sueb, S. (2020). The role of eco-school program (adiwiyata) towards environmental literacy of high school students. *European Journal of Educational Research*, 9(3), 1089-1103. <https://doi.org/10.12973/eu-jer.9.3.1089>
- Oguz, A., Fortner, R., Adadan, E., Gay, K., Kim, C. K., Yalcinoglu, P., Bektasli, B., Cook-Hoggarth, K. L., McDonald, C., Mishler, K., & Manzo, L. (2004). A look at environmental education through science teachers' perspectives and textbooks' coverage. In *Proceedings of the Annual Meeting of the School Science and Mathematics Association*.
- Oliver, S. K., Fergus, C. E., Skaff, N. K., Wagner, T., Tan, P. N., Cheruvelil, K. S., & Soranno, P. A. (2018). Strategies for effective collaborative manuscript development in interdisciplinary science teams. *Ecosphere*, 9(4), 1-13. <https://doi.org/10.1002/ecs2.2206>
- Olsson, D., Gericke, N., & Boeve-de Pauw, J. (2022). The effectiveness of education for sustainable development revisited—a longitudinal study on secondary students' action competence for sustainability. *Environmental Education Research*, 0(0), 1-25. <https://doi.org/10.1080/13504622.2022.2033170>
- Olsson, D., Gericke, N., & Chang Rundgren, S. N. (2016). The effect of implementation of education for sustainable development in Swedish compulsory schools—assessing pupils' sustainability consciousness. *Environmental Education Research*, 22(2), 176-202. <https://doi.org/10.1080/13504622.2015.1005057>
- Olsson, D., Gericke, N., Sass, W., & Boeve-de Pauw, J. (2020). Self-perceived action competence for sustainability: The theoretical grounding and empirical validation of a novel research instrument. *Environmental Education Research*, 26(5), 742-760. <https://doi.org/10.1080/13504622.2020.1736991>
- Pedro, Á. S., & Pedro, V. M. (2010). Developing sustainable environmental behavior in secondary education students (12-16): Analysis of a didactic strategy. *Procedia-Social and Behavioral Sciences*, 2(2), 3568-3574. <https://doi.org/10.1016/j.sbspro.2010.03.553>
- Peffer, M., & Renken, M. (2016). Practical strategies for collaboration across discipline-based education research and the learning sciences. *CBE Life Sciences Education*, 15(4), 1-10. <https://doi.org/10.1187/cbe.15-12-0252>
- Piasentin, F. B., & Roberts, L. (2018). What elements in a sustainability course contribute to paradigm change and action competence? A study at Lincoln University, New Zealand. *Environmental Education Research*, 24(5), 694-715. <https://doi.org/10.1080/13504622.2017.1321735>
- Pranckute, R. (2021). Web of Science (WoS) and Scopus: The titans of bibliographic information in today's academic world. *Publications*, 9(12), 1-59. <https://doi.org/10.3390/publications9010012>
- Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: In search of conceptual origins. *Sustainability Science*, 14(3), 681-695. <https://doi.org/10.1007/s11625-018-0627-5>

- Reddy, C. (2021). Environmental education, social justice and teacher education: Enabling meaningful environmental learning in local contexts. *South African Journal of Higher Education*, 35(1), 161-177. <https://doi.org/10.20853/35-1-4427>
- Ribeiro, R. A. (2012). Sustainable development: an ecological economics perspective. *Estudos Avancados [Advanced Studies]*, 26(74), 65-92. <https://doi.org/10.1590/S0103-40142012000100006>
- Richey, R. C. (1994). Developmental research: The definition and scope. In *Proceedings of the 1994 National Convention of the Association for Educational Communications and Technology* (pp. 714-720).
- Robertson, J. (2017). Health promotion as an underlying concept in health education professional learning and development resource. *New Zealand Health Education Association*. https://healtheducation.org.nz/wp-content/uploads/2018/11/8-nzhea-position-statement_health-promotion-in-hed_sept_2017.pdf
- Ruge, D., Nielsen, M. K., Mikkelsen, B. E., & Bruun-Jensen, B. (2016). Examining participation in relation to students' development of health-related action competence in a school food setting: LOMA case study. *Health Education*, 116(1), 69-85. <https://doi.org/10.1108/HE-08-2014-0087>
- Sánchez, W. G. V., & Arias, E. A. A. (2021). Effects of the didactic model of game action competences on tactical performance, motivation, and perception of skill in young football players. *Journal of Physical Education and Sport*, 21(6), 3556-3568. <https://doi.org/10.7752/jpes.2021.06481>
- Sass, W., Boeve-de Pauw, J., Olsson, D., Gericke, N., De Maeyer, S., & Van Petegem, P. (2020). Redefining action competence: The case of sustainable development. *Journal of Environmental Education*, 51(4), 292-305. <https://doi.org/10.1080/00958964.2020.1765132>
- Sass, W., Claes, E., Pauw, J. B. de, De Maeyer, S., Schelfhout, W., Van Petegem, P., & Isac, M. M. (2022). Measuring professional action competence in education for sustainable development (PACesd). *Environmental Education Research*, 28(2), 260-275. <https://doi.org/10.1080/13504622.2021.1976731>
- Sass, W., De Maeyer, S., Boeve-de Pauw, J., & Van Petegem, P. (2022). Honing action competence in sustainable development: What happens in classrooms matters? *Environment, Development and Sustainability*, 0123456789, 1-22. <https://doi.org/10.1007/s10668-022-02195-9>
- Sass, W., Pauw, J. B. de, Maeyer, S. De, & Petegem, P. Van. (2021). Development and validation of an instrument for measuring action competence in sustainable development within early adolescents: The action competence in sustainable development questionnaire (ACiSD-Q). *Environmental Education Research*, 27(9), 1284-1304. <https://doi.org/10.1080/13504622.2021.1888887>
- Shutaleva, A., Nikonova, Z., Savchenko, I., & Martyushev, N. (2020). Environmental education for sustainable development in Russia. *Sustainability (Switzerland)*, 12(18), 1-26. <https://doi.org/10.3390/su12187742>
- Silo, N. (2013). Dialogue-Missing in action competence: A cultural historical activity theory approach in a Botswana school. *Journal of Environmental Education*, 44(3), 159-179. <https://doi.org/10.1080/00958964.2012.742033>
- Silo, N., & Mswela, N. (2016). Creating healthy school environments through children-an action competence approach. *European Journal of Education Studies*, 2(6), 46-62. <https://doi.org/10.5281/zenodo.159533>
- Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, 104(July), 333-339. <https://doi.org/10.1016/j.jbusres.2019.07.039>
- Svalfors, U. (2017). Education for sustainable development and multidimensional implementation. A study of implementations of sustainable development in education with the curriculum of upper secondary school in Sweden as an example. *Discourse and Communication for Sustainable Education*, 8(2), 114-126. <https://doi.org/10.1515/dcse-2017-0020>
- Teaching and Learning Research Initiative. (2010). *A framework for developing action competence in Efs* (C. Crown (ed.)). TLRI.
- Thor, D., & Karlsudd, P. (2020). Teaching and fostering an active environmental awareness design, validation and planning for action-oriented environmental education. *Sustainability (Switzerland)*, 12(8), 1-17. <https://doi.org/10.3390/SU12083209>
- Torkar, G. (2014). Learning experiences that produce environmentally active and informed minds. *NJAS-Wageningen Journal of Life Sciences*, 69, 49-55. <https://doi.org/10.1016/j.njas.2014.03.002>
- UNESCO. (2021). Reimagining a new social our futures contract for together education. *United Nations Educational, Scientific and Cultural Organization*. <https://unesdoc.unesco.org/ark:/48223/pf0000379707.locale=en>
- Universiteit Utrecht. (2022). Dr. J.N.A. (Jelle) Boeve-de Pauw. <https://www.uu.nl/staff/JNABoevedePauw>

- University of Antwerp. (2022). *About Wanda Sass*. <https://www.uantwerpen.be/en/staff/wanda-sass/>
- Uzzi, B., Mukherjee, S., Stringer, M., & Jones, B. (2013). Atypical combinations and scientific impact. *Science*, 342(6157), 468-472. <https://doi.org/10.1126/science.1240474>
- van Poeck, K., & Vandenabeele, J. (2012). Learning from sustainable development: Education in the light of public issues. *Environmental Education Research*, 18(4), 541-552. <https://doi.org/10.1080/13504622.2011.633162>
- Verma, G., & Dhull, P. (2017). Environmental education as a subject in schools. *International Journal of Advanced Research*, 5(8), 1547-1552. <https://doi.org/10.21474/ijar01/5214>
- Vicencio, M. A. A. (2012). *Dialogue based strategies in the teaching of environmental education in Baja California Sur, Mexico (Issue September)* [PhD thesis, University of York].
- Wals, A. E. J., & Kieft, G. (2010). *Education for sustainable development: Research overview*. Sida.
- Wibowo, Y. G., & Sadikin, A. (2019). Biology in the 21st-century: Transformation in biology science and education in supporting the sustainable development goals. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 5(2), 285-296. <https://doi.org/10.22219/jpbi.v5i2.7956>
- Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, 39(1), 93-112. <https://doi.org/10.1177/0739456X17723971>
- Yeşilyurt, M., Balakoğlu, M. Ö., & Erol, M. (2020). The impact of environmental education activities on primary school students' environmental awareness and visual expressions. *Qualitative Research in Education*, 9(2), 188-216. <https://doi.org/10.17583/qre.2020.5115>
- Yuan, X., Yu, L., Wu, H., She, H., Luo, J., & Li, X. (2022). Sustainable development goals (SDGs) priorities of senior high school students and global public: Recommendations for implementing education for sustainable development (ESD). *Education Research International*, 2022(2555168), 1-14. <https://doi.org/10.1155/2022/2555168>
- Zhan, Y., He, R., & So, W. W. M. (2019). Developing elementary school children's water conversation action competence: A case study in China. *International Journal of Early Years Education*, 27(3), 287-305. <https://doi.org/10.1080/09669760.2018.1548346>

<https://www.ejmste.com>