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PRELIMINARY INFORMATION ON THE DEVELOPMENT OF MEASUREMENT TOOLS FOR PLANT AWARENESS: A REVIEW STUDY[1]

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ABSTRACT

Despite plants being of great importance for life on Earth, they are often overlooked. This oversight, known as "plant blindness" (a cognitive bias where people tend to ignore plant species), has increased over time as students prefer spending their leisure time with modern media rather than nature. "Plant blindness" describes the inadequacies of individuals in identifying and appreciating plant diversity, highlighting a significant gap in biology education, especially considering the central role of plants, critical components of photosynthesis, in ecosystems. However, current pedagogical tools fall short in comprehensively evaluating students' plant awareness. The purpose of this research is to develop new pedagogical approaches and assessment strategies to overcome the phenomenon of "plant blindness" in the field of education. Plant blindness encapsulates the deficiencies in individuals' abilities to recognize and evaluate plant diversity, exposing a notable deficiency in biology education. The focus of the research is to enhance students' knowledge and awareness of plants, thereby making them more sensitive and conscious individuals towards nature. The research aims to examine plant consciousness in four main dimensions: visual perception of plants, classification of plants, basic plant knowledge, and attitudes towards plants. The findings of this research are expected to shed light on new pedagogical approaches and assessment strategies proposed to overcome "plant blindness" in biology education. Additionally, the research aims to encourage students to better understand nature and the critical roles plants play in ecosystems, motivating them to take environmental responsibility. Moreover, it aims to provide biology teachers and educators with information and tools to enrich their lesson plans and teaching methods. This study will be an important step in the fight against plant blindness and will enhance future generations' respect and awareness of biological diversity.

Anahtar kelimeler: Plant awareness, plant blindness,measurement tool, measurement tools.

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INTRODUCTION

Plants form the foundation of nature. They are unique and productive beings that help meet many of mankind's needs. Since the beginning of their existence, humans have been in relation with plants. Archaeological findings from ancient times suggest that humans primarily relied on plants for sustenance and to address health issues (Allen, 2003). Plants, one of the most crucial elements of the biosphere and ecosystems, are not only the primary source of essential nutrients for most organisms but are also utilized in various sectors (food, cosmetics, pharmaceuticals, textiles, paper, etc.) (Çil, 2016).

Barriers specific to botanical education have been observed since the 1900s. Nichols (1919) noted insufficient representation of plants during laboratory sessions in university biology classes, while Monahan (1930) found a significant decline in enrollment for high school botany courses. Going further back, Ganong (1906) criticized the simplification of botany and teaching methods in schools. Moreover, both university biology students and general students tend to perceive botany as an irrelevant subject (Elster, 2007; Uno, 2009). With the introduction of the term 'Plant Blindness,' Wandersee & Schussler (2001) took a first step in addressing the underlying issue and attempted a systematic search to uncover the roots of the observed barriers.

Coined by Wandersee & Schussler (2001), the term Plant Blindness describes the phenomenon where individuals frequently overlook plants in their daily lives. Meanwhile, numerous studies have confirmed a discrepancy in remembering plants (Schussler & Olzak, 2008; Schussler et al., 2010) and recognizing them visually (Balas & Momsen, 2014; Zani & Low, 2022) compared to animals. Additionally, humans tend to classify plants as lifeless organisms (Yorek, Şahin, & Aydın, 2009; Amprazis, Papadopoulou, & Malandrakis, 2021). Furthermore, botanical knowledge, plant species, and their roles in various fundamental cycles are inadequately represented in curricula (Hershey, 1992) and in general human understanding.

As a potential explanation for this phenomenon, researchers accept the assumption that plants did not actively threaten or harm humans or their ancestors, leading attention during evolution to focus on animals that moved or posed threats. Furthermore, plants often move slowly (Attenborough, 1995), lack eyes that can look at us (New, Cosmides, & Tooby, 2007), and are generally perceived as less impressive (Nyberg, Brkovic, & Sanders, 2021). Interestingly, even botanical scientific research can be affected by plant blindness, as the selection of research subjects is influenced by colors and morphological features (Adamo et al., 2021).

Research conducted over the past 20 years has illuminated various aspects of Plant Blindness. These include an inability to recall plants from memory (Zani & Low, 2022; Schussler & Olzak, 2008), reduced ability of students and teachers to identify and name different plants (Borsos, Borić, and Patocskai, 2021; Kaasinen, 2019; Bebbington, 2005; Frisch et al., 2010; Palmberg et al., 2015), failure to recognize or notice plants on the way to school (Lindemann-Matthies, 2006). Researchers have also noted inadequate or incorrect information about plant reproduction (Lampert et al., 2020) and a lack of knowledge about the necessity of plants' sexual reproduction through pollen. Hence, plant blindness poses a significant obstacle to biology studies as both teachers and students often overlook the role of plants (Hershey, 1993).

The importance of understanding plants is crucial to addressing future challenges like the climate crisis. It's important for individuals to comprehend the vital biological roles of plants, such as the carbon cycle (Dillon et al., 2006; Howard et al., 2022). However, most people are unaware of what plants need for their growth (Barman et al., 2006). They often think that plants derive their mass solely through their roots (Driver et al., 2014). Moreover, there's a misunderstanding about the materials required for photosynthesis (Marmaroti & Galanopoulou, 2006). As a result, many fail to grasp the necessity of photosynthesis for plant growth (Messig & Groß, 2018). Without this knowledge, understanding the crucial role of trees (and forests) as carbon reservoirs is not possible.

Furthermore, Ryplova & Pokorny (2020) identified a lack of understanding about the impact of vegetation on its surroundings through transpiration-driven natural cooling. Similar findings were described by Bofferding & Kloser (2015); fewer than one-tenth of students were able to name steps taken using plants to adapt to the climate crisis, such as planting trees. The relationships between basic botanical knowledge gaps and globally impactful topics like these underscore the need for educators to combat plant blindness and promote plant awareness.

The primary objective of this research is to understand the depth and scope of "Plant Blindness" among students and its implications in biology education. By dissecting plant consciousness across four distinct dimensions, this study aims to uncover not only the extent to which students recognize and appreciate plants but also the limitations in current educational methodologies that contribute to this cognitive bias. The significance of this study lies in its potential to transform the way biology education addresses plants. Recognizing and combatting "Plant Blindness" is not merely an academic endeavor but a necessary step towards fostering a generation that values and conserves biodiversity. In an age where environmental challenges are mounting, nurturing an intrinsic respect and understanding for plants among students becomes imperative. The anticipated pedagogical approaches and assessment strategies resulting from this study could pave the way for a more holistic and engaged biology curriculum, reducing the prevalence of "Plant Blindness" and promoting a more sustainable future.

METHOD

Model of the Study

This study is constructed upon a review methodology aimed at examining both national and international researches to provide foundational knowledge on potential measurement instruments for plant awareness. The review research method is defined as a strategy employed by researchers to illuminate the overarching trends and outcomes associated with a particular subject or discipline (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, Demirel, 2017). In essence, the review method revolves around the scrupulous selection of literature concerning the investigational subject, irrespective of its quantitative, qualitative, or mixed nature, based on specific criteria. This is followed by an extraction of descriptive data from the chosen literature and a

subsequent interpretative analysis. Within this methodological structure, the core objective is to ascertain how the focal subject has been approached by scholars, and to delineate its temporal evolution using various thematic constructs either established prior to or post the review process. Predominantly, the researcher's endeavor within this methodology is to elucidate the objectives of academic pursuits associated with the chosen topic, ascertain the theoretical underpinnings and methodologies they employ, and to elucidate their findings (Hallinger, 2018).

Data Collection Process

For the data aggregation phase of this study, an exhaustive scan was executed using national and international databases as of April 30, 2023. A thorough literature review was orchestrated in alignment with the study's intent of establishing foundational knowledge concerning potential measurement instruments tailored for plant awareness. Inclusion criteria for the studies integrated into this research were defined by advanced search parameters, amalgamating various combinations of terminologies such as “plant”, “plant awareness”, and “plant blindness” within the title and abstract domains. Notably, this search was devoid of temporal constraints.

Data Analysis

Descriptive analysis was the chosen methodological tool for the examination of articles that met the stipulated criteria in this research. Drawing from this, codifications were subjected to a descriptive analysis leaning heavily on the theoretical framework elucidated in the pertinent literature (Miles & Huberman, 2015). Subsequent to this, the collated data were systematically categorized into relevant thematic clusters.

RESULTS

The Importance of Understanding Plants

To tackle significant future challenges such as the climate crisis, it is essential for humans to understand the role of plants in vital biological processes, such as the carbon cycle (Dillon et al., 2006; Howard, Ougham & Sanders, 2022). However, many individuals are unaware of what plants require to grow (Barman et al., 2006). They often mistakenly believe that plants obtain their mass primarily through their roots (Driver et al., 2014). Furthermore, misconceptions exist regarding the elements necessary for photosynthesis (Marmaroti & Galanopoulou, 2006). Consequently, the majority fail to grasp the indispensability of photosynthesis for plant growth (Messig & Groß, 2018). Without this knowledge, understanding the critical role of trees (and forests) as carbon stores becomes untenable.

Additionally, Ryplova & Pokorny (2020) identified a lack of understanding regarding the environmental impact of vegetation through transpiration as natural cooling. Bofferding & Kloser (2015) reported similar findings: fewer than one in ten students could identify steps to adapt to the climate crisis facilitated by plants, like tree planting. The link between this fundamental botanic knowledge deficiency and issues affecting the global

community underscore some of the primary reasons educators need to combat plant blindness and foster plant awareness.

Combatting Plant Blindness

Numerous initiatives have been undertaken to address plant blindness, encompassing both formal and informal biology education that focuses on plants. These interventions range from introducing plants as fundamental to global nutrition (Drea, 2011) to leveraging specific plant species or groups students find particularly interesting (Pany, 2014). Borsos, Borić, and Patocskai (2021) have successfully incorporated gamification into plant knowledge. A significant emphasis has been placed on fostering emotional connections through planting and nurturing plants (Strgar, 2007; Krosnick, Baker & Moore, 2018; Stagg, 2020).

Moreover, informal learning environments like botanical gardens play a role in combating plant blindness (Lindemann-Matthies, 2006). Various studies have identified a positive impact on students' plant awareness post educational interventions in botanical gardens, as these visits enable sensory explorations beyond the visual (Krishnan et al., 2019). Kissi & Dreesmann (2018) have adeptly utilized digital tools in such informal learning spaces. Additionally, field studies of plants enhance recognition skills (Borsos, Borić & Patocskai, 2021). Outdoor education not only enhances knowledge about plant species but also positively influences attitudes towards plants (Fančovičová & Prokop, 2011).

Furthermore, Lohr & Pearson-Mims (2005) affirmed that early exposure to nature positively influences attitudes towards trees, fostering emotional connections (Moormann, Lude & Möller, 2021; Gebhard, 2001). This is salient because while living organisms are often utilized in environmental education to motivate learners towards conservation, educators frequently place less emphasis on plants (Balding & Williams, 2016). This leads to underfunding and inadequate protection of endangered plants (Roberson et al., 2020), even as plant species extinctions are at an all-time human history high (Lughadha et al., 2020).

From Plant Blindness to Plant Awareness

The foundational definition of 'plant blindness' by Wandersee & Schussler (2001) remains unaltered. Initially identifying a critical issue extensively researched over the past two decades (Allen, 2003; Amprazis & Papadopoulou, 2020; Mung & Williams, 2016; Krosnick, Baker & Moore, 2018; Frisch, Unwin & Saunders, 2010; Zani & Low, 2022; Jose, Wu & Kamoun, 2019; Schussler & Olzak, 2008). However, the term is becoming increasingly nebulous and challenging to decipher (Amprazis & Papadopoulou, 2020). Therefore, clarifying and updating the definition of plant blindness is necessary for a robust discussion.Recently, Parsley (2020) enriched the plant blindness discourse, proposing a shift to the term 'plant awareness inequity' due to the problematic implications of 'blindness'. This proposal has gained traction among researchers (Parsley, 2021; Laura & Dreesmann, 2022). As language significantly influences our thinking (Bloom & Keil, 2001; Topping et al., 2004), we prefer a positive approach when addressing the issue of plant blindness.

Adhering to recent academic findings (Ädel, 2017; Harker, Dean & Monsen, 2017; Watts, 2017; Olsen, 2018), we seek a solution-focused approach to the long-standing issue of plant blindness. Following the ideas of McDonough MacKenzie et al. (2019), we aim to invigorate the discussion by emphasizing a quality we desire students to develop, namely 'plant awareness,' rather than a deficiency to be avoided.

Lastly, shifting the terminology and focus from a deficiency to an aspiration aligns with the modern education trend of promoting resilience, self-efficacy, and positive development (Westerhof & Keyes, 2010; Wang & Neihart, 2015; Aburn, Gott & Hoare, 2016). This redirection signifies that educators must no longer solely combat plant blindness. Instead, they need to foster plant awareness, thereby underlining the indispensability of plants in tackling significant future challenges.

Preliminary Information on the Development of Measurement Tools For Plant Awareness

Within the context and objectives of this research, both national and international studies aimed at forming preliminary information on possible measurement tools for plant awareness are discussed below, under the aforementioned headings. Stemming from the initial definition of "plant blindness" by Wandersee & Schussler (2001), the literature has evolved. Notably, Parsley's (2020) recent endeavors to redefine the term "plant awareness disparity" in contemporary literature have been addressed. In line with this, Parsley (2020) outlines potential indicators of this concept, enumerating them across four domains: attention, knowledge, attitude, and interest. Subsequent to extensive scans within national and international databases, plant awareness has been perceived as a concept constituting these four domains. Preliminary insights regarding potential instruments for measuring plant awareness have been conceptualized in Figure 1.

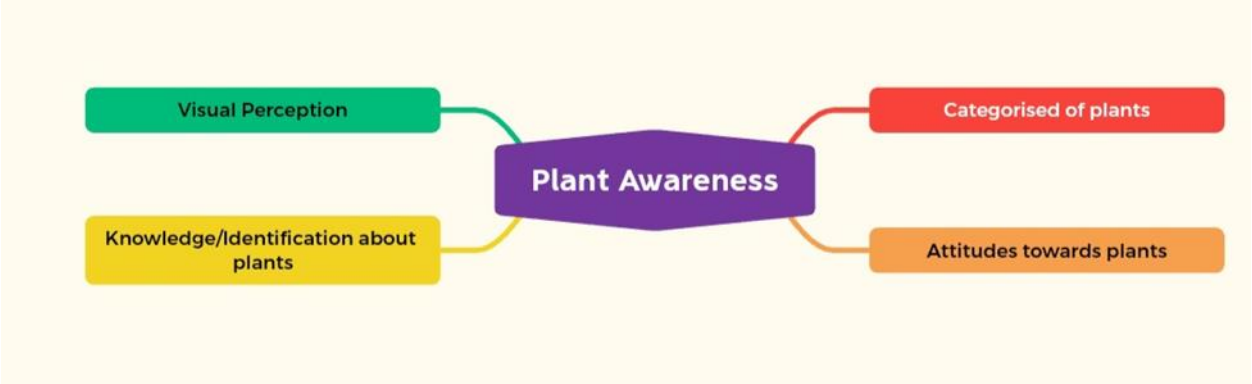

Figure 1. Conceptual Domains Of Plant Awareness

Plant awareness, an intricate understanding of the significance and nuances of plant life, can be conceptualized across various domains. These domains encompass different aspects of how individuals perceive, understand, and relate to plants. Here are the identified domains:

(1) Visual Perception of Plants: This domain pertains to how individuals visually recognize and interpret plant forms, structures, and colors. The visual element is vital, given that many people's first interaction with plants is often sight-based (Balas & Momsen, 2014; Schussler & Olzak, 2008; Zani & Low, 2022).

(2) Classifying Plants as Living Organisms: Recognizing plants as living entities distinct from inanimate objects, understanding their biological processes, and categorizing them correctly within the tree of life falls under this domain. This aspect underscores the significance of acknowledging plants' vitality and roles in ecological systems (Lindemann-Matthies, 2005; Yorek, Şahin & Aydın, 2009; Ahi, Atasoy & Balci, 2018; Amprazis, Papadopoulou & Malandrakis, 2021).

(3) Knowledge about (Recognition of) Plants: This domain focuses on the cognitive understanding of plants – identifying different species, knowing their functions, and understanding their ecological roles. A deeper knowledge of plants can foster appreciation and informed conservation efforts (Barman et al., 2006; Anderson, Ellis & Jones, 2014; Palmberg et al., 2015; Kaasinen, 2019; Sanders et al., 2022).

(4) Attitudes towards Plants: This encompasses the emotional and behavioral responses of individuals towards plants. Attitudes can range from appreciation, reverence, and affection to neglect or even aversion. Positive attitudes can lead to conservation actions, while negative ones might result in neglect or harm (Lohr & Pearson-Mims, 2005; Fančovičová & Prokop, 2010;Colon et al., 2020; Kubiatko, Fančovičová & Prokop, 2021).

Studies such as those by Amprazis et al. (2021) or Kubiatko, Fančovičová, & Prokop (2021) emphasize the importance of understanding these domains in order to address potential gaps or misconceptions and to promote a more holistic plant awareness among the populace.

DISCUSSION and CONCLUSION

The deficiency in plant awareness, commonly referred to as 'plant blindness' or 'plant awareness inequality,' constitutes a significant impediment in comprehending the paramount role of plants in sustaining life on Earth. This deficiency becomes especially conspicuous when we consider the extraordinary significance of plants in performing photosynthesis – a fundamental process that not only fuels their growth but also forms the bedrock of various food chains and acts as a pivotal carbon reservoir. Moreover, this deficiency impedes our capacity to holistically grasp the intricate interconnections inherent within nature's intricate tapestry. As a consequence, it engenders multifaceted challenges for students attempting to fathom and evaluate imminent challenges such as climate change and sustainability (Wandersee & Schussler, 2001; Dillon et al., 2006; Mung & Williams, 2016; Roberson et al., 2020; Howard, Ougham, & Sanders, 2022). Hence, it falls upon educators to strategically devise methodologies to elevate students' consciousness concerning the indispensable role of plants.

Aligning with the prevailing academic discourse (Lindemann-Matthies, 2005; Yorek et al., 2009), our research findings underscore that plants often assume the role of being perceived as "less animated" when juxtaposed

with animals. This perspective offers an intriguing insight into evaluating the aptness of employing the evaluative scale of "plants as living organisms" to discern students' perception of plants as animate entities. Nevertheless, our study delves more profoundly when students are tasked with enumerating five living organisms (as exemplified by the study conducted by Amprazis et al., 2021). In this context, our results offer a more nuanced comprehension of the life attributes that are infrequently attributed to plants. The incapacity to demonstrate mobility, in stark contrast to the agility exhibited by animals, emerges as a salient rationale underpinning the perception that plants are inherently "less animated" compared to their animal counterparts. Adding another layer of complexity, our findings extend their purview by revealing that plants are regarded as "more animated" when juxtaposed with bacteria. This discovery resonates harmoniously with the proposition that organisms sharing human-like characteristics are accorded a heightened status of "living beings." Regrettably, the relative unfamiliarity of plants compared to animals casts a shadow of bias upon this perception.

Following an exhaustive survey spanning national and international databases, we meticulously identified that the intricate concept of plant awareness encompasses a quartet of distinctive domains: visual perception, the categorization of plants as living organisms, the acquisition of knowledge about plants (inclusive of their identification), and the cultivation of attitudes toward plants. The hierarchical organization of these presumed domains within the construct of plant awareness presents an avenue ripe for exploration in forthcoming research endeavors. It is plausible that the foundational bedrock of plant awareness resides within the precincts of visual perception, a foundational premise championed by Wandersee & Schussler (2001). When individuals demonstrate the ability to discern an individual plant amid a verdant backdrop, they are endowed with the capacity to classify plants as living entities. Should individuals genuinely perceive plants as animate entities, they are bestowed with the tools to amass a corpus of knowledge spanning plant physiology, anatomy, and ecology, thereby fostering a capacity to discern and recognize them. Lastly, an appreciation of the diversity intrinsic to plants empowers individuals to discern their pivotal roles within our ecosystem, potentially serving as a catalyst for nurturing attitudes toward plants that transcend the realm of mere aesthetic admiration.

To cast an even more penetrating light upon this prospective structure of plant awareness, it becomes incumbent upon researchers to embark on an explorative journey into other realms of plant awareness, particularly those of visual perception and attitudes. To this end, educators are in dire need of a rigorously validated instrument that could facilitate a comprehensive assessment of plant awareness spanning the four posited domains. By dissecting inter-domain correlations, it becomes increasingly evident that the conceptualization of plant awareness assumes a pivotal role in the development of an overarching scale for the theory of plant blindness. In summation, the endeavor of enabling students to comprehend the pivotal significance of plants assumes the stature of a foundational pillar within the domain of biology education. Augmented plant awareness, seamlessly melded with an enriched understanding of botanical knowledge and an enhanced grasp of biological systems, emerges as a fundamental prerequisite for the attainment of

consequential global objectives, foremost among which is the trajectory towards sustainable development (Howard, Ougham, & Sanders, 2022).

RECOMMENDATION

Consequently, a nuanced understanding of the gradient of plant awareness assumes the character of an indispensable facet underpinning efficacious botanical education across informal learning settings encompassing schools, universities, and botanical gardens. The conception and deployment of a comprehensive plant awareness survey, poised to be embraced by biology educators globally, represents a pivotal catalyst in nurturing elevated levels of plant awareness among students. Through concerted efforts in this direction, the pathway toward heightened plant awareness, coupled with an elevated recognition of the indispensable role of plants, assumes the potential to contribute tangibly to a more sustainable future for our planet.

Ethics Statement

This article adheres to the journal's writing standards, publication principles, research and publication ethics rules, and journal ethical guidelines. The author is responsible for any and all violations related to the article. Since this article was conducted through document analysis, one of the qualitative research methods, it does not require ethical board approval.

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