ISSN: 2149-214X

Journal of Education in Science, Environment and Health

www.jeseh.net

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To cite this article:

Rulli, M., Bruni, E., Di Domenico, A., & Mammarella, N. (2024). Educating preschoolers to pro-environmental actions: A metacognition-based approach. *Journal of Education in Science, Environment and Health (JESEH), 10*(3), 179-189. https://doi.org/10.55549/jeseh.727

JESEH
Journal of Education in Science, Environment and Health
Volume 10, Issue 3, 2024
https://doi.org/10.55549/jeseh.727

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Article Info

Article History

Published:
01 July 2024

Received:
22 April 2024

Accepted:
30 June 2024

Keywords

Metacognition
Sustainability
Environmental education

Abstract

Metacognition is the process of thinking about one's own thinking, learning, and problem-solving strategies. It involves being aware of one's own cognitive processes and knowing how to regulate and monitor them. Sustainability, instead, refers to the ability to maintain or preserve resources and ecosystems for future generations. Here, we draw from the classical metacognitive approach and propose that metacognition plays an important role in sustainability. The PRISMA (Preferred Reporting Items for Systematic Reviews and MetaAnalyses) Statement was used to perform and recode this review. Given that metacognitive abilities develop early during childhood, metacognition can be viewed as a useful approach to teach pro-environmental behavior from early childhood. Although the interaction between metacognition and sustainability in preschoolers appears to be insufficiently explored, the final aim of this review is to offer a new education-based perspective about metacognition that can be implemented in early childhood to foster pro-environmental actions in the long-term.

Introduction

Metacognition typically refers to the ability to think about the potential of our cognition or, to say it differently, to the knowledge of and control over our cognitive processes, such as learning, memory and decision-making (Flavel, 1979; Hacker, Dunlosky, & Graesser, 2009). Sustainable behavior, instead, can be generally viewed as a series of actions that reduce harmful environmental consequences and result in the use of natural resources (Gardner & Stern, 2002). Metacognition and sustainability are important concepts that can be applied across various fields such as education, business, and environmental protection. In this review, we will explore how metacognition can be used to promote sustainable practices and behaviors in preschoolers.

Generally speaking, metacognition can be used to promote sustainable practices and behaviors in several ways. For example, individuals who are aware of their own thinking processes can identify and challenge their own assumptions and biases about sustainability. They can also evaluate the effectiveness of their own actions and make adjustments as needed to ensure that they are acting in a sustainable manner. Furthermore, metacognition can help individuals develop critical thinking skills that are necessary for making informed decisions about sustainability. By reflecting on their own thinking processes, individuals can become more aware of how their decisions impact the environment, and they can use this information to make more sustainable choices (e.g., Abrahamse et al., 2005). In addition, metacognition can be used to promote sustainability in educational settings. Teachers can help students develop metacognitive skills by encouraging them to reflect on their own learning processes and to think critically about sustainability issues (e.g., Schunk & Pajares, 2005). By doing so, students can develop a deeper understanding of sustainability and become more engaged in efforts to promote it. Overall, metacognition is an important tool for promoting sustainability: by fostering awareness of one's own thinking processes and developing critical thinking skills from early childhood (Flavell et al., 1995), individuals can become more effective advocates for sustainable practices and behaviors later in life.

Although researchers in the sustainability field have indirectly emphasized the role of metacognition (e.g., in terms of self-efficacy, affective reactions, etc., Schutte & Bhullar, 2017; Milfont & Duckitt, 2010), as far as we know, few theoretical or empirical studies have explored how metacognition may influence sustainable behavior in preschoolers and very few studies involved 3 to 5 years old children. The main rationale being that metacognition in early childhood is difficult to be studied under controlled experimental conditions. This review wants thus to further the discussion about the current theories of sustainability in education (e.g., Somerville & Williams, 2015), but also provide a new direction for the culture of sustainable behaviors in early childhood. For instance, previous studies emphasized the importance of contextual knowledge in education (e.g., knowing when/where/how/why to act in a sustainable manner, for a review see Brown, Collins & Duguid, 1989). In

addition, a recent review (Mason et al., 2022) have highlighted the relationship between metacognition and environment learning in terms of the following three aspects: (1) the role of environmental cues (; (2) the motivational aspects; (3) the role of monitoring and control processes.

Although theoretical and some empirical studies have thus pointed out that sustainability may benefit from metacognition, the discussion about how the interaction between these two develops during early childhood needs further investigation. This work wants to describe how metacognition and sustainability may be related within the context of sustainability and point out to a series of educational aspects that are relevant for teaching sustainability during early childhood.

Method

The PRISMA (Preferred Reporting Items for Systematic Reviews and MetaAnalyses) Statement was used to perform and recode this review (Liberati et al., 2009).

Eligibility Criteria

The inclusion criteria were relationship between metacognition (knowledge, affective reactions, strategies) and sustainability (behavior, actions); relationships between sustainability and preschoolers, between sustainability and education in early childhood; articles written in English.

Inclusion/Exclusion Criteria

Studies that meet the following criteria were included:

1) Works providing a definition of metacognition, and/or highlighting the relationship between metacognition and sustainability (sustainable behavior, sustainable actions).
2) Works focusing on the relationships between sustainability, education and early childhood.
3) Works on the educational sustainability programs adopted and/or those offering suggestions for teachers.
4) Written in English.

The exclusion criteria were considered as follows:

1) Unrelated topic.
2) Studies without sufficient data provided (e.g., study site, study period, and sample size).
3) Case reports/Editorial comments/Letters to Editor, etc.

Information Sources

A systematic electronic search was undertaken in the following databases between February 2024 and April 2024, with no time limits: PubMed, Scopus, PsychINFO, and Google Scholar. Where applicable, MeSH and Emtree terminology were utilized. A hand search of relevant studies was also carried out. The Rayyan online program was used to import and categorize all of the references.

Search Strategy

Computer searches of the PubMed, PsycINFO, Scopus, and Google Scholar databases were used to perform this review; searches were run until the 15th of April 2024. There were two stages to the article selection process. There was no time limit, no search filters, and no constraints. The first search included the keywords “metacognition”, “sustainability”, “preschoolers”. Then, we searched for some combinations of keywords between sustainability and “knowledge”, “affective reactions”, “control and monitoring”, “childhood”. The articles were identified and then listed in an excel table. Titles and abstracts unrelated to the topic were then excluded, as well as duplicate records. As a result, we read the entire content during the eligibility verification step. All items selected in the previous phases were examined for quality evaluation in the final step; low-quality studies (i.e. insufficient data provided) were excluded.

Data Collection

Following the application of the search strategy, a total of eighty works were identified. Eighty publications were screened after the duplicates were removed. Studies were first included for their titles and abstracts' relevance to the research question. Following that, the screening process resulted in the retrieval of sixty-five works. The full text of the remaining articles was obtained and evaluated for eligibility. Twenty-two reports were reviewed for eligibility and then ranked according to the inclusion criteria. Finally, we included in the present review fifteen publications.

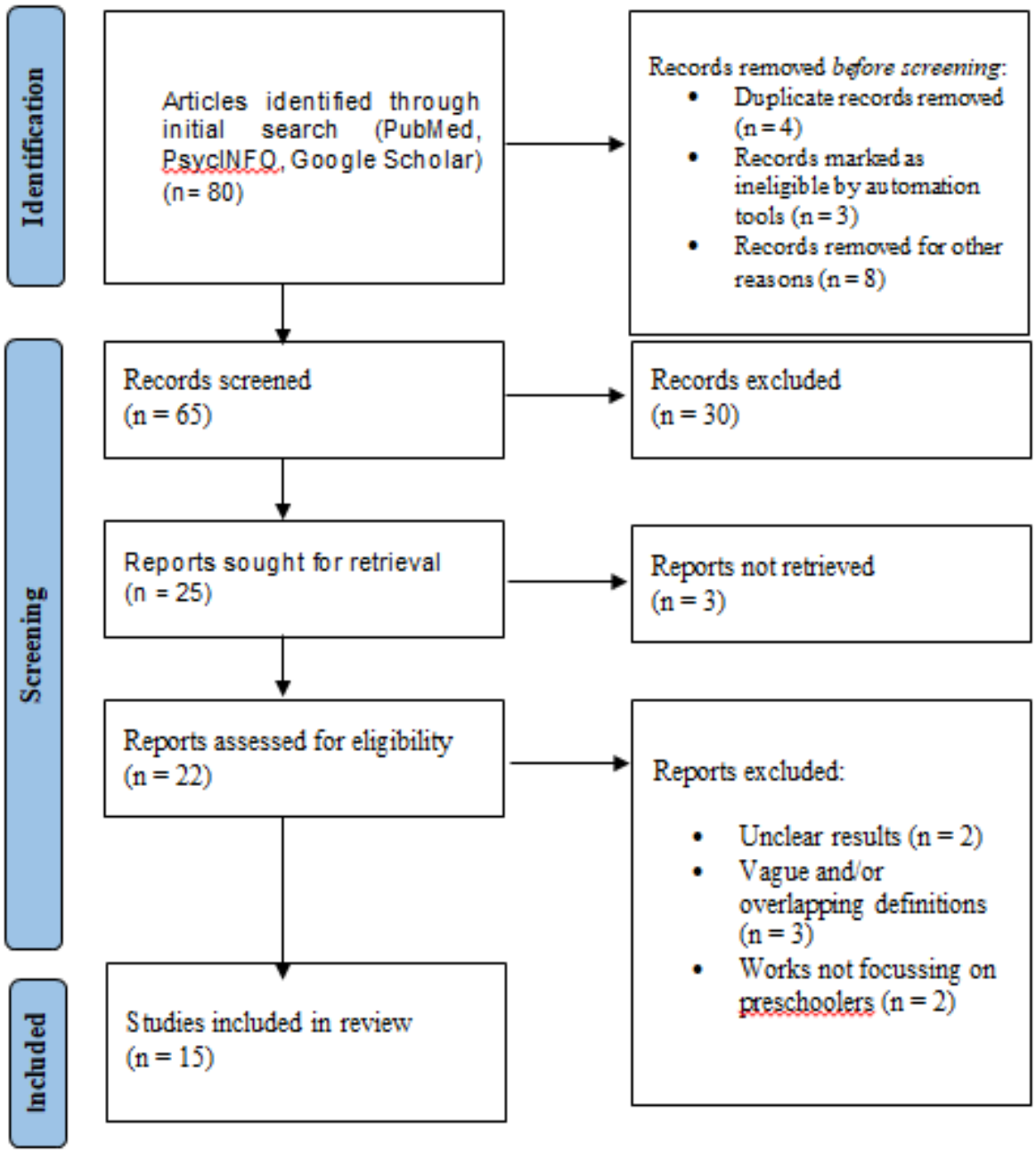

Figure 1. The PRISMA flow diagram depicts the selection process as well as the inclusion decision

For data analysis, we used a standardized form to extract relevant data from each study. This included information on study design, participants, interventions, outcomes, results and discussion. For review studies or book chapters, relevant paragraphs and general discussions were considered. We then summarized and interpreted the findings of the studies. The list of included studies with their main focus of discussion is presented in Table 1.

Table 1. Overview of Included Studies

Authors, year	Focus
Davis (2005)	sustainable education and kindergarten
Davis (2009	sustainable development and early education
Davis (2010)	sustainable development and early education
Edwards and Cutter-Mackenzie (2011)	environmental education and early childhood curriculum
Elliott and Davis (2009)	sustainable education and preschoolers
Elliott and Young (2015)	nature and sustainability and children
Ernst and Burcak (2019)	education to sustainability in preschoolers
Guler- Yıldız et al. (2021)	sustainable development and early education
Haas and Ashman (2014)	sustainable education and practices in kindergarten
Hedefalk et al. (2015)	sustainable development and early education
Musser and Diamond (1999)	environmental attitudes in preschoolers
Sobel (2017)	education to nature and children
Sobel (2020)	education to nature and emotion in children
Somerville and Williams (2015)	sustainability education and preschooler
van de Wetering et al. (2022)	environmental knowledge and children

Results and Discussion

Metacognition in Early Childhood

Metacognition is a crucial cognitive skill that can help individuals become efficient learners and problem-solvers. While it may seem like a complex concept that only applies to adults, metacognition is also important for young children, including preschoolers. In fact, metacognitive skills can be developed at an early age through various activities and experiences (e.g., Godfrey et al., 2022). By fostering metacognition in preschoolers, we can help them become more aware of their own thinking processes and develop strategies to regulate and monitor their learning. In this section, we can explore the importance of metacognition in preschoolers. In particular, early developmental theories of metacognitive abilities typically distinguished between explicit and implicit metacognition. Explicit metacognition refers to the explicit knowledge, monitoring and control over our cognitive abilities, whereas implicit metacognition may be considered a more behaviorally-driven type of metacognition which affect our performance without conscious awareness. These two types of metacognitive abilities may develop at different ages. In fact, while explicit metacognitive knowledge develops later during childhood (from school-aged children to adolescence e.g., Schneider, 2008), some metacognitive implicit abilities may develop earlier between 3 to 5 years old (e.g., Lyons & Ghetti, 2010, Paulus et al., 2011), that is, preschoolers are able to use metacognitive skills before accessing to verbal skills. For example, a series of studies (e.g., Balcomb and Gerken, 2008; Kim et al., 2016) showed that the feeling of uncertainty that preschoolers can show during cognitive tasks (e.g., feeling not sure about the answer, asking for help) may be considered an instance of implicit metacognition that impact on their cognitive performance without explicit control over their judgements. Other instances of implicit metacognition refer to non-verbal behaviors such as gestures that indicate that he/she is not sure about the answer (e.g., shaking their heads or shoulder). In this regards, eye-tracking studies (Paulus et al., 2013) identified some gaze behaviors (e.g., duration of gaze towards the target, persistent searching for information) that also indicate the confidence level and uncertainty shown by children during a cognitive or more-social based task (e.g., Kuzyk et al., 2019). All these more behaviorally-driven metacognitive skills seem to point out that a metacognitive approach (although implicitly-based) can be used among preschoolers to foster different degree of knowledge about learning to act pro-environmentally.

Sustainability in Early Childhood

Sustainability programs for preschoolers are becoming increasingly popular as more and more people recognize the importance of teaching young children about environmental responsibility. These programs aim to instill in young children a sense of care and respect for the environment, as well as an understanding of the impact that their actions can have on the world around them. Through hands-on activities and engaging lessons, preschoolers can learn about topics such as recycling, energy conservation, and reducing waste. By introducing sustainability concepts at a younger age, children can develop a lifelong appreciation for the environment and a commitment to making sustainable choices. As reviewed by Somerville and Williams (2015), the research focus on preschoolers can be grouped according to three main categories. The first category refers to the main aim of connecting children to the natural world, to teach them about its values and to act for its conservation. The

second one has the goal of empowering children in relation to major sustainability issues such as social, cultural, and economic global issues of sustainable development. The third one is based on educating children to overcome the classical nature/culture binary, that is, learning to view human sociality and the natural world as interdependent systems. A more recent review (e.g., Yildiz et al., 2021) also highlighted that the most frequently discussed topic when teaching sustainability in preschoolers is the protection of our environment. Another interesting meta-analysis was conducted by van de Wetering et al. (2022): although studies on both children and adolescents were included, it showed that environmental education improved students' environmental outcomes on a series of different categories such as environmental knowledge, attitudes, intentions, and behavior. One of the first interesting attempt to study sustainability in early childhood can be found in the "Children's Attitudes Toward the Environment Scale for Preschool Children" (Musser & Diamond, 2010) which showed that preschoolers' attitude towards the environment was correlated with their engagement in environment-friendly activities at home. Preschoolers were thus able to identify improper actions with regard to the environment if they got used to environment-friendly behaviors at home. This finding points to the need of a continuous interplay between school and family goals for sustainable education to be effective.

The New Concept of "Meta-Sustainability"

In order to show how metacognition may interact with sustainable behavior, we can reframe the concept of sustainability as "meta-sustainability", that is, the ability to have knowledge, awareness, and control over pro-environmental behavior. This approach may help describe the different components of metacognition better within the context of preschoolers' education as shown in the next sections. Knowledge, affective experience, and control are the principal components of meta-sustainability. In particular, meta-sustainability knowledge can be broadly defined as the declarative knowledge of sustainable behaviors that can be person-centered (e.g., ways of thinking about pro-environmental behavior; pro-environmental self-efficacy); action-centered (e.g., actions' goals directed to the protection of the environment); and utility-centered (e.g., pros and cons, the feasibility of each pro-environmental behavior). The affective reactions that may occur during sustainable behavior refer to the subjective perception of the ease or difficulty of certain sustainable actions and thus to the positive or negative emotions that may derive from performing that particular action. Finally, control refers to monitoring and regulation of our sustainable actions, for example, by planning, supervising, executing, and evaluating a sustainable action in terms of goals, time, and attention deployment. Sustainability can be considered as a metacognitive process in that the combination of individual's environment knowledge and action evaluation results in a continuous dynamic integration. Specifically, sustainable behavior requires the acquisition of knowledge and skills that are crucial for the final long-term goal of protecting the planet Earth. An example can be any recycling activities. For recycling to be successful, relevant prior knowledge must be consciously retrieved, and an action plan must be implemented (according, for instance, to a delivery calendar). Moreover, actions can be monitored, for instance, in terms of time spent in recycling and the utility of these actions evaluated. We assume that using all these metacognitive functions would likely enhance sustainable behavior. In the next sections we first detailed how knowledge, affective reactions and control functions generally works and subsequently how they can be applied to preschoolers' learning of sustainability.

Knowledge and Sustainability

Knowledge plays a crucial role in sustainable behavior. In order to act in a sustainable manner, individuals need to have a good understanding of the environmental, social, and economic impacts of their actions. This knowledge can help individuals make informed decisions about how to live in a way that is more sustainable. For example, individuals who are aware of the negative impacts of single-use plastics on the environment may choose to use reusable bags, bottles, and containers instead. Similarly, individuals who are aware of the carbon footprint of various modes of transportation may choose to walk, bike, or take public transit instead of driving. In addition, knowledge can help individuals understand the importance of sustainability and motivate them to take action. When individuals understand the implications of their actions on the environment and future generations, they may be more motivated to make changes in their own behavior. Education and awareness-raising initiatives play a vital role in promoting sustainable behavior by providing individuals with the knowledge and tools they need to make informed decisions. By increasing knowledge and awareness of sustainability issues, individuals can become more engaged in efforts to promote sustainability and can work towards building a more sustainable future. According to the knowledge-deficit model, the assumption is that when people do not know about a specific environmental problem, or they do not know in detail what to do about it, do not engage in sustainable actions (Schultz, 2002). For example, participants who possess much more knowledge of plans, goals, and descriptions of sustainability performed better and feel more engaged in

sustainable actions compared with individuals who show lower levels of knowledge. Several intervention studies (for a review see Osbaldiston & Schott, 2012) have found that the training of knowledge promotes sustainable actions. In particular, interventions that focused on knowledge acquisition include typically two types of information. The first one refers to inform about the reasons for performing a specific behavior (also called declarative information or why-to information), such as information about the differences across materials and why we should recycle them. The second one refers to inform on how to perform a specific behavior (also called procedural knowledge), e.g., sort plastics according to their codes. Altogether these results showed that knowledge training can significantly improve sustainable behavior.

Affective Reactions and Sustainability

Understanding the relationship between affective reactions and sustainable behavior is crucial in promoting environmentally friendly actions. Affective reactions, or emotional responses, can have a significant impact on sustainable behavior. Research has shown that positive emotions, such as happiness and joy, can increase pro-environmental behaviors, while negative emotions, such as guilt and anger, can decrease them (for a review see Petersen & Austin, 2017). For example, if an individual feels happy and satisfied after using a reusable water bottle instead of a disposable one, they are more likely to continue using the reusable bottle in the future. This positive emotional response reinforces the behavior and makes it more likely to become a habit. On the other hand, if an individual feels guilty or ashamed after forgetting to bring their reusable bag to the grocery store and having to use plastic bags instead, they may be less likely to use the reusable bag in the future. The negative emotional response can create a barrier to behavior change and make it harder to adopt more sustainable practices. In addition, affective reactions can also be influenced by social norms and the attitudes of others. For example, if an individual sees their friends and family members engaging in sustainable behaviors and expressing positive emotions about them, they may be more likely to adopt those behaviors themselves. Overall, affective reactions play an important role in sustainable behavior. By understanding how emotions can influence behavior, individuals can work to cultivate positive emotional responses to sustainable practices and behaviors, and to minimize negative emotional barriers to behavior change (e.g., O'Brien & Wilson, 2015). Different studies have shown that the core aspect of affective positive reactions during sustainable actions is processing fluency, that is, how individuals perceive the ease of performing that particular action. Previous research, in fact, has highlighted that fluency is crucial in goal setting (e.g., Storbeck & Clore, 2007) which is a relevant aspect for sustainable actions to be performed.

Monitoring and Control of Sustainable Actions

Metacognitive monitoring and control refer to a set of components, such as goal setting, planning execution, strategy selection, and evaluating (Flavell, 1976) that are all crucial for sustainable behavior. Metacognitive monitoring refers to evaluating the process of initiating a sustainable action or current state of knowledge. Metacognition can be a valuable tool for monitoring and controlling sustainable actions. By reflecting on their own thinking processes, individuals can become more aware of how their behaviors impact the environment and the broader community. This awareness can help individuals identify areas where they can make changes to their behavior to become more sustainable. For example, if an individual is trying to reduce their carbon footprint, they can use metacognition to monitor their own behavior and identify areas where they can make changes. They might reflect on their daily routine and identify times when they are using excessive amounts of energy or producing unnecessary waste. Using this information, they can make adjustments to their behavior and develop new habits that are more sustainable. In addition to monitoring their own behavior, individuals can use metacognition to control their sustainable actions. By setting goals and tracking their progress, individuals can hold themselves accountable for their sustainable actions. For example, an individual might set a goal to reduce their water usage by a certain percentage each month. By tracking their water usage and reflecting on their progress, they can adjust their behavior and work towards their goal. Overall, metacognition can be a powerful tool for monitoring and controlling sustainable actions. By fostering awareness of one's own thinking processes and developing strategies for regulating and monitoring behavior, individuals can become more effective advocates for sustainable practices and behaviors. For example, people may engage in monitoring to discover that he/she felt confident in her understanding about recycling and less confident about climate change and to estimate her performance accordingly. Metacognitive control is the regulation of sustainable activities. Individuals decide when to recycle, what strategies he/she would use, and after the action, how he/she would do differently for future actions. Each of these aspects of metacognition can limit or enhance the number of sustainable actions depending on the quality of the students' knowledge, monitoring, and control processes, –how individuals regulate their behavior can make a real difference in sustainability.

A "Meta-Sustainability" Approach for Educational Practice in Preschoolers

Introducing sustainability concepts to preschoolers is an important step in promoting sustainable behaviors and attitudes early on in life. Sustainability programs for preschoolers can include a variety of activities that help them understand the importance of taking care of the environment and its resources (Williams & Sobel, 2017). One approach to sustainability education for preschoolers is through hands-on activities that engage their senses and curiosity. For example, activities such as gardening or composting can help preschoolers learn about the natural world and the importance of reducing waste (e.g., Sobel, 2008). Another approach is through storytelling, where books and stories can be used to introduce concepts such as recycling, conservation, and protecting the environment. Furthermore, preschoolers can be encouraged to engage in sustainable practices such as turning off lights when leaving a room, using reusable containers, and conserving water. These practices can be incorporated into their daily routines to help them develop sustainable habits that they can carry with them into adulthood (Davis, 2009; 2010). Overall, sustainability programs for preschoolers can be effective in promoting sustainable attitudes and behaviors in the next generation (Davis, 2014; Elliott & Young, 2015). By introducing "meta-sustainability" concepts early on, preschoolers can develop a sense of responsibility towards the environment and become more aware of their impact on the planet (e.g., Diamond & Lee, 2011). Here we present some strategies that can be used to increase "meta-sustainability" in preschoolers according to the three main components described above:

Knowledge in preschoolers. Preschool is a critical time to introduce children to the concept of sustainability and encourage them to develop eco-friendly habits. Educational practices may include:

1. Hands-on activities: Preschoolers learn best through hands-on activities. Activities such as planting seeds, composting, and recycling can help children understand the importance of sustainability. 2.Storytelling: Storytelling is an effective way to introduce sustainability concepts to preschoolers. Books that focus on environmental themes can help children learn about sustainability in a fun and engaging way. 3. Role modeling: Adults can model sustainable behaviors for preschoolers. For example, teachers can demonstrate composting, recycling, and conserving energy in the classroom. 4. Field trips: Field trips to local parks, gardens, and farms can help preschoolers connect with nature and learn about sustainability in real-world contexts. 5. Art and craft activities: Art and craft activities that use recycled materials can help preschoolers understand the importance of reusing and repurposing resources. By using these strategies, educators and parents can help preschoolers develop a deeper understanding of sustainability and encourage them to make eco-friendly choices in their daily lives (Schneider & Lockl, 2002).

Affective reactions. There are several ways to increase positive emotions about sustainability in preschoolers. Here are a few strategies:

1. Use positive language: When communicating with preschoolers, it's important to use positive language that emphasizes the benefits of sustainable practices. For example, instead of saying "don't waste water," say "let's save water so we have more for later." This helps children develop a positive attitude towards sustainability. 2. Make sustainability fun: Children learn best through play, so incorporating sustainability into games and activities can be an effective way to promote positive emotions. For example, you can create a recycling sorting game or a gardening activity to teach children about sustainability in a fun and engaging way. 3.Encourage exploration: Preschoolers are curious by nature, so providing opportunities for them to explore and discover the natural world can help foster positive emotions about sustainability. Take children on nature walks, visit local parks, or create a nature corner in the classroom to encourage exploration and appreciation of the environment. 4.Model sustainable behaviors: Children learn by example, so it's important for adults to model sustainable behaviors. This includes things like turning off lights when leaving a room, using reusable bags, and recycling. When children see adults engaging in sustainable practices, they are more likely to adopt these behaviors themselves. By implementing these strategies, preschoolers can develop positive emotions about sustainability and become advocates for environmental protection.

Monitoring and control. Promoting sustainable behavior in preschoolers is essential for creating a greener and healthier future. One way to increase monitoring and control of sustainable behavior in preschoolers is by using visual aids and modeling. Here are some strategies that can be used:

1. Visual Aids: Use visual aids such as posters, pictures, and diagrams to illustrate the importance of sustainable behavior. For example, posters can be placed in the classroom or playground to remind children to turn off the lights, recycle paper, or conserve water.
2. Modeling: Teachers and parents can model sustainable behavior by demonstrating eco-friendly practices such as turning off lights when leaving the room, using reusable bags, and recycling materials. When children see adults engaging in sustainable behavior, they are more likely to adopt these practices themselves.
3. Reinforcement: Positive reinforcement can be used to encourage sustainable behavior in preschoolers. For example, teachers can offer praise or small rewards such as stickers or stamps to children who engage in eco-friendly practices such as turning off the lights or recycling.
4. Engaging Activities: Engaging children in fun and interactive activities related to sustainability can help them develop an appreciation for the environment. For example, teachers can organize nature walks, gardening activities, or recycling games that can help children learn about the importance of sustainability.
5. Education: Providing education about sustainability can help increase monitoring and control of sustainable behavior in preschoolers. Teachers can teach children about the importance of reducing waste, conserving resources, and protecting the environment.

In conclusion, increasing monitoring and control of sustainable behavior in preschoolers can help create a greener and healthier future. By using visual aids, modeling, reinforcement, engaging activities, and education, teachers and parents can promote sustainable behavior in preschoolers and encourage them to become stewards of the environment.

Conclusion

The present review primarily focuses on highlighting the interaction between metacognition and sustainability. Although increasing research points out that metacognition may play an important role in sustainability, the empirical studies reviewed here point to a lack of studies mainly in the area of early childhood. We believe that a metacognition-based approach can be used to study meta-sustainability in preschoolers and show how, by focusing on the differentiated aspects of metacognition, we can teach and foster sustainable behaviors. In fact, promoting metacognitive skills and sustainability in preschoolers can have a significant impact on their future behaviors and decision-making processes. By teaching young children to think about their own thinking and to understand the importance of preserving resources and ecosystems, we can help them develop a deeper understanding of sustainability and its relevance to their lives. This can also help them become more responsible and engaged citizens who are committed to making positive contributions to the environment. By incorporating metacognition and sustainability into early childhood education, we can help create a more sustainable future for generations to come (Davis, 2014). Accordingly, this work offers some advice on how to use metacognition in order to foster sustainable actions. Our goal in reviewing these studies was twofold. First, we wanted to offer to preschoolers' teachers a metacognition-based approach when dealing with sustainability in the classroom. If, for example, a child shows inaccurate beliefs about the use of plastic, he/she can learn how to use different materials and be trained on how to improve their monitoring and control of their own actions. Thus, finding ways to improve children's metacognitive knowledge, monitoring, and control can lead to insights into how to improve their sustainable actions (e.g., Steg & Vlek, 2009). Second, sustainable education focuses on teaching children about environmental and social responsibility, and how to live in a way that ensures a sustainable future for the planet. By introducing sustainable education in preschoolers, we can help them develop a sense of respect and responsibility towards the environment and instill values that will stay with them for life. This can be achieved through a variety of engaging and interactive activities that are age-appropriate and fun for young children (Ernst & Burcak, 2019). In this context, preschool teachers play a vital role in shaping children's attitudes towards sustainability and the environment. By providing a strong foundation in sustainable education, we can help create a generation of environmentally conscious and responsible citizens who will work towards a sustainable future.

Within the theoretical frameworks of sustainable education, the transformative learning approach fits well with our "meta-sustainability" view. In fact, transformative learning theory is a way of understanding how individuals can learn and change their perspectives, values, and behaviors in response to new experiences and information (Mezirow, 2012). In the context of sustainable education, transformative learning theory can be used to help preschoolers to develop a deeper understanding of the interconnectedness of social, environmental, and economic systems, and to encourage a shift towards more sustainable thinking and practices. According to transformative learning theory, learning is not simply a matter of acquiring new information or skills, but involves a process of reflection, questioning assumptions, and challenging existing beliefs and values. This process can be facilitated through experiences that challenge individuals' existing ways of thinking and being, and that encourage them to consider alternative perspectives and ways of living. In sustainable education, transformative learning can be

fostered through a variety of approaches, such as, for instance, experiential learning. These approaches provide opportunities for young children to engage with real-world problems and to develop a deeper understanding of the complex social, environmental, and economic issues that underlie sustainability challenges. Transformative learning in sustainable education can also involve the development of critical thinking skills, such as the ability to analyze complex information, to evaluate different perspectives, and to identify underlying assumptions and biases. By developing these skills, children can become more effective problem-solvers later and agents of change in their communities and beyond. Overall, transformative learning theory provides a powerful framework for understanding how children can develop more sustainable ways of thinking and living, and how education can play a role in facilitating this process by using a "meta-sustainability" approach. In conclusion, teaching sustainability to preschoolers is an important step towards creating a more environmentally conscious future generation: by instilling the values of conservation, recycling, and reducing waste in young children, we can help them develop a lifelong commitment to protecting the environment. Studies (e.g., Somerville & Williams, 2015).) have shown that preschoolers are capable of understanding and engaging in sustainable practices, and that early education in these areas can have a positive impact on their attitudes and behaviors towards the environment. By incorporating meta-sustainability into preschool curriculums and daily routines, we can help shape a better future for our planet and for generations to come.

Recommendations

In the light of our research finding, it is recommended that educational institutions consider adopting and integrating metacognition into their curriculum for preschoolers in order to enhance learning experiences for sustainable behavior. Integrating sustainability concepts into various subjects across storytelling, songs, and laboratory activities may foster early sustainability awareness. For example, teachers may ask preschoolers to think how they can apply sustainability principles in real-life scenarios or encourage them to think about their thinking by asking reflective questions such as "Why do you think recycling is important?" or "What can we do to help the Earth? Furthermore, by promoting a think-aloud method, institutions and teachers can model metacognitive strategies by thinking aloud during activities, demonstrating children how to plan, monitor, and evaluate their actions related to sustainability. Finally, even at a young age, children can draw or use simple words and sentences to reflect on what they learned and how they feel about sustainability activities, so institutions may be recommended towards the use of a reflective drawing or word-based journal on sustainability concepts.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors..

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