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Examination of the Role of Species Diversity (Biodiversity) in the Environmental Education and Awareness Raising

Theses for doctoral (PhD) dissertation

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2023

Declaration of Work Autonomy and Proper Citation of Literary Sources

I, the undersigned, Éva Nagy, hereby declare that I have independently prepared the theses abstract of the doctoral dissertation titled "*Examination of the Role of Species Diversity (Biodiversity) in Environmental Education and Awareness Raising*" and I have used only the sources listed in the references of the academic literature. I have attributed every section taken directly or paraphrased from another source with clear and unambiguous citations.

Eger, 2023. július 24.

Signature of the doctoral candidate

"The world is as delicate and as complicated as a spider`s web, and like a spider`s web, if you touch one thread, you send shudders running through all the other threads that make up the web."

Gerald Durrell

"To recognise that if we have become powerful enough to change the entire planet
then we are powerful enough to moderate our impact- to work with nature rather than against it." Witness statement

David Attenborough

"Every single one of us makes some impact on the planet every single day, and we get
to choose what sort of impact we make."

Dr Jane Goodall

"Every individual matters. Every individual has a role to play. Every individual makes
a difference"

Dr Jane Goodall

1

"I do it for me."

Brooke Wells

[1] Tree stump and the human fingerprint. „*In the spirit of nature everything is connected.*"

Table of contents

1. Introduction of the Research Problem and Relevance of Topic Selection

In today's world, environmental protection, environmental management, and consequently health preservation have become the most crucial economic, social, and political factors worldwide. Concepts such as environmental policy, sustainable development, epidemic management, and environmental and health education have evolved into terms that directly impact the entire humanity. Nowadays, everyone can feel firsthand that unprecedented disruptions, such as the ones caused by urbanization, are entering our lives more frequently (The UNU-EHS Report, 2021 - 10 disastrous events, 2020/2021) (1. Amazon rainforest fires 2. Arctic heatwave 3. Beirut explosion 4. Central Vietnamese floods 5. Chinese paddlefish extinction 6. COVID-19 pandemic - emergence of a new disease 7. Amphan cyclone 8. Desert locust outbreak 9. Great barrier reef bleaching 10. Texas cold wave), often without realizing that these disruptions might be linked to our lack of understanding of Earth as a living organism. We might not fully recognize the intricate connections we have with the planet and the consequences of our actions, or we might not have acknowledged the importance of various plant and animal species, their functions, benefits, essential elements, tolerance limits, and the significance of preserving their habitats. The Gaia theory posits that Earth's biosphere is a self-organizing, living system that maintains its equilibrium in a meta-stable state, which is highly conducive to life, and the atmosphere is in homeostasis with and for the biosphere. Therefore, living matter stabilizes the atmosphere's composition and temperature through homeostatic feedback. (Nemecz Ernő, 2007). According to the Gaia Hypothesis "*clouds over the great oceanic regions of Earth are formed by the organisms living at the surface, the algae. They produce gases that go into the air, oxidize, and create the atoms around which cloud droplets form and reflect sunlight into space. The Earth would be about 10 degrees warmer if these clouds and the organisms that produce them were not there.*" (Lovelock, 2000. 2min22sec) "*We also know that the removal of carbon dioxide from the air would not be as rapid as it is, if it were not for the presence of life in soils and rocks and everywhere on the land and in the ocean.*" However, catastrophic die-offs are reported in the upper layers of the sea, leading to the extinction of the species that depend

on them (Howarth, 2022), although sometimes the refinement of the Gaia theory and a more thoughtful comparison between theory and data are suggested (Kirchner, 2003).

Basic environmental and ecological knowledge have to some extent become an integral part of general education. In contrast, in Hungary, there is not a long-standing tradition of environmentally friendly education based on modern ecological principles. Developing, redefining, and revitalizing (rekindling) environmental education, teaching, and upbringing that are centered around the living organism, not just in textbooks, but much closer to reality and based on ecological principles, is an exceptionally important task (Pénzesné Kónya 2015, p. 115). This is even more significant since several recent reports have placed topics related to Sustainability and Environment within the Top 20 or Top 20-40 categories among the 100 fastest-growing professions globally for the years 2018-2022. (Figure 1)

A 100 Number of the 100 Fastest-Growing Professions (2023)

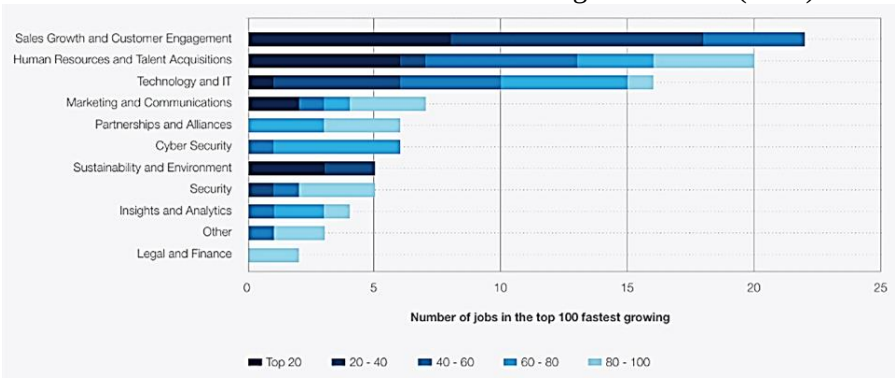

Figure 1 Source: World Economic Forum (2023): Future of Jobs Report, Insight Reporr May 2023

Moreover, on the Planetary Boundaries diagram, although "basic limits" for changes in the integrity of the biosphere (i.e., decreasing biodiversity and species extinction) were listed in 2015, they were not quantifiable. However, in the 2022 radar chart, these are included among the

three most critical areas (1. novel phenomena, mainly chemical substances and genetically modified organisms, 2. atmospheric particle deposition, along with 3. *functional biodiversity*, a sub-area of species richness loss), where we have already surpassed the limits that would ensure safe existence. (Persson et al., 2022)

Planetary Boundaries 2022

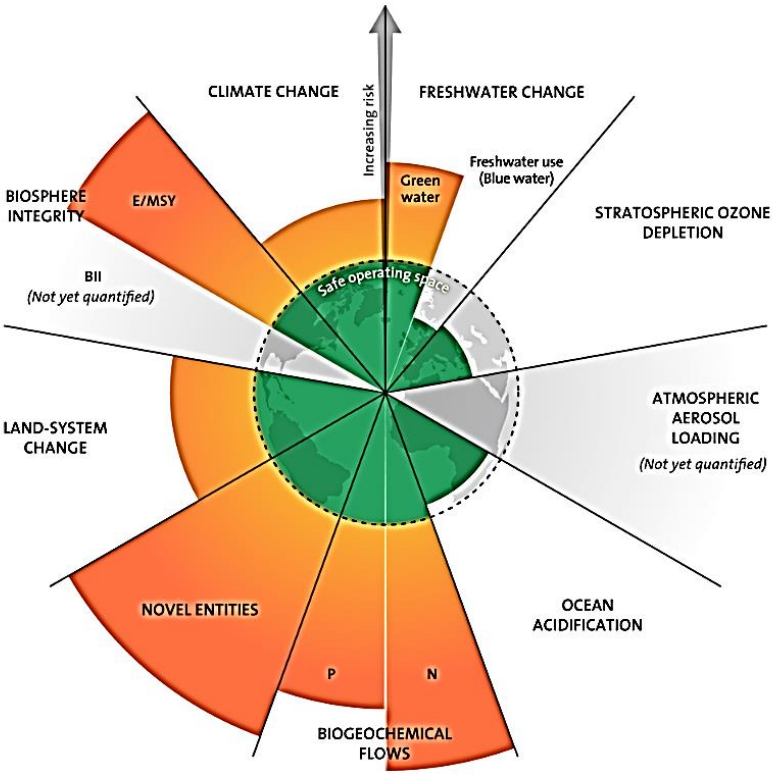

Figure 2 Planetary Boundaries diagram complemented with Boundaries of New Substances Source: Persson et al., 2022

The impact of human activity constantly alters the living world. (Orbán, Újfaludi, & Mika, 2015) Just a few decades ago, concerns were

raised about the environmental impact of economic development; however, today, we must also focus on the economic and social consequences of ecological stress, prompted by what is known as the "*explosion of globalization*." (Rakonczai, 2008) The guarantee of a sustainable future lies in a new, "environmentally sensitive" generation, drawing from experiences, scientific knowledge, and continuous observations. They should be active participants in the processes, decisions, and actions happening around them. Small-scale, data-gathering activities that lead to broad-scale conclusions (global citizenship mindset) are essential. As a result, biomonitoring research activities, observing and actively participating environmental and conservation movements gain more significance within biology. There is a growing need for up-to-date, socially and individually useful knowledge, skills, and competencies. (Pénzesné Kónya, 2015, p.115)

The environmental crisis that surrounds us and encompasses us can still be addressed through environmental education, even today as educators (Nahalka, 1997). Environmental education, or as the concept has evolved over time, sustainability education, primarily falls within the realm of educators teaching environmental awareness, natural sciences, or biology subjects. The question arises: what opportunities are available in our country for imparting knowledge, and to what extent do they encompass current changes, remain up-to-date, and can effectively be applied to introduce Hungary's biodiversity? To what extent do the current curriculum contents align with global sustainability challenges? What possibilities exist in Hungary today for the development of teacher and student competencies related to species diversity, meaning how does education concerning biodiversity and species diversity manifest itself? (Orbán, 2017) This becomes particularly relevant as the long-term acquisition of up-to-date information from the mandatory curriculum can serve as a significant motivation not only for sustaining the human species but also for curbing the unprecedented decrease in species diversity.

The integration of disadvantaged (HH) or cumulatively disadvantaged (Triple H, HHH) – often of Roma origin) students into high school settings is increasingly pronounced, wherein the formation of attitudes or integration into everyday life holds paramount importance. Many

underprivileged children are already engaged in various agricultural activities (crop cultivation, animal husbandry) at an early age at home; however, fewer and fewer choose careers in agriculture. It is possible that they do not truly understand the species or their precise roles in the ecosystem. This year has seen the lowest enrollment in natural science programs, including biology-health education exams. Due to an increasing shortage of educators and a lack of domestic commitment to the subject, the subject has seemingly become less popular. The content of our biology education and the methods of processing educational material largely stem from the 1960s and 1970s (Franyó, 2012), and in today's teaching practice of the biology subject, it is increasingly evident that the available teaching materials and requirements, despite the biosphere crisis, do not sufficiently approach present-day changes and updates. As a result, they may not accurately depict the real health status of the "Z" (specifically 9th, 10th, 11th, and 12th-grade) high school generation's environment. (Nagy, 2020) Yet, the acquisition of knowledge concerning students' immediate environment could guarantee the successful preservation of biodiversity and species diversity. While efforts have been made towards more effective teaching of the subject (smart textbooks, Harriet Dyer: "Little Green Book" 2021, "Green Earth" textbooks and educational programs for 9th and 10th, 11th and 12th grades, one of the highlighted themes of the 2022/23 Sustainability Theme Week is biodiversity, and there has already been a scientific competence assessment this year, which includes measuring knowledge of the biology-health education subject), a more in-depth situational assessment can bring recurring deficiencies to the surface, identify elements to be eliminated, and offer alternative approaches. Such considerations could significantly impact students' perspectives, sustainability endeavors, relationship with their environment, vision of the future, and commitment to preserving the planet's health.

The tender EFOP-3.6.2-16-2017-00014, "*Establishing an International Research Environment for Light Pollution Investigation*," with its focus on the effects of light pollution on living organisms, also confirms that people inadequately recognize representatives of the animal and plant world in terms of the impacts of light pollution on them. Yet, through simple methods and learned behaviors, we could safeguard the values that still

remain in our environment. Unfortunately, even the educational curriculum inadequately incorporates this theme. (Nagy, 2021) "Since environmental education is not executable without digitalization" (Lükő, 2020), the use of digital teaching aids and the introduction of transformative learning methods (a discovery process that extends consciousness and transforms individual belief systems) can prove fruitful.

To gain a comprehensive understanding of the current curriculum contents concerning biodiversity and species diversity in biology education and their effectiveness, it is worthwhile to examine the present opportunities and results from various angles, both from the perspective of students and teachers. A multi-aspect approach is necessary for conducting the research and analyses. My aim was to follow the principle of triangulation, embracing multidimensionality and merging various methods to approach scientific processing. (Sántha, 2015)

The foremost motto of my work is a profoundly meaningful quote by Gerald Durrell. This choice is not coincidental, given Durrell's unique conservation efforts, including his attempts to acquire and relocate individuals of species threatened with extinction to the Jersey Island Zoo. His work was driven by saving and studying endangered animals. I first encountered his thoughts during a visit to a zoo, and they deeply resonated with me, eventually underpinning the true purpose of my research. Specifically, to minimize the factors responsible for shaking the web of life to the utmost extent within my capacity, in the spaces I interact with or am connected to. The second motto, equally poignant and inspiring, originates from Jane Goodall. Nowadays, her thoughts are indispensable in every facet of environmental education. Every individual plays a unique role within the global ecosystem, and it is our distinguished task to protect all of them with all our might. This is a challenging endeavor that requires significant effort, permeating every life situation. The struggle for the subject is tantamount to a genuine CrossFit workout (Brooke Wells). To achieve this, Attenborough's worldview can provide a reliable solution, which is why I chose them.

During the analysis of my practical experiences and the mentioned data, the current shortcomings of environmental education have become apparent to me, necessitating methodological renewal. In today's high school

education, successful environmental education criteria include the necessity of direct observation and engagement with the immediate environment.

In Chapter 1 of the dissertation, I present the timeliness, background, and structure of the research, along with the objectives, sub-objectives, and previously formulated hypotheses. Additionally, I delve into the three fundamental concepts that define my topic: biodiversity, species diversity, and environmental education. I also explore the concept of environmental attitude, as well as the tools and methods closely related to the themes of biodiversity and species diversity. Chapter 2 introduces the methods I employed. Chapter 3 presents the research results, providing a detailed account of key current aspects, including the Biodiversity Strategy (2015-2020), the New National Core Curriculum (Nat2020), and the relevant content of the examined framework curricula. This chapter includes an in-depth situational analysis of surveys and document analyses, aligned with the research objectives, and evaluates the hypotheses. Chapter 4 summarizes the conducted research and its most significant findings. Subsequently, Chapter 5 offers a perspective, while Chapter 6 provides the bibliography, Chapter 7 the list of electronic sources, Chapter 8 the list of abbreviations used in the dissertation, Chapter 9 the list of figures, Chapter 10 the list of tables, Chapter 11 acknowledgments, and finally, Chapter 12 lists the appendices.

1.1. Research Objectives

In the title-conveyed scope of the dissertation (in which: species diversity is not identical to biological diversity (biodiversity), as species diversity is a subset of biodiversity. According to the Convention on Biological Diversity (1992, 2020 resolutions) *"biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*"), I extensively examine the National Biodiversity Strategy (2015-2020), the Convention on Biological Diversity

(1992, 2020 resolutions), as well as key documents and key stakeholders of secondary education:

Through document analysis, I uncover the prescribed content for education in the context of the National Biodiversity Strategy and the Convention on Biological Diversity, aligned with the new National Core Curriculum (Nat2020) and the related biology Framework Curricula.

Through document analysis, I uncover the prescribed content for education in the context of the National Biodiversity Strategy and the Convention on Biological Diversity, aligned with the new National Core Curriculum (Nat2020) and the related biology Framework Curricula.

I compare this to earlier documents (Nat2012 and its Framework Curricula).

Likewise, through document analysis, I examine whether approved and current high school textbooks encompass essential concepts and principles in the field.

By conducting and evaluating in-depth interviews, I gather insights into the experiences of professionals engaged in the topic.

As the primary context, I conduct questionnaire surveys among high school students to gather information about their subject knowledge and attitudes in the topic. Additionally, I supplement this by employing similar methods to assess the current experiences of biology teachers in Hungary.

I conclude my thesis with a comprehensive assessment, summarizing the experiential nature of outdoor education and its primary current implications in the teaching of the biology subject.

My scientific objectives are to thoroughly examine the following:

1. How does the scientific key competence manifest in accordance with the National Biodiversity Strategy (2015-2020) and the Convention on Biological Diversity (1992, 2020 resolutions) in the new National Core Curriculum (NAT2020)?

2. How is the allocated class time for natural science education portrayed in the National Core Curriculum (NAT2020)?

3. What references and objectives related to biodiversity and species diversity are contained in the National Core Curriculum (NAT2020)?

4. What references and objectives related to biodiversity and species diversity are present in the associated Framework Curricula for the National Core Curriculum (NAT2020), and in some cases, local curricula?

5. What references and objectives related to biodiversity and species diversity are included in the National Core Curriculum (NAT2020), in comparison to the one version earlier National Core Curriculum (NAT2012)?

6. What references and objectives related to biodiversity and species diversity are contained in the associated Framework Curricula for the National Core Curriculum (NAT2020), and in some cases, local curricula, in comparison to the previous National Core Curriculum (NAT2012) and its Framework Curricula?

7. What references to biodiversity and species diversity are found in the approved high school textbooks subsequent to the National Core Curriculum (NAT2020)?

8. What references to recent events and data are included in the content of centrally approved textbooks following the National Core Curriculum (NAT2020) regarding biodiversity and species diversity?

9. What teaching practices and methods are employed by current biology teachers, primarily at the secondary level, regarding biodiversity and species diversity education in Hungary?

10. How familiar is the topic of biodiversity and species diversity among high school students today?

11. What attitudes do students from grades 9, 10, 11, and 12 hold towards biodiversity and species diversity?

12. To what extent can the students' attitudes towards species be changed during live presentations or outdoor classroom activities?

13. How does students' attitude towards species diversity and biodiversity change during their everyday habits (e.g., daytime or nighttime walks) when observing the occurrence and activity of animals (e.g., bats)?

14. How closely is the basic knowledge of high school students related to biodiversity and species diversity connected to real-life situations? In other words, how does their **lexical knowledge** about biodiversity and species diversity **relate to events in real life**?

1.2. Hypotheses formulated based on the initial research objectives of the dissertation

1. hypothesis: The development of "environmentally responsible citizenship and mindset formation" as outlined in the National Biodiversity Strategy (2015-2020) and the Convention on Biological Diversity (1992, 2020 resolutions) is more consciously realized in the context of secondary school teaching activities concerning biodiversity and species diversity in the new National Core Curriculum (NAT2020).

2. hypothesis: The new National Core Curriculum (NAT2020) and its associated framework curricula provide greater support for the development of competencies related to biodiversity and species diversity compared to the previous National Core Curriculum and framework curriculum (NAT2012).

3. hypothesis: The prescribed content in the framework curricula presented in the new National Core Curriculum (NAT2020) more extensively includes required topics on biodiversity and species diversity compared to the content of previous framework curricula.

4. hypothesis: The current curriculum content (prescribed textbooks in circulation at secondary schools) appropriately supports the development of key competencies related to the conservation, enhancement, and evaluation of biological diversity.

5. hypothesis: In the educational practices of Hungarian institutions of general education (primarily at the secondary level), a progressively more deliberate and innovative methodological structure promoting the precise understanding of biodiversity and species diversity is emerging among educators' work.

6. hypothesis: A sub-topic area, the realm of biodiversity and species diversity, remains unfamiliar to today's secondary school students.

7. hypothesis: A sub-topic area, the education on biodiversity and species diversity, does not significantly contribute to environmental education and mindset formation among young individuals in terms of their environmental attitudes, both within and outside the school environment.

8. hypothesis: The current environmental education curriculum does not integrate knowledge related to current events, nor does it connect everyday life occurrences to the environmental education content for secondary school students.

2. Research Tools and Methods

Chapter 2 presents the methods I employed in this study. The foundation of my research work is to assess how the mindset formation outlined in the new National Biodiversity Strategy (2015-2020) has changed within the framework of the new National Core Curriculum (Nat2020) in the context of school education.

Furthermore, a significant research objective is to investigate the role of teaching a sub-topic area, biodiversity and species diversity, in environmental education and mindset formation among young individuals, both within and outside the school environment.

Concurrently, involving experienced professionals, key programs with a sustainability perspective, informational lectures, and events are organized. Additionally, sustainability aspects are addressed through activities such as ecological footprint calculation, garden programs focusing on native plant species, presentations about the EKKE TTK Pollen Center, as well as organizing further eco-school initiatives and the Bisel competition. Through these initiatives, I explore, analyze, and evaluate the current knowledge of the crucial age group (mainly secondary school grades 9-12) in terms of environmental education practices, both before and after the implementation of these programs.

2.1. Research Methods Employed in the Dissertation

The planned strategy of this pedagogical research is simultaneously deductive and inductive. It is analytical in nature, as I aim to formulate principles and regularities through analyzing sources and documents (the National Biodiversity Strategy (2015-2020); the Convention on Biological Diversity (1992, 2020 resolutions); the National Core Curriculum (2012), the new National Core Curriculum (2020) and its Framework Curricula). Additionally, it is empirical as I strive to draw conclusions based on experiential, statistical measurements, and their analysis.

The research strategy also has a deductive aspect, as my conclusions are based on research findings from the field of natural sciences. (Falus, 2000)

Furthermore, it is inductive and descriptive in nature as I aim to describe the existing state of environmental education, particularly in the sub-topics of biodiversity and species diversity.

It is also inductive in the sense of exploratory research, as I investigate the correlation of different variables within the existing pedagogical context. I intend to examine the impact of nature-centric education (independent variable) on the effective acquisition of the curriculum (dependent variable). (Lengyelné, 2013)

The research is inductively experimental as well, as I employ varying methods to teach biology to grades 9-12 students, thereby intervening in the pedagogical processes. This involves modifying independent variables (presence or absence of nature-centric approaches) with targeted sustainability programs, lectures, involvement of speakers, or the implementation of extracurricular nature-centric activities. These three strategies build upon and complement each other.

I apply a mixed methods approach, utilizing the "convergent parallel design" subtype. This means that I plan to carry out quantitative and qualitative data collection and analysis independently and complementarily. (Király, et al. 2014) The methodology is quantitative, aiming to provide numerically supported results, draw conclusions from observed regularities, and gather quantitatively processable information from larger groups. Additionally, it is qualitative and analytical as the employed quantitative methods contribute significantly to the pedagogical interpretation of research results, presenting numerical data alongside the exploration of regularities and the determination of causal relationships.

The critically important quantitative and qualitative research methods (and their data collection tools, in parentheses) I employ can be summarized as follows:

- *Quantitative Research Methods:*

✓ Individual written surveys, questionnaire method (online questionnaires): (Investigation of research objectives 9, 10, 13, 14)

✓ Individual written surveys, application of attitude scales: (Objectives 11, 12)

- *Qualitative Research Methods:*

✓ Qualitative research methods applying the method of intervention-free research - concurrently exploratory methods:

✓ Content analysis, Document analysis: (Objectives 1, 2, 3, 4, 5, 6, 7, 8)

Qualitative research methods employing the intervention approach – also *exploratory methods*:

✓ Individual oral interviews, (skype/video/telephone) interviews (interview guide): (Objective 13)

2.1.1. Statistical Methods

Within the categorization of research methods, another grouping pertains to the applied *statistical processing methods*: (Falus, 2000)

➢ Method of Statistical Analysis:

Parametric examinations, Two-sample t-test and Cronbach's alpha (Objective 7) – comparison of results from pre-test and post-test before and after organizing nature science programs: Objective 14 (Calculations in Appendices: Calculation 2: Calculation of Cronbach's alpha value in the case of pre-test, Calculation 3: Calculation of Two-sample t-test using SPSS software for the entire sample (Nat2012 and Nat2020), Calculation 4: Calculation of Two-sample t-test using SPSS software for the Nat2012 sample, Calculation 5: Calculation of Two-sample t-test using SPSS software for the Nat2020 sample)

Parametric examinations, One-sample t-test - originally - application in the case where I aim to demonstrate that high school students perform

similarly in the nature science assessment as Hungarian high school students did during the measurement of nature science competence, under the precondition that the central nature science competence assessment is introduced in high schools at least until the first semester of 2022. Since the National Office for Education did not grant access to the documentation, I had to modify it, thus I inquired the students who took the test about the appearance of plant and animal species featured in the digital year-end assessments, and I summarized this.

Pearson-type Chi-squared test – examining correlation based on the results of the questionnaire filled out by 800 biology teachers, and I provided the Chi-squared test and Yates' correction probability for high schools in relation to outdoor teaching. (Calculation in Appendices: Calculation 1: Chi-squared test).

Occasionally, analysis of multi-dimensional contingency tables through visual inspection or mathematical calculations, which I also employed during the analysis of the 800-sample questionnaire.

Utilization of Excel and SPSS statistical software with the applicable statistical calculations.

Throughout the research, I employ triangulation for several sub-problems in order to arrive at more reliable conclusions, as triangulation implies the parallel, simultaneous utilization of different methods, techniques, or source groups (Sántha, 2007). Furthermore, I aim to follow the methodological counsel of Ágnes Szokolszki, which states that a "multi-perspective approach provides a more accurate representation of reality" (Szokolszky, 2006). Therefore, I examine the chosen topic from multiple angles and perspectives.

2.1.2. Document Analysis

Using the qualitative method of Document Analysis, I examine the extent to which the recommendations of the National Curriculum (2012 and

2020) governing the content of education deviate from the topic of biodiversity and species diversity.

2.1.3. Content Analysis

Through the qualitative method of Content Analysis, I investigate the extent and content with which high school biology textbooks represent elements related to biodiversity and species diversity.

2.1.4. Interviews

Applying additional qualitative strategic methods, I employ the individual structured interview method to uncover the issue from the perspectives of teachers, students, and experts.

2.1.5. Online Questionnaires (Student and Teacher)

Using the method of individual written inquiry through online questionnaires, I further explore various approaches to the topic.

2.2. Hypotheses and Theses of the Dissertation

Based on the objectives, I have formulated 8 hypotheses in advance, which I will now detail along with the theses.

Hypothesis and Thesis 1

Hypothesis 1. The establishment of "environmentally responsible citizenship behavior and mindset formation" formulated in the National Biodiversity Strategy (2015-2020) and the Convention on Biological Diversity (1992, 2020 resolutions), is more consciously realized in the new National Basic Curriculum (NAT2020) regarding biodiversity and species diversity during high school teaching activities.

To test this hypothesis, I first examined the relevant parts of the new National Basic Curriculum (Nat2020) (see Hypothesis 2) in relation to the teaching of biological sciences, and I also examined textbook contents in relation to the establishment of "environmentally responsible citizenship behavior and mindset formation" in the National Biodiversity Strategy (2015-2020) and the Convention on Biological Diversity (1992, 2020 resolutions).

Based on document analysis, Nat2012 contained a total of 44 mentions, whereas Nat2020 contained a total of 53 mentions related to the "environmentally responsible citizenship behavior and mindset formation" aspect from the National Biodiversity Strategy (2015-2020) or the Convention on Biological Diversity (1992, 2020 resolutions). This difference may stem from a slightly increased emphasis on these topics in the curriculum, but the distinction is not particularly significant.

Moreover, it is interesting to note that expressions like "*species diversity*" (0), "*taxon diversity*" (0), "*invasive species*" (0), and "*populations*" (0) had no mentions, and significant concepts were only included in a few instances within the Nat2020 curriculum. Sustainability (43) appeared slightly more frequently, perhaps attempting to compensate for this.

It's also important to note that essential facts did not find their way into the mandated curriculum text.

To test this hypothesis, I also reviewed the content of the mandatory and in-use textbooks to assess whether they incorporated the aspects of "environmentally responsible citizenship behavior and mindset formation" from the National Biodiversity Strategy (2015-2020) and the Convention on Biological Diversity (1992, 2020 resolutions). I compiled a table summarizing which publications made references to these aspects. Throughout the research, I examined 7 editions published prior to 2020 (based on Nat2012) and 8 editions from 2020 or later, including 2021, as well as digital textbooks.

In summary, based on the content analysis of keywords and chapter titles in the textbooks, it can be concluded that the occurrence of aspects related to "environmentally responsible citizenship behavior and mindset formation" from the National Biodiversity Strategy (2015-2020) and the Convention on Biological Diversity (1992, 2020 resolutions) is significantly lower in textbooks based on Nat2012 compared to textbooks based on Nat2020.

The occurrence of *species diversity* and *biodiversity* aspects in the selected 7 most common, in-use, mandatory textbooks based on Nat2012 is 1 each, whereas in the same category of textbooks based on Nat2020, it's 2 for species diversity and 4 for biodiversity. In both groups of textbooks based on the two National Basic Curricula, these terms are consistently very rare.

Thesis 1

Based on my research, it can be concluded that the establishment of "environmentally responsible citizenship behavior and mindset formation" formulated in the National Biodiversity Strategy (2015-2020) and the Convention on Biological Diversity (1992, 2020 resolutions) is somewhat more intensively present in the new National Basic Curriculum (Nat2020) regarding biodiversity and species diversity. However, it is still realized in relatively small quantities during high school teaching activities and

education. Therefore, the hypothesis is not supported, and the null hypothesis can be accepted.

Hypothesis and Thesis 2

Hypothesis 2. The new National Basic Curriculum (Nat2020) and its related framework plans provide slightly more support for the development of competencies related to biodiversity and species diversity compared to the one-year-earlier National Basic Curriculum (Nat2012)

To test this hypothesis, I conducted content analysis and examined the specific content related to natural science competencies according to Nat2012 and Nat2020.

At first, analyzing **Nat2012**, I found the following relevant content, quoted from the pages of Nat2012.

1.Development Areas - Educational Goals

In the Development Areas and Educational Goals, sustainability and environmental awareness are placed 8th, focusing on the rich diversity of lifestyles in both nature and culture, as well as the conscious, thrifty, and responsible use of resources considering their renewability. The goal of education according to Nat2012 is to be based on love for nature and knowledge of the environment, fostering environmentally conscious, value-preserving, sustainability-committed students. The institution must prepare students for acquiring environmental citizenship responsibilities. The curriculum aims for students to understand economic and social processes that lead to changes and crises, as well as engaging in preserving and enriching the natural (and social) values and diversity of their immediate and broader environment, thus addressing species diversity and biodiversity.

2. Key Competencies (9 competencies)

Key competencies are the knowledge, skills, and attitudes that citizens of the European Union need to adapt to the rapidly changing modern world and influence the direction and content of change. These competencies are intertwined and include **scientific and technical competencies**, encompassing the following content elements. (11 references)

3.Man and Environment – Our Earth – Our Environment Literacy Area (p101-118) (23 references)

4. Our Earth and Environment Literacy Area (p137-144) (10 references)

Hereinafter analyzing Nat2020, I found the following relevant content:, quoted from the pages of **Nat2020**

1. Science Education (p8) (3 references)

However, among the mentioned key competencies (7) of Nat2020, there is no mention of natural science competence at all, within the scope of subjects for learning. In order to develop knowledge in the field of natural sciences and particularly in MTMI skills, in high schools, during the 11th grade, students who are not taking an advanced or specialized course in natural sciences must study an integrated natural science subject, or one of the subjects: Physics, Chemistry, biology, or Geography, for two hours per week.

In grades 9-10, natural science subjects are taught and learned in a discipline-specific manner. The study of natural science subjects can be continued at an advanced level during grades 11-12.

2.Nature and Geography - Key Contents of Nat2020 – (p77) (7 references)

3.Biology - For Secondary Education (p86-87) (9 references)

4.Specific Characteristics of Teaching the Subject in Grades 9-10 (p87) (8 references)

5.Main Topics in Grades 9-10 (p88) (1 reference)

6. Comprehensive and General Requirements for Learning Outcomes in Grades 9-10 (p90-94) (25 references)

Summarizing, relating to the first hypothesis, there are 44 references related to Nat2012 and 53 references related to Nat2020, which is not a very high number and cannot be considered significantly increased or decreased, but rather requires supplementation. (see hypothesis 1)

Thesis 2

Unfortunately, it cannot be concluded that the new revised National Basic Curriculum (Nat2020) and its related framework plans significantly provide more support for the development of competencies related to biodiversity and species diversity compared to the one-year-earlier National Basic Curriculum (Nat2012). This is due to the fact that the term "*scientific and technical competency*" present in Nat2012 completely disappears from the competencies list in Nat2020, as well as other changes in literacy areas and study areas. Therefore, the hypothesis is not supported, and the null hypothesis can be accepted.

Hypothesis and Thesis 3

Hypothesis 3. The prescribed content in the curriculum guidelines appearing in the new National Basic Curriculum (Nat2020) includes a higher proportion of content related to biodiversity and species diversity compared to the previous curriculum guidelines.

High school students are a valuable target group for us to provide up-to-date environmental and conservation knowledge, from which they can gain real insights and take a leading role in issues related to the preservation of species and biological diversity, which are fundamental to our existence. However, do we teach them the knowledge about living organisms, and thus the techniques of conservation, with which they can save what can still be saved?

My article titled *The appearance of biodiversity knowledge, the emergence of critical thinking in current biology education*, summarizes the results of the content analysis, which attempts to answer the above question. It focuses primarily on the updated content that appeared in the curriculum guidelines most frequently used in grades 10, 11, and 12 in high schools in 2018, concerning the colorful topics of species and biological diversity. The analysis aims to determine what knowledge can currently be considered modern in terms of species diversity based on the research and mentions the required knowledge of species composition prescribed by the curriculum guidelines, exploring the results, which enable the effective implementation of environmental education in the 21st century. (Nagy, 2018)

Currently, global education, the concept of global responsibility education, or global citizenship, is also considered modern knowledge. It aims to represent the relationship between sustainability education and global responsibility. It represents a perspective that arises from the fact that today's people live and act in an increasingly globalized world. Global education forms a global perspective, allowing students to approach their living conditions and problems holistically in the context of the world. (Marcus, Schulze-Vogel & Schulze, 1995) This concept is essential and closely related to the themes of species diversity and biodiversity. Unfortunately, this concept cannot be found in any of the examined curriculum documents. The reason for this is explained as follows: The Ministry of Foreign Affairs and Trade, in cooperation with the Ministry of Human Resources, developed the concept of introducing global education and NEFE knowledge into formal and non-formal education in Hungary. It was published under the title "Global Responsibility Education in Formal and Non-Formal Education in Hungary" in Government Decree 1784/2016. Despite the fact that elements of global education are already functioning in educational systems and the National Public Education Strategy, as well as the current National Basic Curriculum, provide numerous opportunities for it, there is no systematic and comprehensive interpretation of applying global education. As of 2017, it cannot rely solely on the knowledge provided by traditional subjects without a global perspective, understanding connections, critical thinking, and active participation. (United Nations Educational, Scientific and Cultural Organization, 2017) (Nagy, 2018)

A fundamental deficiency in addition to all of these, and in connection with them, is that the curriculum guidelines prescribed in high schools leave only a very minimal time frame for biodiversity and even less so for species diversity. This is usually limited to the last few hours of the mandatory 72-hour total annual class time. However, the teaching of biology should begin with this, and all classes should be held much more consciously by starting with this knowledge and continuously referring to it. (Nagy, 2018)

The Curriculum is an intermediate regulatory framework between the local curricula, adjusted curricula, and the National Basic Curriculum. The curriculum guidelines for each educational stage (2-year cycles) and school types specify the knowledge to be acquired and the output requirements for each 2-year learning cycle (Réti, 2015), thus their content is extremely crucial.

I conducted a summary of previous curriculum guidelines in 2018 (Nagy, 2018). For secondary education, the Education Research and Development Institute made the curriculum guidelines approved and issued by the Minister of Human Resources available on the curriculum.ofi.hu website. In the list of detailed descriptions, there are mentions of ”*biodiversity”*, ”*species diversity”*, ”*individual diversity”*, ”*species richness”*, ”*diversity”*, ”*biological diversity”*, ”*species lists”*, and the concept of ”*biological species”*. The consolidated curriculum guidelines provided in the table address the specified topics. I searched for synonymous expressions in the curriculum guidelines. I reviewed 12 synonymous expressions marked in the table in the following 8 curriculum guidelines:

1. Curriculum Framework for Grades 9-12 in High Schools, Version A
2. Curriculum Framework for Grades 9-12 in High Schools, Version B
3. Curriculum Framework for Grades 9-12 in Vocational High Schools
4. Natural Science Curriculum Framework for Art Vocational Secondary Schools
5. Curriculum Framework for Grades 9-13 in Vocational Secondary Schools

6. Curriculum Framework for Bilingual High Schools' Target Language Civilization Subject Instruction
7. Curriculum Framework for Bilingual High School Target Language Instruction
8. Natural Science Curriculum Framework for Art Vocational Secondary Schools

As a result of the analysis, it can be concluded that out of the curriculum guidelines, only the first 4 specifically addressed the searched synonymous concepts, and the curriculum guidelines prescribed for vocational high schools relatively extensively included the sought-after expressions. (Nagy, 2018)

Furthermore, it is particularly noteworthy that in the curriculum guidelines prescribed for regular high schools, there is no mention of the concept of "*species diversity*" or "*species variety*." However, typically, the majority of students participate in this type of education.

There is also a remarkable difference between the content of the natural science curriculum guidelines and the occurrences related to the curriculum for regular high schools. Throughout the entire document, "*biological diversity*" is emphasized 3 times, "*diversity*" once, and "*genetic diversity*" is also highlighted once. Additionally, terms like "*species richness*," "*individual richness*," " *species diversity*," "*individual diversity*," and " *species variety*" are not mentioned at all. However, especially in the curriculum of natural science, these concepts should be interwoven completely, if we want to achieve lasting results in implementing sustainability education. (Nagy, 2018)

Through a more detailed search as part of testing Hypothesis 3, compared to the 2012 National Basic Curriculum (Nat2012), I similarly examined the recommendations and content of the 2020 National Basic Curriculum for high schools, using the method of keyword search for synonymous terms related to species diversity and biodiversity. This was done for 7 different types of content regulations aligning with the 2020

National Basic Curriculum and within these, a total of 13 different (10 Hungarian and 3 Roma) curriculum guidelines:

1. Curriculum for high schools grades 9–12
    a. Biology 9–10
    b. Natural Science 11
2. Curriculum for high schools grades 7–12
3. Biology 7–10Curricula for vocational education
    a. Natural Science

4. Curricula for specific school types, educational stage, subject, or fulfilling special public education tasks
    b. Arany János Talent Development Program curriculum
    c. Sports School grades 9–12 curriculum
    d. Arany János College Program 9/AJKP grade
        i. Natural Science - Natural Science 9/AJKP grade
    e. Basic knowledge of natural science (1 hour/week), 9th grade

5. Curricula for specific school types, educational stage, subject, or fulfilling special public education tasks
    a. Natural Science curriculum for artistic vocational high schools grades 9–12
    b. Sustainability (9th or 10th grade)
    c. Sustainability (11th–12th grade)

6. Curricula for national minority education
    a. Curriculum for Roma minority education
    b. Curriculum for Beás minority education
    c. Curriculum for Romani minority education

Out of the highlighted curriculum guidelines, the following contained examples of the designated expressions and frequently used terms for each type. I expanded these terms with "*taxon diversity*," "*invasive species*," "*species conservation*," "*species conservation program*," "*plant species*," or "*animal species*" as supplementary terms in comparison to Nat2012:

When comparing the research on the 2012 National Basic Curriculum (Nat2012) and the 2020 National Basic Curriculum, the following comparisons can be made:

Among the Nat2020 curriculum guidelines, 9 curricula contained examples of at least one expression. I was surprised to find that the term "*plant species*" was only present in 1 curriculum, and there were quite a few references to animal species (a total of 19 in 9 curricula). There were slightly more mentions of biodiversity and biological diversity in the Nat2020 curriculum compared to Nat2012. However, the term " *species diversity*" was found in only 1 curriculum, and diversity, species list, and species conservation program appeared only twice each. The term "*invasive species*" was found in 9 cases, and the term "*species*" appeared relatively frequently, a total of 158 times.

Thesis 3

After reviewing the content elements of the 13 types of curriculum guidelines in relation to the new National Basic Curriculum (Nat2020), compared to the previous National Basic Curriculum (Nat2012), the following facts can be observed: While the curriculum guidelines related to the new Nat2020 declare the importance of species protection with a significantly higher number of occurrences of the term "*species*," the curriculum guidelines appearing in the new National Basic Curriculum (NAT2020) do not proportionally include the prescribed content elements related to biodiversity or species diversity compared to the previous curriculum guidelines. Therefore, based on this, the hypothesis is not supported, and the null hypothesis can be accepted.

Hypothesis and Thesis 4

Hypothesis 4. The current content of textbooks (prescribed and available high school textbooks) adequately supports the development of the main competencies aimed at preserving, increasing, and evaluating biological diversity, specifically species diversity, within it.

To test this hypothesis, I examined the content of textbooks for previous years in the context of the old National Basic Curriculum (Nat2012) and the new National Basic Curriculum (Nat2020) for the year 2022. All the textbooks I tested were widely used and mandatory publications, both before and after 2020.

Based on my research, it can be stated that despite the need to emphasize the threat of decreasing species diversity and biodiversity in individual subjects or in certain specialized textbooks, there is relatively little information, particularly about the importance of species diversity and biodiversity, in the curriculum and textbooks based on the 2020 National Basic Curriculum.

Similarly, there is limited information about different species. I examined textbooks for 10th, 11th, and 12th grades to see which plant species were mentioned and whether they were native or invasive species. I also documented their value (protected, taxonomical example, wild, relict species, glacial relict, toxic, cultivated, or edible wild):

In the textbooks based on Nat2012, the number of mentioned plant species is quite small, and in many cases, there is little or very rare information related to plant species knowledge, descriptions, and images.

Analogously, I examined the content of the most popular textbooks based on Nat2020, this time regarding both plant and animal species. I documented how the term "*species*" was represented in Latin or Hungarian in the textbooks. Here's what I found:

In the Nat2020 9th-grade textbook, there are significantly fewer mentioned plant species. However, when a species is mentioned, it is always accompanied by a picture. Nonetheless, there is hardly any explanation provided for each species.

In the "Biology 10" (Nat2020) textbook, 81 plant species and 67 animal species are mentioned, often accompanied by brief descriptions, making the publication quite valuable. However, many textbooks in circulation include only a fraction of these species, and teachers often choose these textbooks due to time constraints. It would be useful if the use of a

specific textbook was uniformly mandated. In terms of species description, this publication is the most detailed so far.

For the 11th grade, there is no recommended e-textbook on the nkp.hu website. Therefore, I examined the "Biology module 11" textbook.

After analyzing it, it is clear that there are significantly fewer plant species than animal species, similar to other 11th-grade textbooks.

Continuing the content analysis, within the framework of a significant project (*EFOP-3.6.2-16-2017-00014 "Creating an International Research Environment for the Study of Light Pollution*"), I also examined the content of textbooks from another aspect: whether they address light pollution issues and the presence of nocturnal animal species. I summarized the results in an EKKE publication (Annexes: Annex 3) and presented them in detail in a poster presentation at the 2021 ALAN Conference through our Eco-School activities (Annexes: Annex 6). In one of the most commonly used textbooks (Dr. Gábor Lénárd, Biology 10. (OFI) Research Institute for Education, 2019), the number of mentioned nocturnal animals is quite large (out of the 79 species mentioned in the textbook, 70 are nocturnal). However, while the aspects of species are mostly in line with the 10th-grade curriculum requirements, there is no mention of light pollution. In the other textbooks I examined for 9th, 10th, 11th, and 12th grades, there was no reference to light pollution or nocturnal animal species either.

Thesis 4

After reviewing the collected data, comparing the number of plant and animal species and their attributes in previous and current textbooks, the inclusion of these aspects in the curriculum, with the exception of the Nat2020 10th-grade textbook content, which saw a slight increase in mentioned plant and animal species, there is no significant change. The current content of textbooks (prescribed and available high school textbooks) often still only moderately supports the development of the main competencies aimed at preserving, increasing, and evaluating biological

diversity, including species diversity. Therefore, the hypothesis is not supported, and the null hypothesis is confirmed.

Hypothesis and Thesis 5

Hypothesis 5. In the teaching practice of Hungarian educational institutions (primarily high schools), a more consciously designed and innovative methodological structure promoting the accurate understanding of biodiversity and species diversity is becoming increasingly evident in the work of educators.

To test this hypothesis, I attempted to explore the current role of biodiversity and species diversity in environmental education and the work of Hungarian educators through three online surveys. I managed to reach a total of **839 educators** in Hungary who teach **natural sciences**, including biology. First, I conducted a 30-question survey (*Developing Outdoor Education*) with **800 Hungarian biology teachers** in 2017. Then, I used a similar 46-question online survey (*Bisel Stream Examination - Questionnaire Summarizing PEDAGOGIC Experiences*) to question **14 educators** who participated in the Bisel competition in 2022. Finally, in December 2022, I administered a newly compiled 42-question online survey (*Questionnaire Summarizing the Experiences of Biology Teachers Teaching Biodiversity and Species Diversity in High Schools*) to **226 school principals**. Unfortunately, in the latter survey, I encountered the fact that some school principals responded that they could not complete the survey as there were no biology teachers currently in their institutions. However, **25 educators** returned their responses, and there was considerable feedback indicating gratitude for being consulted.

I also conducted a Chi-square test to determine if the presence of schoolyards in high school institutions with the 800 surveyed teachers influenced whether outdoor classes were held there. **The probability of the Chi-square test** was **0.5676473656**, and the probability after **Yates' correction** was **0.8151939962** (Calculations Annex: Calculation 1), indicating no correlation between the two variables (the null hypothesis was accepted). Therefore, whether a teacher teaches in a high school does not

influence whether they hold classes outdoors. Similarly, whether a teacher holds classes outdoors does not depend on whether they teach in a high school or not.

Thesis 5

After summarizing the results of the three surveys, I concluded that, unfortunately, a more consciously designed and innovative methodological structure promoting the accurate understanding of biodiversity and species diversity is not yet increasingly evident in the teaching practice of Hungarian educational (high school) institutions. The integration of animal and plant species in the curriculum does not meet the essential and necessary knowledge acquisition needs, and it does not utilize the opportunities available to educators. In many cases, possibilities are mentioned (e.g., having a schoolyard), but they are not fully utilized due to lack of requirement or limited class time. In light of these findings, I was able to confirm the null hypothesis.

Hypothesis and Thesis 6

Hypothesis 6. A subtopic related to biodiversity and species diversity is not sufficiently known among present-day high school students.

To thoroughly investigate this hypothesis, I first administered a test ("*Biodiversity - Species Diversity 2. Test Your Knowledge!*") to high school students (9th, 11th, and 12th grades) using the gamification method and the Quizizz online polling system. Students accessed the test on the joinmyquiz.com website by entering a code generated by me each time a game started. The test could be taken immediately, primarily on mobile phones, as well as laptops. The species knowledge assessment test comprised 42 questions, each with 4 answer options, of which only one was correct. Additionally, in the event of an incorrect answer, the correct answer was briefly displayed along with an explanatory note for educational purposes. I supplemented the test with examples of the most endangered species, each accompanied by photos. A total of **105 students** learning according to the

new National Curriculum **(Nat2020)** and **97 students** learning according to the old National Curriculum **(Nat2012)** completed the test.

The test content measures up-to-date knowledge of biodiversity and species diversity by summarizing relevant questions from various institutions and organizations, using the Quizizz program's evaluation mechanism. I expressed their knowledge level in terms of high school graduation percentages, which the program automatically displayed at the end of the task. However, I emphasized that they would not receive grades for this, except if they scored above 80%, in which case I recommended a top score of 5. The utilized tests and resources were as follows:

1. A downloadable publication popularized by the Jane Goodall Institute, "*Material for Incorporating Fair Trade into Public Education*," published by the Védegylet in 2016.
2. The list of most endangered species: "About Our Environment for European Youth"
3. The Earth Day Foundation website
4. Living Planet Report 2022

I initiated new tests for each class, with the same content, and administered the survey in a total of 7 classes. For absent students, I later administered the test. Out of the 7 selected classes, 4 were taught according to the new National Curriculum (Nat2020), while the remaining 3 were taught according to the old National Curriculum (Nat2012). I categorized and analyzed the results based on their National Curriculum version, and I also marked the number of Roma students.

Regarding the knowledge level achieved in the biodiversity - species diversity topic, the 3 complete classes (a total of **97 students**, including **4 Roma students**) taught according to the old National Curriculum (Nat2012) obtained the following results on the pre-test.

The 4 complete classes (a total of **105 students**, including **4 Roma students**) taught according to the new National Curriculum (Nat2020) achieved the following knowledge level on the pre-test.

In both cases (Nat2012 and Nat2020 students), the class with the lowest percentage achieving was the one with Roma students, while the highest percentage of correct answers was given by classes of bilingual (English-Hungarian) education on the 9th and 12th grade levels, and in the 12th grades, according to the displayed program the class value was naturally higher than, the so-called *Accuracy* value, i.e., the value of Correctness as compared to the 9th grades.

Furthermore, I examined the results question by question, focusing on the pre-test questions closely related to biodiversity or species diversity topics. Specifically, I analyzed questions 2, 3, 7, 8, 10, 11, 13, 14, 15, 18, 21, 26, 35, 36, 37, 38, 39, 40, 41, and 42. I obtained the following results for Nat2012 and Nat2020 classes, highlighting which classes answered these questions with the highest and lowest percentages:

In the case of the human class, there were 4 instances, the mathematics-economics class had 6 instances, and the bilingual class had 12 instances where the listed questions 2, 3, 7, 8, 10, 11, 13, 14, 15, 18, 21, 26, 35, 36, 37, 38, 39, 40, 41, or 42 were answered with the highest percentage. Conversely, the humanities class answered in 11 instances, the mathematics-economics class in 7 instances, and the bilingual class in 4 instances the aforementioned questions 2, 3, 7, 8, 10, 11, 13, 14, 15, 18, 21, 26, 35, 36, 37, 38, 39, 40, 41, or 42 with the lowest percentage. In 5 cases, a perfect score of 100% was achieved, with the respective classes achieving this result 1, 2, and 3 times in order, while performance below 50% occurred a total of 4 times, with 2 occurrences in each class as listed above. In all three classes, the listed questions yielded results above 80% (indicating an excellent performance): Question 8: How many species do you believe we distinguish on Earth? Question 13: Why is the preservation of biodiversity and species diversity important? Question 15: Do you think the extinction of species threatens the existence of humanity? Question 18: In your opinion, what primarily threatens species today? Question 26: How does the environmental pollution of industrialized countries and the deforestation of developing countries affect animal and plant species? Question 36: Do you believe you can contribute to solving the decrease in species diversity and biodiversity through your everyday actions? Question 37: Which endangered mammal

species do you observe in the picture? Each of these questions achieved a performance above 80%, which is indicative of excellent results in this context.

In two cases, the Ajtp class, in six cases, the Preparatory class, in six cases, the Bilingual class, and finally, in seven cases, the Humanities class answered the listed questions 2, 3, 7, 8, 10, 11, 13, 14, 15, 18, 21, 26, 35, 36, 37, 38, 39, 40, 41, or 42 with the highest percentage. Conversely, the Ajtp class answered in twelve cases, the Preparatory class in four cases, the Bilingual class in three cases, and the Humanities class in two cases the aforementioned questions 2, 3, 7, 8, 10, 11, 13, 14, 15, 18, 21, 26, 35, 36, 37, 38, 39, 40, 41, or 42 with the lowest percentage. No cases achieved a perfect score of 100%, and performance below 50% occurred a total of 24 times, with 9, 6, 4, and 5 occurrences per class in the aforementioned order. All four classes, without exception, achieved results above 80% (which is indicative of excellent results in the school leaving exam) on the following questions: Question 13: Why is the preservation of biodiversity and species diversity important? Question 15: Do you believe that the extinction of species threatens humanity's existence? Question 18: In your opinion, what primarily threatens species today? Question 37: Which endangered mammal species do you see in the picture?

Additionally, I tested the reliability of the test. The calculated **Cronbach's alpha value** was **0.929649** (Calculation Annex: Calculation 2), which is quite close to 1, indicating that the test is reliable and measures what it was originally designed to measure.

Furthermore, in order to validate Hypothesis 6, I summarized the responses provided by all participants to the relevant questions.

Thesis 6

Based on the investigation, it can be concluded that the surveyed **494 high school students** are quite knowledgeable about species diversity and biodiversity topics but lack adequate knowledge on certain current issues (I expected more results above 80% for species recognition). The rounded

values are based on the high school grading system, not mathematical rounding. However, it is evident that the students are quite receptive to the gamification testing method and show interest in learning precise content. Therefore, I was able to confirm the null hypothesis.

Hypothesis and Thesis 7

Hypothesis 7. A subtopic related to biodiversity and species diversity education does not play a significant role in environmental education and shaping the environmental attitudes of young high school students, both inside and outside the school context.

Expanding on the questionnaire-based measurement that supported Hypothesis 6, I conducted a more comprehensive study to investigate how outdoor and indoor biodiversity-themed classes and events influenced the further development of students' knowledge and attitudes.

To explore this, I organized **56** different classes in the selected 7 **classes**, followed by post-tests using the quiz *("Biodiversity - Species Diversity 2. Test Your Knowledge!"*) as described in Hypothesis 6. I began by holding thematic classes in all **7 classes**:

1. Introducing invasive species through live animal presentations (e.g., red-eared slider turtle) in all 7 classes.
2. Studying aquatic animals and riparian vegetation along the newly formed Eger Creek beaver dam and recently planted vegetation using magnifiers and phone apps (Google Lens, Plant Net) to identify plant species in all 7 classes.
3. Discussing the 33rd curriculum of Nat2020 Biology about biological diversity, taxon diversity, and changes in species number with interactive tasks in all 7 classes.
4. Participating in the European Week for Waste Reduction, including attending a sustainability-themed presentation that discussed the importance of biodiversity, sustainability, and students' contributions to preserving species.

5. Conducting a practical exercise analyzing "human spittle" based on the "owl pellet" exercise presented at the Humusz Association training in all 7 classes.
6. Viewing and discussing a video recording of Dr. Jane Goodall's lecture at a chimpanzee researcher island festival, exploring concepts related to the global ecosystem, biodiversity, and altruism.
7. Discussing the significance of the Jane Goodall "Pass It On Sis" program, emphasizing mobile phone recycling, the importance of protecting animal habitats, especially gorillas, and introducing the informative video created for Hungarian youths.
8. Bird feeding, cleaning birdhouses, setting up water bowls for tits, learning about bird species, and allowing students to care for animals with the assistance of the Hungarian Ornithological and Nature Conservation Society (MME) experts.

After the 8 different classes, with the same students, I administered the test again *("Biodiversity – Species Diversity 2. Test Your Knowledge!")* with a modification, as it was officially announced that there are 8 billion people on Earth, and I adjusted the test accordingly. Both the pre-test and post-test are available in the annexes of the dissertation.

Furthermore, I extracted the questions most closely related to species diversity and biodiversity from the tests (questions 2, 3, 7, 8, 10, 11, 13, 14, 15, 18, 21, 26, 35, 36, 37, 38, 39, 40, 41, and 42) and examined which class answered these questions correctly and in what percentage. I summarized these results in the tables for both the pre-test and post-test cases.

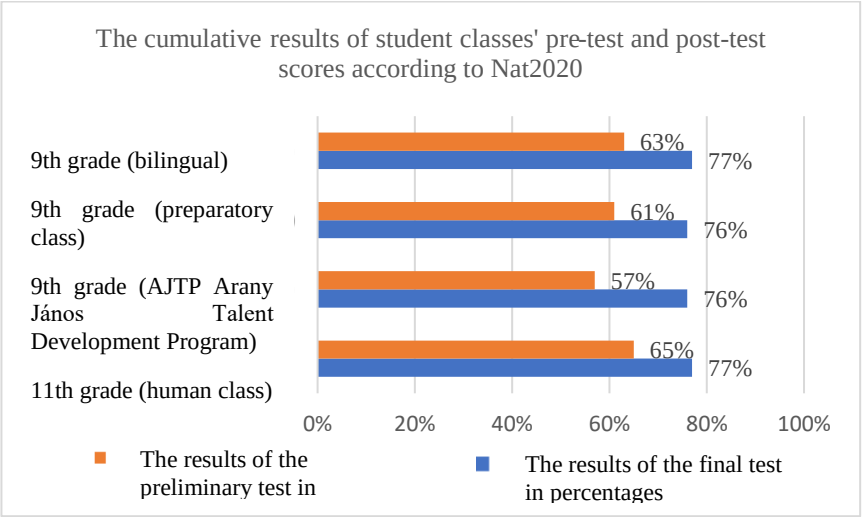

Figure 3. Cumulative results of student classes' pre-test and post-test scores according to Nat2020

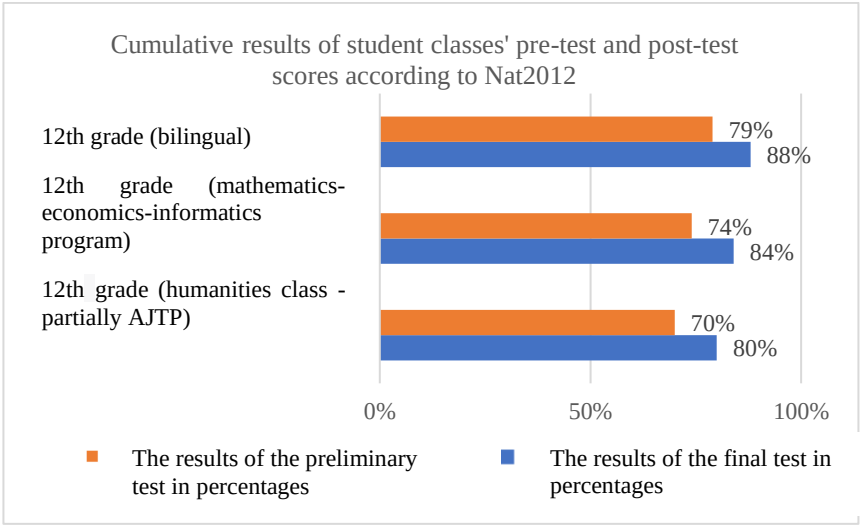

Figure 4. Cumulative results of student classes' pre-test and post-test scores according to Nat2012

For the further testing of Hypothesis 7, following the school programs described earlier in the chapter, I administered online forms tests to students. These tests used a 5-point attitude scale for evaluation and were related to programs such as:

1. The BISEL competition
2. The Bird-friendly School program
3. The Botanic Garden open day biodiversity program

Lastly, I performed an **F-test** after considering a significance level of 95% and then conducted **two-sample T-tests**. First, I performed the T-test on the entire student sample (all 7 classes), and then separately for Nat2012 (3 classes) and Nat2020 (4 classes) students, comparing their pre-test and post-test percentage results. The results of the T-test were significantly smaller than the alpha value of 0.05 for all cases (*Calculations Annex: Calculation 3*) for the entire sample, (*Calculations Annex: Calculation 4*) for Nat2012 students, (*Calculations Annex: Calculation 5*) for Nat2020 students. Therefore, the null hypothesis, suggesting that the method is not effective, can be rejected.

Based on the obtained results and test evaluations, I reached the following conclusion:

Thesis 7

According to my investigations, a subtopic related to biodiversity and species diversity education plays a significant role in environmental education and shaping the environmental attitudes of young people, both inside and outside the school context. Furthermore, there is great interest in implementing the practices conducted during this research. Therefore, I have confirmed the null hypothesis.

Hypothesis and Thesis 8

Hypothesis 8: The current environmental education curriculum does not sufficiently integrate knowledge related to current events and everyday occurrences that are relevant to high school students.

To test this hypothesis, I examined the content elements of the current (2022) central and advanced level written and oral high school graduation requirements based on *the Detailed Examination Requirements*. The results of this analysis are presented in Section *3.7.2 "Content Elements of the 2021 Central and Advanced Level Graduation Requirements related to Species Diversity and Biodiversity*."

In the mentioned section, I conducted a qualitative content analysis to investigate to what extent the biology graduation requirements for high school students incorporate content elements related to biodiversity and species diversity.

Throughout my analysis, I focused on keywords such as "*biodiversity*" and "*species diversity*", as well as any similar terms with related meanings, such as "*species variety*", "*species variability*", and broader themes like "*biological diversity*", "*biological variety*", or "*biological variability"*. I also identified in which specific sections these terms were found.

Thesis 8

Based on my findings, I concluded that one of the most crucial topics – biodiversity, specifically special diversity, which poses the greatest threat and risk to the human species and represents a significant danger if degraded – is underrepresented in the current high school curriculum. The emphasis on this topic is notably limited in both quantity and importance in the curriculum. Consequently, I have confirmed this hypothesis.

3. Conclusions

Section 3 summarizes the conducted research and its most important results in detail.

Biodiversity, particularly species diversity, forms the foundation of our existence. When it's threatened, we fervently seek out causes and explore all possible avenues of restoration. However, foremost, we must understand – and as educators, we must impart – that if, for instance, we lose bees that pollinate our plants, and possibly even the trees, our own survival is at risk. In other words, without essential ecosystem services, we cannot breathe or nourish ourselves. What could be more imperative than this? Thus, I structured my research around a topic profoundly influential for the human species and every plant and animal species alike, encompassing habitats and even genes, manifesting at levels both individual and collective.

Throughout my research, I aimed to examine the current role and status of biodiversity and species diversity in environmental education from every possible angle and to comprehensively synthesize the findings.

In my dissertation, I delved into the accepted conceptual frameworks for species diversity and biodiversity, their occurrences, key milestones in their development, their roles in the Convention on Biological Diversity and the National Biodiversity Strategy, as well as their inclusion in essential documents in Hungary (such as the National Core Curriculum of 2012 and 2020) and the content of current textbooks. Additionally, I explored the educational possibilities both within and outside the classroom for high school (grades 9-12) groups, implementing various forms of these possibilities, measuring their effects, and distilling lessons from these experiences to either confirm or refute my hypotheses.

During my research, I assessed the experiences of students and educators related to species diversity and biodiversity. I scrutinized the content of numerous mandatory **textbooks** (**48**), conducted focused species diversity and biodiversity-oriented lessons (**56 lessons**) with my groups, and distributed online questionnaires to **students** (**629 questionnaires**), **school principals** (**261 questionnaires**), educators (**839 questionnaires**), participants of the **Bisel competition through the Ministry of Agriculture**

(**265 questionnaires**), and conducted interviews (**32 interviews**), predominantly over the phone due to the COVID situation, and thoroughly analyzed the gathered data.

Based on my research, it can be concluded that the establishment of "*environmentally responsible citizenship behavior, attitude formation*" as formulated in the National Biodiversity Strategy (2015-2020) and the Convention on Biological Diversity (1992, 2020 resolutions) is realized to a certain extent in the new National Core Curriculum (Nat2020) concerning biodiversity and species diversity, albeit somewhat more intensively. However, it still remains relatively limited in the context of school education (Hypothesis 1). Unfortunately, it cannot be established that the new revised National Core Curriculum (NAT2020) and its related framework curricula provide greater support for the development of competencies related to biodiversity and species diversity compared to the previous curriculum (NAT2012). In fact, the scientific and technical competency entirely disappears from the array of competencies in NAT2020, as do changes in fields of study, now categorized as learning areas (Hypothesis 2). Although the prescribed requirements related to species diversity appear more frequently in the new framework curriculum associated with the new National Core Curriculum (NAT2020), indicating a possibly increased emphasis on species protection, the required content elements related to biodiversity or species diversity do not appear more significantly in NAT2020's framework curriculum compared to the previous one (Hypothesis 3). The current curriculum content (mandatory and available high school textbooks) often still fails to adequately support the development of the key competency for the preservation, enhancement, and evaluation of biological diversity (Hypothesis 4). Within the teaching practice of Hungarian public education (primarily high schools), among educators, a methodological structure that progressively fosters a precise understanding of biodiversity and species diversity still doesn't emerge in a more conscious manner. Neither the inclusion of animal species nor plant species content follows the necessary requirements for acquiring essential knowledge, and it doesn't leverage the opportunities available to educators. In many cases, opportunities (e.g., having a schoolyard) are available, yet remain unutilized either due to lack of requirement or insufficient class hours for

implementation. I also conducted a Chi-square test, which investigated whether the presence of a schoolyard in the institutions affects the incorporation of outdoor lessons. **The Chi-square test probability: 0.5676473656, Yates correction probability: 0.8151939962**, indicating that no correlation exists between the two variables (the null hypothesis is accepted) (Hypothesis 5). The surveyed 494 high school students are periodically well-informed about topics related to species diversity and biodiversity, but are insufficiently informed about certain current issues (I expected more results above 80% correctness in species identification). However, it is clear that they are open to gamification-based testing methods, and they value precise content acquisition. The surveyed students are open-minded and inquisitive, and as a supplementary measure, I tested the reliability of the test. The calculated **Cronbach's alpha** value for the pre-test is **0.929649**, which is quite close to 1, indicating that the test is reliable and measures what I initially intended it to measure (Hypothesis 6). Based on my research, it is evident that the education of biodiversity and species diversity, despite my initial assumption, plays a significant role in shaping the environmental attitudes and perspectives of young individuals both within and outside the school environment. This is substantiated by conducting a **two-sample T-test** on 7 classes, as well as separately for students following the NAT2012 (3 classes) and NAT2020 (4 classes) curriculum, assessing their percentage results before and after the pre-test, and taking into account a 95% significance level, after the **F-test**. The results of the two-sample T-test, as well as the results for students following the NAT2012 and NAT2020 curriculum, are significantly lower than the alpha value of 0.05. Therefore, the null hypothesis that the method is ineffective can be rejected (Hypothesis 7). Despite being crucial and coupled with the highest threat level and representing the greatest danger when degraded – the topic of biodiversity, particularly species diversity – it remains scarcely emphasized within the requirements of the present-day curriculum (Hypothesis 8).

Based on the content provided, it can be concluded that the education of species diversity and biodiversity requires careful consideration in the present day, but it is still salvageable. Opportunities that can lead to success and progress are accessible, including engaged students, tangible points of interest, innovative methodological structures, acceptance of digitization,

gamification, and, notably, the experiential value of the natural world's proximity and relevance.

In accordance with the National Core Curriculum, novel textbooks, smart textbooks, and online practice opportunities have been introduced. Within high schools, various topics can be associated with experiences (transformative learning), aiding in the easier acquisition of knowledge. This holds true even for students who, for various reasons, may be at a disadvantageous or severely disadvantaged position, often including Roma students. Such knowledge is essential for the preservation of our environment and thereby the human species. Furthermore, programs allow members of the younger generation to "*individually venture into nature*," as emphasized by Nikoletta Keszthelyi, Deputy State Secretary responsible for environmental protection, during the award ceremony of the Bisel Stream Assessment and Species Recognition competition held in 2022. Our team, the Water SpiderWonder Spiders, achieved national 1st place for the second year in a row.

Human existence is not possible without species diversity. The more aspects we consider regarding species diversity, the more comprehensive knowledge students gain about their immediate environment, plant and animal species. However, until diversity in biology is only sporadically covered in the curriculum or remains absent (e.g., the adverse effects of artificial light on living beings), significant progress cannot be achieved. (Skribanek, 2021)

The same unfortunate situation applies to plant species. The results of a project titled *EFOP-3.6.2-16-2017-00014 "Establishing an International Research Environment for the Study of Light Pollution Effects on Biodiversity,"* which investigates the effects of light pollution on the living world, also confirm that people do not properly recognize representatives of animal and plant life in relation to the effects of light pollution on species, even though we could protect these values that still exist in our environment through simple methods and learned behaviors. This theme is insufficiently integrated into the curriculum. (Nagy, 2021) "*Since environmental education cannot be implemented without digitization*"

(Lükő, 2020), the use of digital teaching tools and the introduction of transformative learning methods may be effective.

What is most necessary for both us and the rising generation now is for species and biological diversity, the preservation of flora and fauna values, to be much more intensively embedded in the curriculum. Only in this way can we contribute to the survival of natural vegetation and wildlife, thus protecting the health of the natural capital. The further decline of ecosystem services will be humanity's downfall. It depends on our students what they understand from all of this, and it is up to us to equip them with knowledge through appropriate means. Perhaps through our efforts and their perspectives, a more livable future will be fulfilled.

4. Utilization of Results

In contemporary times, the necessity to assess the richness of our natural environment, namely the biological diversity surrounding us, as well as the role of educational-based awareness-building focused on understanding species diversity within biodiversity, has been increasingly evident.

The global decline of biodiversity, specifically within species diversity, is far more severe today than in previous times (Rockström, 2009) (Steffen, 2015). The underlying reasons for this trend are illuminated by a recent study (Persson et al., 2022) that quantifies Earth's new boundaries of tolerance. Depicting the biosphere as a newly updated radar graph in the form of a threatening ring, it highlights the factors severely endangering life, including our material consumption – primarily plastic, chemicals, and pharmaceuticals entering the environment. This, coupled with previous climate change and poor land use practices, results in unprecedented biodiversity loss, standing among the nine planetary boundaries essential for maintaining the biosphere's integrity. (Dr. Tóth, 2022)

My conclusions concerning further development are grounded in the necessity to take continual strides, preferably in highlighted environmental areas where human activities already surpass certain thresholds or "*tipping points*." This is to prevent potential irreparable changes in the biosphere, ensuring the stable conditions characteristic of the Holocene epoch for future generations.

Increasingly, individuals with a new type of environmentally conscious attitude – both societally and individually up-to-date – are emerging. As I presented, numerous endeavors are underway to enable a broader range of today's high school students to navigate these topics. Yet, a well-developed, unified methodology is not currently available.

The current National Core Curriculum (Nat2020), the framework curricula, and the two-level biology graduation exams do not comprehensively address the issue of biodiversity in alignment with scientific expectations (National Biodiversity Strategy, Biological Diversity Convention). Thus, further developments and testing in this direction remain

justified. The same applies to certain currently used textbooks. In curriculum development work, a focus on consistency and building on experiential, investigative, and active learning processes in the natural environment is necessary. Learning about living beings through direct presence in nature should not be replaced by any other method. Knowledge of biological diversity at a given place and time, as well as monitoring its condition (e.g., population size, species diversity), enables the identification of significant or endangered natural values (populations, communities, habitats). It also facilitates understanding the processes affecting their maintenance or decline, examining the accuracy of our assumptions regarding these processes, and, last but not least, verifying the effectiveness of measures taken for their protection. (Standovár et al., 2001) Nothing provides a greater platform for this than the Bisel investigation or active and continuous participation in the Eco-School project, including addressing the education of Roma students.

Among parametric analyses, the application of the one-sample t-test could be useful in a future study to measure how selected groups of high school students perform in nature-related surveys, compared to the national digital scientific competency results of Hungarian high school students. This presupposes that the tasks of the test sets become accessible in some form or measure.

The development of a methodological guide is also warranted to effectively support the development of scientific thinking. In today's world, students are less informed about the practical benefits of living beings, why the survival of the human species is essential, as there are few references comprehensively collected in compulsory textbooks. Currently, there is no up-to-date, universally accepted, easily accessible, comprehensive digital guide available to deepen the actual knowledge of scientific thinking and encourage modern, stimulating, experiential-based learning.

Interpreting biodiversity and species diversity accurately and up-to-date in education can effectively enhance and strengthen current species diversity. This can be achieved by integrating the appropriate amount of content into all regulatory documents, educational materials for high school, and prescribed textbooks. This will encompass the richness of species and

all related aspects, as well as provide students with much more frequent opportunities for field learning. Moreover, constructive pedagogy and preparedness for experiential learning methods among perspective-altering educators require sufficient time and space for preparation, alongside opportunities presented by digitalization. It is through these avenues that the path leads toward the rising generations.

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6. Publications and Conference Presentations on the Dissertation Topic

Éva, Nagy (2021): Impact of light pollution on biodiversity: Challenges for education (Poster presentation) In: *ALAN 2021* 169 p. pp. 54-55., 2 p. Közlemény:33103172 konferenciaközlemény

Nagy, Éva (2021): A biodiverzitás, azon belül a faji diverzitás, fény tematikához kötődő tudáselemeinek vizsgálata, aktuális tananyagtartalmi aspektusai a jelen biológia oktatásban In: Skribanek, Anna (szerk.) *Fényszennyezés kutatási eredményei*: Tudomány Heti Konferencia Program és összefoglalók Szombathely, Magyarország: ELTE Berzsenyi Dániel Pedagógusképző Központ pp. 9-9., 1 p. Közlemény:33098076 Könyvrészlet Tudományos

Nagy, Éva (2021): A biodiverzitás, azon belül a faji diverzitás, fény tematikához kötődő tudáselemeinek vizsgálata, aktuális tananyagtartalmi aspektusai a jelen biológia oktatásban. Paper: ISBN 978-963-489-403-2 Megjelenés: Magyarország, Közlemény:33097931 Nyilvános Forrás Egyéb (Kutatási jelentés (közzétett)

Éva, Nagy (2021): Impact of Light Pollution on Biodiversity - Challenges for Education: Biodiversity knowledge elements in Biology education: Nocturnal Animals in Hungarian Education: Biodiversity knowledge elements in Biology education: Nocturnal Animals in Hungarian Education Közlemény:32470677 Nyilvános Forrás Poster presentation

Nagy, Éva (2020): A biológiai sokféleség iskolai oktatásának összehasonlító elemzése In: Mika, János; Pajtókné, Tari Ilona (szerk.) *Környezeti nevelés és tudatformálás II* Eger, Magyarország: Líceum Kiadó (2020) Paper: N11, 10 p. Közlemény:30900124 Könyvrészlet (Szaktanulmány) Tudományos

Nagy, Éva Some (2020): Aspects of Teaching Species Diversity in and out of schools in Hungary *JOURNAL OF APPLIED TECHNICAL AND EDUCATIONAL SCIENCES / ALKALMAZOTT MŰSZAKI ÉS PEDAGÓGIAI TUDOMÁNYOS FOLYÓIRAT* 10: 2 pp. 41-60., 20 p. DOI Teljes dokumentum Közlemény:31341879 Folyóiratcikk (Szakcikk) Tudományos

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Erika, Pénzesné Kónya; Éva, Nagy; Jana, Táborská (2019): Educational programs for making trees more attractive Megjelenés: Olaszország, Közlemény:30894287 Nyilvános előadás

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Nagy, Éva; Pénzesné, Kónya Erika (2016): Biodiversity as the tool of environmental education (*IEEC - First International Environmental Conference*) lecture, Megjelenés: Magyarország, Közlemény:3089422

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