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Preface

Environmental education is no longer a fashionable activity for today's people, but a necessity dictated by life. In our ever-changing world, our primary goal must be to understand the operation of our natural environment and to develop our societies responsibly taking into considerations our natural limits and the interest of the whole living world in order to reach the sustainability of our societies. Education for sustainability cannot be started early enough, that is why kindergartens and schools are one of the most important institution in of the realization of it. Fortunately these institutions today can use a very diverse set of methodological tools to achieve their educational goals concerning sustainability.

In the thematic issue of jATES 2020/2, we publish articles on environmental education, the topic of which is very colorful, presenting methodological innovations and good practices from pre-school to teacher training.

The first article of the issue by Avid Gal from Israel gives an insight how a complex learning about one bird species, the lesser kestrel could give a complex understanding about environmental end sustainability issues. The main virtue of this article is that beside the strength of the presented method it is also describes and limits of it and analyse the possibilities to exceed these limits.

In the second article Farhana Borg and Monika Vinterek from Sweden introduce the readers in a rarely investigated of environmental education, namely preschool principals' view on education for sustainability. It is widely acknowledged that professional leaders's actions have a key role in the effectiveness of an educational institute, but little is known how principals' personal views influence their professional actions. The article is starting point to explore this unknown terrain.

Scientists are more and more convinced that biodiversity is a key factor in sustainability on the one hand and on the other hand that humanity is destroying biodiversity in a accelerating speed. The importance of the theme of biodiversity is represented in the current issue too. There are two articles dealing with the theme of biodiversity on different levels. The third article of the issue by Éva Nagy present a research on the everyday pedagogical pratice of Hungarian teacher concerning the topic of biodiversity while the fourth article of the issue by Csilla Szabó and, Kunigunda Macalik provide us a meta-analysis of scientific articles on biodiversity communication and identifying effective methods of biodiversity communication on the bases of the metadata.

Bence Norbert Együd and his colleagues describe a scientific research on how some man made object became a polarilezed light traps for special group of inscects. This article is not just

simple a description of an interesting scietific research but at the same time review of the possibilities of the implementation of the methods of and lessons learnt from the research into the educational practice of schools a teacher training institutions.

The closing article of the current issue by Katalin Hill and Veronika Fülöp present an innovative way of introducing the issue of life-cycle analysis of cell-phones into teacher training. The aricle highlights that the presented method increasing the environmental awareness and the pedagogical skills of teacher students at the same time. I think it is worthy closing thought to develop our environmental awareness and the pedagogical skills is a permanent tasks for all of us who wants to contribute to the success of environmental education and education for sustainable development.

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Zsuzsanna Angyal, editors of this issue

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The contribution of the Lesser Kestrel to environmental literacy

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Abstract

Since 1996, fifth-grade students from the Alona School in the north of Israel have been leading "The Lesser-Kestrel" environmental education program designed to promote environmental literacy as well as the conservation of this endangered raptor. Therefore, the goal of this study was to examine the environmental literacy of fifth-grade pupils after one, two and three years. The study was based on quantitative questionnaires from 147 pupils completed during and after the program and also interviews with 6 of those pupils who had completed the program in the past. Pupils filled out the questionnaire at four different points of time throughout their educational program: prior to their studies in the environmental program, at the end of their studies in the program, about four months following their studies in the program and about one year after the completing of their studies. New research tools was used to evaluate the results included the Roth's level of environmental literacy combined with Simmons' components. The findings indicate that even three years after graduating, the pupils achieved a functional level of environmental literacy in all three components of these. In conclusion, it seems appropriate to promote long-term environmental educational programs that help retain environmental literacy for at least three years.

Keywords: environmental literacy; Lesser Kestrel; elementary school

1. Introduction

The Lesser Kestrel (LK) Program was established in 1996 by a bird watcher whose children went to Alona School in the north of Israel. She identified the decline of the LK population and was determined to make a difference. The bird watcher convinced the principal to commit to an Environmental Education (EE) program that would contribute to the protection of the LK. They designed a student program emphasizing social, educational, and environmental values.

Since then, the program has been helping to protect the lesser kestrel population that has been nesting in the school and in the surrounding area.

2. Theoretical framework

The concept of environmental literacy (EL) was first coined by John Roth (Roth, 1968). Roth defined EL as the ability to understand and interpret environmental problems and to act for change or conservation of environmental systems (Roth, 1992). Since Roth's first publication of his definition of the concept, the various uses and interpretations of it have varied. Roth himself claimed: "*Unfortunately there became almost as many perceptions of the nature of environmental literacy as there were people who used the term*" (Roth, 1992, p.7) or "*Most had never read, or heard of, the original article and were not using modifications of it as a basis of their own concepts of the term*" (Roth, 1992, p. 7). Today, the most widely accepted meaning of EL includes awareness of environmental concern and its associated problems, as well as the knowledge, skills and motivations to work towards current problem solving and prevention (McBride, Brewer, Berkowitz, & Borrie, 2013). For the purpose of this study, EL has been examined according to two EL constructs: Roth's level of environmental literacy (Roth, 1992).and Simmons's components of environmental literacy (Simmons, 1995).

2.1. Roth's level of environmental literacy

According to Roth, there are three levels of EL: Nominal – the level at which a person can easily identify how natural and human systems work and how they interact, including basic perceptions of conflict between nature and human; functional – the level at which a person has the ability to gather information, analyse and evaluate interactions based on evidence, values and ethics. These people not only retain their information, but share it with others along with their feelings about the subject; operational – the level at which a person has an in-depth knowledge of environmental issues and knows how to collect, analyse and choose alternatives while taking proactive measures to improve the environmental situation and create a healthier environment.

2.2. Simmons' components of environmental literacy

According to Simmons, there are seven EL components: emotions; ecological knowledge; political social knowledge; knowledge of environmental issues; skills and action strategies; locus of control and acceptance of personal responsibility; behaviour (Simmons, 1995). All

seven relate to three categories: environmental knowledge, environmental attitudes, and environmental behaviour.

Therefore, the purpose of the study was to examine the EL of pupils according to Roth's level combined with Simmons' components, one, two and three years after graduation from the Lesser Kestrel environmental education program.

3. Methodology

3.1. Research context - The Lesser Kestrel environmental education program

The program meets two hours a week as an extracurricular activity integrated into the school's schedule. The program emphasizes values, beliefs, norms, knowledge, and skills related to local social and environmental challenges. Many of the classes engage in outdoor learning, allowing pupils to observe the LK as well as contributing to the local action plan of LK conservation including building nest boxes for them. One of the highlights of the program is "LK Day," a ceremony held in late May when young LK first open their wings and prepare to leave the breeding colony at the school. As part of the event, fifth-grade pupils have guided over 1,500 visitors through the grounds and explain the plight of the endangered species.

3.2. Research population

147 fifth-grade pupils from 2012, 2013 and 2014 answered the quantitative questionnaires. They filled out the questionnaire four times during their studies: at the beginning of the fifth grade before starting to study in the LK environmental education program (pre), at the end of the fifth grade – when they finished studying in the program (post1), at the beginning of the sixth grade, about four months after completing their studies in the environmental program (post2) and at the end of the sixth grade - about one year after graduation the environmental program (post3).

In addition, during 2015, six pupils were interviewed. Two of them, Ayla and Anya (pseudonyms) were in fifth grade LK program in 2012 and were in the first class to complete the questionnaire. Two of them, Adi and Arya (pseudonyms), were in the LK program in 2013 and were in the second class completing the questionnaires. Two others, Tammy and Guy (pseudonyms) were in the LK program in 2014 and were in the third class completing the questionnaires.

3.3. Research approach

The study was carried out using a mixed-method approach. The quantitative section included statistical analysis and the qualitative section used an interpretive-constructivist paradigm (Burrell & Morgan, 1994) as a lens to capture the subjective reality of former pupils of the LK environmental education program. The qualitative analysis in this study is a deductive study and focuses on identifying well-known concepts (Armat, Assarroudi, Rad, Sharifi, & Heydari, 2018) related to EL and include knowledge, environmental attitudes and behaviour.

3.4. Research tools

3.4.1. Questionnaire

The questionnaire had four sections, but only three are presented in this study. The questionnaire was designed to create a supplementary picture of the students' environmental literacy and each section of the questionnaire examined a different aspect of environmental literacy. Part I had 10 general knowledge closed questions about the LK. Part II examined environmental attitudes by describing a case study story in which pupils encounter a fallen LK nest with cats (predators of LK) circling around. Pupils had four options which were divided into desirable or undesirable environmental positions. A desirable or undesirable position was determined by conservation values and by what pupils learned about the importance of animals in the ecosystem. The positions were: ignore - defined as an unwanted environmental position; report to a friend - defined as a desirable environmental position, but less desirable than reporting to an authority; report to an authority - defined as a desirable environmental position; and a personal care - defined as the most desirable environmental position.Part III had 10 questions using a five-level Likert scale (1 - never 5 - always) regarding behavioural environmental aspects (in all four questionnaires, pre, post1, post2, post3, Alpha Cronbach was higher than 0.765).

3.4.2. Semi structure interview

This kind of interview enables exploration of certain topics with a defined protocol while allowing some flexibility. The flexibility allows the interviewer to deepen and clarify various issues that arise from the interviewee's answers while linking the topics he / she wishes to explore (Fossey, Harvey, Mcdermott, & Davidson, 2002). The pupils were asked about the LK

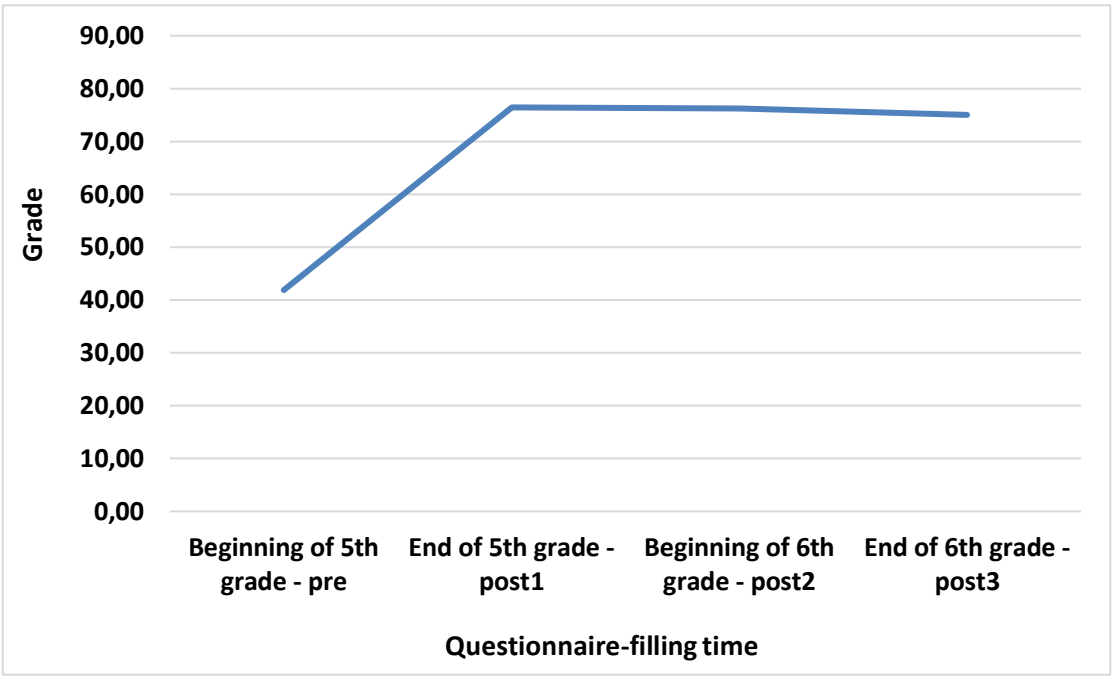
environmental education program, while pupil presented with different environmental situations, which are unrelated to the LK, and their reaction to these situations was examined.

4. Results

4.1. Knowledge

Knowledge significantly increased statistically (pre/post1, t = -18.04, P <0.0001) and remained fairly stable for a year when pupils were tested twice more (post2/post3, t = 0.752, P = 0.453) (Fig. 1). This means that knowledge was retained over time even though the pupils did not engage in programs related to the LK and did not have any additional lessons on the subject.

Figure 1. The change in pupil scores in the knowledge test conducted at four different time points.



In addition to the quantitative findings, there were qualitative results from the interviews showing that the knowledge level was retained for two years after the pupils finished their studying in the LK program (Table 1).

Table 1. Examples of pupil quotes in the various classrooms indicate the level of knowledge

Class	Quotes from semi structure interview
Sixth grade	The Myna is an invasive species that does not originate from Israel and causes damage to the LK... In the food chain if one animal is missing then the whole chain breaks like vertebrae ... If the insects disappear from the world the flowers will not reproduce and if there are no flowers and plants then there will also be no air.
Seven grade	We learnt that it's not good because he imprint the animal ... so it [animal] won't leave you and it's also not good because it can't live with animals like him around because it just won't know how to do things like they do…. I also learned a lot about how to protect the environment
Eight grade	I remember that we learnt that the LK needs open fields where they can find food such insects, they are biological exterminator, but the farmers use pesticides that kill the insects and then the LK can die because they are eating poison insects, it's harmful to the food chain

In summary, their knowledge, especially ecological-based knowledge that the pupils acquired during the LK environmental education program was retained for a few years after they finished.

4.2. Environmental attitudes

The quantitative findings do not indicate a change in environmental attitudes in the desired way of treating offspring of LK that has fallen from the nest and is surrounded by cats (Table 2).

Five of the six youths expressed positive attitudes that addressed broader environmental issues than the LK conservation (Table 3).

Table 2. Distribution (%) of environmental attitudes in response to the way in which a nest of LK that fell from the nest and surrounded by cats should be treated

Options	Pre	post1	post2	Post3
Ignore - (defined as an unwanted environmental position)	0.7	0	0.8	2.4
Report to a friend - (defined as a desirable environmental position but less desirable than reporting to an authority)	6.1	3	3.2	5.6
Report to authority - (defined as desired environmental position)	41.4	50	47.2	41.1
Personal care - (defined as the most desirable environmental position)	51.7	47	48.8	50

Table 3. Examples of program's graduates' reference to environmental issues Examples of references to environmental issues from program graduates (using apostrophes (‘) is generally not desirable)

Class	Quotes from semi structure interview
Sixth grade	Because we are the next generation in this country; we have to educate children not to throw out bags, recycle and protect more
Seven grade	Even if it's some kind of intruder I wouldn't kill it; I would try to help it, take it to a vet or something, but surely not kill
Eight grade	You do not throw out plastic bags, so you're thinking ahead, not just about the endangered LK's, but about other animals that can come and eat it ...

The change in pupils' attitudes toward the environment following the LK environmental educational program can be found in eighth-grade Anna's comments, "*I think it made me see, animals, birds…nature differently than before; I appreciate it more and am more concerned and it's more of an issue. I am interested now*." Anna's environmental awareness that changed as a result of the program. To summarize this section, only the qualitative analysis helps to identify the differences in pupils' attitudes, and the development of their positive attitudes towards the environment following the program.

4.3. Environmental behaviour

The results of the quantitative test indicate that there was no significant statistical difference between environmental behaviour score from before to after the fifth grade program (pre/post1, t = -0.396, p = 0.693). The greatest score of environmental behaviour was observed at the end of the sixth grade (post3, 3.47) and was statistically significantly higher than all other tests, pre, Post1, and Post2 ($p<0.007$). In this case, too, the qualitative analysis adds interesting perspectives about the environmental behaviour (Table 4), which provide insight into the environmental literacy of the students based on the qualitative scale.

Table 4. Quotes of pupils of different ages relating to environmental behaviour

Class	Quotes from semi structure interview
Sixth grade	There is also a green leadership here that I am in… If I had the opportunity to go to the anti-devastation protests in the area, I would not have been like that before the LK program.
Seven grade	When people litter I do reprimand them and I pick up the trash myself... I don't remember doing it before the LK program
Eight grade	Following the program, I also tell my friends, in a nice way, don't litter, pick up the trash.

Contrary to most pupils, Ayala, claimed "*the program didn't contribute anything to me" and criticized the attempt to encourage environmental action among the pupils*…" She also added "*What I do remember about the LK is that we were told not to do things alone [to help the falcon], because we don't know how, and we might just do more harm*." It is evident that Ayla was frustrated by the teachers' reluctance to trust the pupils' ability to work for the LK. In conclusion, it can be said that the environmental program encourage pupils to pro-environmental behaviour initiate environmental activity at various levels, in the private sphere and the desire to act in the public sphere.

The findings in the study suggest that pupils have reached the second level of Roth's EL - functional level. At this level, there is evidence for all of the components of Simmons' EL components (Table 5).

Table 5. Findings of the study according to Roth's EL level and Simmons's EL components.

Environmental literacy components (Simmons, 1995)			Environmental literacy level (Roth, 1992)
Knowledge	**Attitude**	**Behavior**	
Participation in environmental programs, positive response to environmental activity	Awareness and sensitivity, understanding the interaction between social systems and natural systems	Understand and identify basic concepts related to the environment	**Nominal**
Participation in green leadership	Awareness of animals, endangered animals, their importance in the world, human destruction of the environment	Use of concepts such as invasive species, familiarity with taxonomic concepts, use of concepts of livestock habitats	Evidence from the study
Personal motivation to take action for something else close to the heart to change the existing situation	Awareness and expression of negative interactions between human social systems and natural systems, ability to analyze and evaluate information while taking a stand to act for the environment, sharing feelings with others	Extensive knowledge and understanding of the interplay between natural and human systems	**Functional**
Environmental activity in different level, declaration of change in environmental behavior following the program, desire to act in favor of the environment	Dealing with dilemmas about interactions with animals, discovering feelings of satisfaction and success in guiding a community, sharing with friends, explaining about the environment	Presentation of a food chain in nature and sustainable relationships	Evidence from the study

Acceptance of responsibility, ongoing lifestyle management that deals with the prevention of environmental damage	Ability to collect and analyze information and focus on action to protect the environment	An in-depth understanding of environmental concepts and related skills	**Operational**
not found	not found	not found	Evidence from the study

Despite it being a deductive analysis, another theme was raised by the pupils. They expressed very positive emotions regarding the LK environmental program (Table 6).

Table 6. Quotes of pupils relating to emotion regarding LK environmental program

Class	Quotes from semi structure interview
Sixth grade	It's something different ... you don't spend all those hours in the classroom doing nothing, you go on observations, build nest boxes, guide ... it's really nice and teaches
Seven grade	I remember we had tours and also went to explain to people ... it was really fun
Eight grade	…and something else that I loved was that we were allowed to do everything by ourselves. For example, they let us gauge the heat at a certain point in the school to figure out where to place the nest boxes

Even Ayala, who had complained about the LK environmental program, praised the training activity: "*I remember everyone constantly wanted to guide, which is something I remember as a good experience, to make it clear to people, to show that we know, explain to 40-year-olds something they don't know about at all, that's a point I remember - it's a good memory*." The first part of Ayala's words about the positive experience of acting for the LK by guiding, characterizes all the other five pupils' interviews from all grades.

5. Discussion and Conclusion

This study examined the EL of pupils during and one year, two years and three years after graduating from the LK environmental education program. Graduates of the program attested that the program was significant for their environmental literacy development. The study does not suggest a hierarchical relationship between environmental literacy components as is known from other studies (Kollmuss & Agyeman, 2002). The study suggests a new stem-and-flower model to understand the results based on the morphology of the *Brassicaceae.* The stem is the educational program. The receptacle is EL and the four petals match the four findings that emerged in this study: knowledge, attitudes, behavior and emotion. Biologically, the longer and wider the stem, the larger the flower will develop and its receptacle will be wider. This parallels the environmental programs as found in this study. This long-term environmental program that exposes pupils to a variety of environmental issues, created a broader receptacle - EL at a functional level (Roth, 1992) and "wider petals" - EL components: knowledge, attitude, behavior (Simmons, 1995) and emotion. Unlike the biology of most annual members of *Brassicaceae*, in the case of this study, it is evident that a "perennial plant" was created by this environmental program. This unique long-term environmental program (Gal & Gan, 2018) had an impact of at least three years on its graduates. Knowledge was retained, environmental attitudes were very positive, there was a desire to pro-environment behavior and positive emotions were presented in the context of the program.

The "flower of the *Brassicaceae*" created as a result of this educational program did not reach the highest level of EL which is “operational” level (Roth, 1992) in any of the three components of the EL (Simmons, 1995). While the attention of the teachers in the program could allow the operational level within the components of knowledge, attitudes, and pro-environmental behavior, pupils could not be expected to achieve the operational level. The reason for this is that Roth's article in the late 1960s (Roth, 1968) was based on independent adults, while this study is about pupils who are still under their parents' restrictive supervision.

In conclusion, the impact of a long-term environmental education program can be seen on the level of EL and its components, as well as various aspects of emotion, even three years after the program. Therefore, it seems more advisable to promote long-term educational programs that emphasize different aspects of the environment than to use short-term environmental programs that focus on a single subject.

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Principals´ Views on and Descriptions of Preschool Education for Sustainable Development

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Abstract

Principals have an important role to play when it comes to making decisions on organizational reforms and priorities in preschool; however, there has been little focus on their views on education for sustainable development (ESD) at the preschool level, which is a reform that needs to be prioritized. Furthermore, there is little insight into similarities and differences when it comes to how different types of preschools incorporate ESD, especially from the point of view of management. For this reason, this study aims to find out about the views on ESD that principals of eco-certified and non-eco-certified preschools have. A further aim is to examine whether there are any differences between the two types of preschools – eco-certified and non-eco-certified – as made evident in the principals' descriptions of ESD. This qualitative study applies a cross-sectional design. Seven principals, who headed a total of 22 preschools located in six municipalities in Sweden were interviewed: these interviews were audio-recorded and transcribed, and a thematic analysis was conducted. The findings demonstrate that the principals consider ESD to be crucial in early childhood education and feel ESD needs to be integrated into preschool education. Going by the principals' descriptions, it seems that the eco-certified preschools prioritize ESD in their daily educational practices more than non-eco-certified preschools do. Further studies are needed to explore the attitudes and actions of principals when it comes to heading ESD in preschool, since attitudes guide both actions and behavior.

Keywords: early childhood education; eco-certification; organizational leadership; preschool principal; sustainable development

1. Introduction

Globally, people are experiencing the unprecedented impact of climate change on the environment that affects human lives (Climate Council, 2019): for example, the vast wildfires in Australia that wiped out millions of animals and destroyed acres of forest, while also claiming the lives of people. More recently, the coronavirus pandemic has presented a huge global challenge to society and economic systems. As a way to deal with the emerging complex challenges that threaten the existence of people and the planet, education for sustainable development (ESD) was identified as a tool to achieve sustainability (United Nations, 2017).

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2019), the purpose of ESD is to empower learners 'to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity'.

Leaders are responsible for shaping organizational conditions and developing the necessary capacity to implement new programs and practices (Davies, 2007; Jackson, 2007). As leaders within education, principals have the authority to facilitate organizational reforms and to decide what activities need to be prioritize. Despite the fact that preschool principals have an important role when it comes to setting directions, there is a considerable gap in knowledge in terms of their views, commitment and functions in childcare and preschool settings, especially in relation to early childhood education for sustainable development (Hayden, 1997; Håkansson, 2017; Jackson, 2007; Lunneblad & Garvis, 2019). Such knowledge is required since sustainable development is a value-laden concept that links to personal beliefs, attitudes, and values.

This study aims to develop knowledge about the views on ESD held by principals of eco-certified and non-eco-certified preschools in Sweden. It further aims to open for insight into the similarities and differences in how different types of preschools work with ESD. In this paper, the term eco-certified preschool refers to preschools that incorporate ESD as based on the curriculum and sustainable school operations. The eco-certification can be either 'Green Flag' certification from the Keep Sweden Tidy Foundation (HSR, 2019) or the 'Diploma of Excellence in Sustainable Development' from the Swedish National Agency for Education. To be eco-certified, preschools need to comply with a set of sustainable development-related criteria: for example, systematic quality work in educational management; involvement of teachers and children in the planning, implementation and evaluation of education activities; and documentation and reporting of education (SKOLFS 2009:19). Although ESD is integrated into Swedish policy documents, there is no national level follow-up (Mogren & Gericke, 2017).

In Sweden, preschool refers to early childhood education that is normally for children under the age of six. From the age of one, all children can attend preschool, with children entitled to three hours per day of free preschool education from the autumn of the year they reach the age of three (Skolverket, 2018). A new curriculum for preschool (Skolverket 2018a) came into effect in July 2019: there, the title 'preschool director or head of the preschool (*förskolechef*)' has been replaced by 'principal (*rektor*)' (Skolverket, 2018a). According to the new curriculum, a principal is an educational leader and head of preschool education and has the overall responsibility of ensuring that education as a whole is such that it accords with national goals.

Given that they have this responsibility, there is a need for scientific knowledge that supports both principals in their positions as leaders and preschools in their inclusion of ESD. Upon this background, this study addresses the following research questions:

- How do principals describe the educational activities concerning sustainable development at their eco-certified or non-eco-certified preschools?
- How do principals view the importance of educational activities in preschool that relate to sustainable development?
- What are the similarities and differences in the principals' views and descriptions of educational work related to sustainable development at their preschools?

2. An Overview of the Field

This section includes a brief description of relevant international and national policies concerning ESD, as well as a review of literature that addresses educational leadership in relation to ESD in early childhood education.

2.1. International and National Policy Documents about Sustainable Development

In 1987, the concept of sustainable development was defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their needs' (WCED, 1987, p. 43). To simplify the complexity of the concept, three interconnected dimensions – the environmental, the social and the economic – were introduced. The environmental dimensions deal with the human relation to nature and the preservation of ecosystems. The social dimensions deal with people's lives in terms of democracy, participation, emancipation, solidarity, and peace. The economic dimensions deal with concerns about reducing the consumption of goods and services, and direct environmental burdens in terms of the production and use of natural resources (Siraj-Blatchford, Smith, & Pramling Samuelsson, 2010).

To promote sustainable development, the General Assembly adopted the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs). The Agenda emphasizes the importance of quality early childhood education and care (Goal 4.2), as well as the need to promote sustainable development through ESD and sustainable lifestyles (United Nations, 2015). ESD stresses the necessity of enabling people to acquire the knowledge, attitudes, values and capacity that are needed to promote sustainable development and of

learners adopting 'behaviors and practices that enable all to live a full life without being deprived of basics' (UNESCO, 2006, p. 4).

International policies are highlighted in early childhood education curriculum in several countries; for example, the Australian Early Childhood Education Framework (ECEF) has integrated the concept of sustainable development, which is to be embedded in educational practices as an aspect of teaching and learning (Ärlemalm-Hagsér & Davis, 2014). Similarly, the new Swedish curriculum for preschool (Skolverket, 2018a) explicitly mentions 'sustainable development' with a focus on preschool education and children's learning. Under the sub-heading 'Sustainable Development, Health and Well-being', the new curriculum requires that preschool education should provide children with the opportunity to acquire an ecological and caring approach toward their surrounding environment and society. In addition, the curriculum emphasizes how everyone who works in preschool needs to promote respect for the intrinsic value of the individual and for sustainable development (Borg & Pramling Samuelsson, 2019).

It is important to begin including ESD in early childhood education (e.g. Davis, 2015; Pramling Samuelsson, 2011), where there is opportunity to work with sustainable development-related issues. ESD 'seeks to empower people of all ages to assume responsibility for creating a sustainable future' (UNESCO, 2002, p. 5). In ESD, children are viewed as agents for change with the capacity to be involved in activities related to sustainable development. In this regard, principals play an important role since they have the responsibility and authority to ensure that preschool staff gain the skills and knowledge needed to carry out work duties in a professional manner (Skolverket, 2018a).

2.2. Educational Leadership and Culture of Sustainability

Schein (2010, p. 7) argues that there is a close connection between leadership and organizational culture, which can be described as 'two sides of the same coin'. Nevertheless, transitioning a preschool's educational practices toward sustainable development requires a reform in the way schools work: this includes many aspects – curriculum, teaching, culture, and resource usage (Jensen, 2005). Accordingly, effective implementation of ESD starts with proactive school leaders (see, Mogren & Gericke, 2017). The authors argue that the proactive school leaders support the process of implementation of transformative education for sustainable development that helps create structures and routines that integrate ESD into the (pre)school organisation.

A number of studies have identified a gap between the self-reported importance of sustainable development and the actual practices of school managements (Gough, 2006; Jackson, 2007;

Zachariou & Kadji, 2009). The findings of a nationwide study in Cyprus, which included 150 primary schools, show that the perceptions most principals have in terms of ESD are limited to environmental education, whereas some principals are able to connect it to social and economic dimensions (Zachariou & Kadji, 2009). The findings of Jackson's (2007) study, conducted in England, indicate that those leaders who support the integration of ESD into their schools are motivated by their own passion for questions related to sustainability.

Creating a culture of change in an organization includes the processes of both working towards a common goal and achieving changes that are appreciated and meaningful (Fullan & Ballew, 2001). Research in the field of early childhood education suggests that strong leadership is crucial for the successful implementation of systems that help to maintain quality and to create a climate that promotes children's maximum growth and development (Bloom & Bella, 2005; Bloom & Sheerer, 1992; Carr, Johnson, & Corkwell, 2009; Kagan & Bowman, 1997; Talan, Bloom, & Kelton, 2014). Therefore, it is important to explore how principals view ESD in terms of its importance and what dimensions of sustainable development they stress in their understanding.

Creating an organizational culture that focuses on sustainable development in early childhood education requires 'shared visions, values, and beliefs at heart' (Sergiovanni, 2003, p. 14). Culture acts like a compass, guiding people in a common direction. Davis (2015, p. 22) argues that the creation of cultures of sustainable development is a process that transforms our ways of 'thinking, practices and relationships around sustainability' and that this occurs from the inside and cannot be imposed by external agents. Therefore, the role principals have in creating cultures of sustainable development in early childhood education is vital, since leaders can either constrain or support an organization's operations (Gibson, 2015).

3. Materials and Methods

To answer the research questions, a qualitative study with a cross-sectional design was used. A semi-structured interview guide was developed to collect data from preschool principals (see Appendix). Brief descriptions of the participants, data collection process, thematic analysis of data and ethical considerations are given below.

3.1. Participants and Data Collection

Of eight preschool principals who were contacted, seven agreed to take part in the study. These seven principals headed 22 preschools located in six municipalities in Sweden. All were

women: this is not surprising since in 2015, only 360 of 4901 principals of Swedish preschools were men (SCB, 2020). Three principals worked at both eco- and non-eco-certified preschools, whereas four principals worked at either eco- or non-eco-certified preschools.

A semi-structured interview guide (see Appendix 1) was developed to explore how the principals view preschool ESD and how they describe educational practices related to sustainable development at their own preschools. Individual interviews were conducted between February and August 2015. The principals were allowed time for reflection and given the opportunity to express their views on various matters relating to the topic (Cohen, Manion, & Morrison, 2011; Creswell & Clark, 2007). Instead of being asked about the differences and similarities between eco- and non-eco-certified preschools, the principals were asked to describe the educational practices at their preschools and to state whether the preschools worked with ESD. During the interview, the principals were encouraged to discuss any additional issues that they felt important.

The interviews were audio-recorded with the permission of the participants. The interviews took between 23 and 45 minutes (the longer interviews were with those who were principals of more than one preschool). Interviews equalling a total of 203 minutes were audio-recorded. The places of interviews were determined by the principals themselves so that they could avoid the inconvenience of travel. Five principals were interviewed alone, while two were interviewed in the presence of two preschool teachers who were directly involved in implementing ESD at their preschools.

Most sections of the interviews were transcribed word for word, whereas others were merely summarized since they were not directly relevant to the research questions. The transcriptions were translated from Swedish into English to prepare publications for international journals. To ensure linguistic accuracy, the translated transcriptions were checked by a native Swedish-speaking researcher who is also fluent in English.

3.2. Thematic Analysis

A thematic analysis (Braun & Clarke, 2006) was conducted in six steps: familiarization with data, generating initial codes, searching for themes among codes, reviewing themes, defining and naming themes, and producing the final findings. For this paper, the audio-recordings of the principals' interviews were listened to several times before they were transcribed. The transcriptions were read and re-read so that the researchers (both authors) became familiar with the data, and then initial codes were generated. Any unclearness or inconsistencies in the

transcriptions were checked by replaying the audio-recording. Repeated words and concepts in the data were noted as repetition, which is one way to identify themes (Ryan & Bernard, 2003). For example, in the principals' descriptions of sustainable development, the repetition of such words as 'environment', 'nature', 'composting', 'Earth' 'world' and 'planet' helped us identify the preliminary theme 'focus on environmental dimensions', indicating that the principals' descriptions emphasize the environmental dimensions of sustainable development. In this way, the initial codes were collated to form potential themes: for example, sustainable development definition, preschool prioritizing sustainable development. The preliminary themes were reviewed as a way to examine their relevance to the research questions, because all themes were not equally important. Finally, the themes that related to each other were merged. The main themes and sub-themes were checked again and refined so as to answer the research questions.

3.3. Ethical Considerations

The study adheres to the ethical codes and guidelines of the Swedish Research Council (Vetenskapsrådet, 2011; 2017). Initially, the principals were informed about the purpose of the study by email and were then contacted by phone so that they could receive additional information if required. All the principals provided their informed written consent to participate in the study. They were informed that their participation was completely voluntary and that all information that related to them, their preschools and the relevant municipalities would be confidential. The study did not include sensitive information or the personal details of the participants. The participants were informed that they could discontinue their involvement at any time without providing a reason. They were also informed that the interview data would be used for research purposes and for presentations at academic conferences.

4. Results

Emerging themes from the analysis are presented in two main categories: Principals' Views on Education for Sustainable Development; and Reported Educational Practices among Eco- and Non-Eco-Certified Preschools, see below.

4.1. Principals' Views on Education for Sustainable Development

The findings are presented under three emerging themes: Environmental and Social Dimensions in Focus; Crucial to Start ESD at an Early Age; and Lack of ESD Competence among Preschool Staff.

4.1.1. Environmental and Social Dimensions in Focus

All principals described education for sustainable development as knowledge about the environment and care for nature and animals. Principal E stated that ESD is about working with organic food and the use of chemicals and the environment. Some of the principals (A, B, C, D and G) view ESD as being about listening to children and creating opportunities for them to learn how to recycle and how to be environmentally aware. The social and, to some extent, economic dimensions were mentioned by a few principals. For example, the principals described how ESD deals with our lifestyles; the relationships between human beings; the way in which human beings treat one another; the consumption of natural resources; our conscience; and fundamental values. According to Principals D and G, ESD is not only about the environment but also about listening to children and respecting their opinions, democracy, and the way in which people may think of living their lives. Principal C stated:

> Yes, it's [ESD is] all about lifestyle, food, how we are towards one another. I think that this set of values is embodied in all these parts; in fact, it may be included in everything we do in preschools.

According to Principal F, 'We together must protect our environment and we have to start with young children to help them to understand that they are the ones who will gradually take over, and they may understand that it is important'. However, one principal (A) talked about the economic dimensions of sustainable development, and her justification was that for some people, the concept of sustainable development can be limited to recycling activities, but it is much more than that: she says that sustainable development 'for us is ecological, economic and humane – everything has to do with everything'.

4.1.2. Crucial to Begin Including ESD at an Early Age

All principals emphasized the importance of ESD in preschool education. They all considered ESD for young children to be both meaningful and urgent. Principal B argued that 'Children should be given the opportunity to take part in everything that has to do with the environment'. Principal E said:

> (…) from my point of view, a simple answer to this is, of course, that we must have sustainable development so that we can keep our Earth for the future, for our children, that's it.

Similarly, Principal A stated that 'We must begin to learn things when we are young; then we can behave in a proper way'. According to Principal B, what children learn when they are young remains with them as adults. She mentioned the Swedish preschool curriculum (Lpfö 98, Rev.

2010), which states that children should have the opportunity to be part of everything that relates to the environment, lifecycles and so on. An early start with ESD was viewed as being crucial by the principals.

4.1.3. Lack of ESD Competence among Preschool Staff

All principals noted the importance of preschool employees integrating ESD into their work, yet they also stated that doing so is both difficult and complicated. According to them, it is especially challenging for preschool teachers who have yet to work with the concept of sustainable development. In this regard, Principal D stated:

> Many may become a bit nervous about this. When they think about the Green Flag, they think about report writing. If you look at this (a report), you see there's a lot of work. So it (a report) requires a lot of writing, it takes time. This is nothing they (teachers) get extra time for. You could say that the preschool already has too little time for planning, so they are careful with their time. So it's a bit overwhelming for some, I would say.

Some principals worried about teachers having a larger workload if preschools were to integrate ESD into their daily activities, stating how teachers already have high workloads.

4.2. Reported Educational Practices among Eco-Certified and Non-Eco-Certified Preschools

The principals described the work done at their preschools in terms of education. From their descriptions, some similarities and differences are identifiable in the ways that eco-certified and non-eco-certified preschools integrate ESD. The findings are presented under four emerging themes: Prioritization of ESD in Preschool; Daily Educational Practices in Preschools; Participation of Parents; and Reporting and Documentation of Educational Activities.

4.2.1. Prioritization of ESD in Preschool

The principals reported that eco-certified preschools gave high priority to ESD in educational activities, whereas non-eco-certified preschools prioritized other educational activities. The personal interests and commitments of individual teachers were also mentioned as being main reasons for why some preschools prioritized ESD in their daily activities. In this regard, Principal D stated that:

> (…) it depends on the teachers who work at the preschool. There are maybe one or two who are proactive, and they have managed to engage the whole preschool, although it has not been easy for them.

Principal A explained that the reason that teachers prioritized ESD at her two eco-certified preschools was that they 'care for the future of children and the survival of Earth'. Principal E stated that 'I think it depends. There are preschool teachers and principals who promote this issue'.

4.2.2. Daily Educational Practices in Preschools

The principals of eco-certified preschools reported that all eco-certified preschools work with different themes, for example, water and electricity consumption, or lifestyle and health, during a certain period ranging from six months to two years. Regardless of the profile of the preschool, findings showed that all 22 preschools work with nature and the environment: for example, teachers take the children to forests; they look at different trees, plants, small animals and insects; and they learn to care for the environment.

Two principals (D and E) stated that despite the activities of non-eco-certified preschools sounding similar to those of eco-certified preschools, the non-eco-certified preschools usually focus on discussion about the environment, whereas eco-certified preschools involve children in exploration or experimental activities in nature. For instance, Principal D explained that her eco-certified preschool worked with a theme called 'lifestyle and health', which included activities relating to friendship, social interaction, health, nutrition and food. In this preschool, she explained, children attended green council meetings, where they could take part in decision-making and influence the planning and activities of the preschool. She compared this eco-certified preschool with her three non-eco-certified preschools and explained that the non-eco-certified preschools did not have these kinds of activities at all. Principal D gave an example of how her eco-certified preschool works with electricity consumption, stating that the teachers and children reflect on the following:

> [H]ow much electricity do we use? Do we save any electricity? How much is used for lighting? Where does water come from? These are the themes of the preschool. They are quite common, but when they get deeper, I don't think they (teachers at non-eco-certified) do so in the same way. One preschool (eco-certified) has this thought – they have, for example, an electricity-free day when they cook over an open fire, yes, and they don't turn any lights on. They use no electricity inside the preschool (on that day).

Principal F described how teachers try to spend time in forests as much as possible and how these outdoor activities lead to discussions about nature and animals between teachers and children. Principal C pointed out that if preschool staff were to follow the Swedish curriculum (Lpfö98 rev 2010), then they would spend a great deal of time in forests involved in different activities, such as playing, eating and exploring. However, Principal B, who was in charge of

four preschools, pointed out that 'I have not seen any differences between eco-certified and non-eco-certified preschools more than the fact that in the Green Flag preschools, trash cans are visible. I have just taken on this position (principal) and have not had the opportunity to see a great deal yet'.

According to all the principals, it is common to have activities related to water, electricity, composting, recycling, planting and the lifecycle of butterflies regardless of whether or not the preschool is eco-certified. For example, Principal D explained that:

> (…) at the [eco-certified] preschool, they work with their Green Flag more on an experimental basis with their children than what they do here [at the non-eco-certified preschool]. Here they do more talking, and adults become role models for children. The [eco-certified] preschool works more actively, experimenting with different things and seeing what happens and so on.

4.2.3. Participation of Parents

Two principals (A and B) spoke about the importance of involving parents and guardians in preschool activities. According to Principal B, it is the responsibility of preschools to inform parents about their activities and to involve them in some of these. Principal A explained how in her two eco-certified preschools, parents take part in different activities related to sustainable development issues and:

> [N]ow the parents will be here on April 20 to work with this garden, which is one way of involving parents in this thinking, what it is to work in the garden and what our themes are and things like that. The parents have various levels of awareness.

These principals felt that the involvement of parents in children's education is crucial and valuable. Principal B stated that 'It is our responsibility to inform parents about how we work, because the parents must have knowledge about the preschool's activities.'

4.2.4. Reporting and Documentation of Educational Activities

The findings also showed that in general, all preschools document their activities and write reports about their educational work on a regular basis; however, they also showed that eco-certified and non-eco-certified preschools report in different ways, as discussed by principals who head both preschool types. Principal D argued that:

> [W]hen I read reports and so on, there is also a difference in children's thinking about sustainable development. However, I can see primarily how teachers think about sustainable development, the importance of food, our lifestyles, what we eat, friendship,

> how we behave toward each other, how we connect with each other, so our basic value is really important. They [the eco-certified preschools] work in a clear way.

The principals who headed both eco-certified and non-eco-certified preschools mentioned that the reason for differences in documentation and reports is that the eco-certified preschools are supposed to submit their reports in a special format in accordance with guidelines and instructions.

5. Discussion

5.1. Results Discussion

The findings demonstrate that the environmental and social dimensions are known and considered to be relevant to ESD, but that the economic dimension is largely missing in the answers given by the principals. This finding is consistent with Zachariou and Kadji's (2009) study, which also demonstrates that the understanding of sustainable development of most principals was limited to environmental education. Considering the role of principals as leaders who are responsible for implementing new programs and practices (Davies, 2007; Jackson, 2007), it is important that they are aware of all three dimensions – the environmental, the social and the economic – of sustainable development. These three dimensions interconnect, and it is important that all of them are taken into account when policies and practices are being developed (Siraj-Blatchford et al., 2010).

The view of the principals is that children need ESD at a young age since it lays the foundation for their future thoughts on sustainable development. This is consistent with Hofstede, Hofstede and Minkov (2010), who stressed that what children learn when they are young is difficult for them to unlearn later in life. To ensure ESD at a young age, the new curriculum for preschool in Sweden (Skolverket, 2018a) has integrated ESD issues that were not explicitly mentioned in the previous curriculum.

Principals talk about the lack of competence among teachers to teach ESD and the lack of inspiring examples for how to teach ESD. This is similar to the findings in other studies that pointed out these same two challenges when it comes to implementing policy (Borg, Gericke, Höglund, & Bergman, 2012; Corney, 2006). Our study also showed that principals considered ESD to be difficult and complex for teachers. According to them, working with ESD is challenging for those who have yet to work with it as a concept. The findings of our study also indicate that two principals viewed ESD as being something additional – something not part of the preschool curriculum, whereas the UNESCO (2005:4) document states that ESD needs to

be ‘embedded in the whole curriculum, not as a separate subject’. This might indicate limited interest in the topic on the part of those principals. However, since ESD is mentioned in the new curriculum (Skolverket, 2018a), the question is how all in-service preschool teachers, child minders, and principals are going to acquire the skills and knowledge they need for their positions. It will therefore be a challenge for the Swedish National Agency for Education to ensure that these issues are handled professionally, and that preschool staff are confident in how to implement the new curriculum.

Some principals felt that the initiative for working with ESD must come from the teachers; it is not something that the principals should propose or decide. All principals, meanwhile, stated how there is no extra time allocated to teachers in eco-certified preschools to prepare reports for certifying organizations. We think that if ESD is integrated with regular pedagogical planning and activities, there would be no need for teachers at eco-certified preschools to write additional reports for certifying organizations. Nevertheless, the creation of an organizational culture of sustainability requires shared visions and values, which means that the principals have an important role to guide the preschools in a common direction (Sergiovanni, 2003). To address this issue, it would be worthwhile exploring what kind of leadership is needed to create a culture of sustainability in preschool settings, because principals are responsible for providing necessary support to develop the capacity required to implement new programs and practices (Davies, 2007; Jackson, 2007). The new Swedish preschool curriculum also states how it is the responsibility of the principal to ensure that education at preschool are in accordance with the goals of the curriculum.

From the results about the educational practices of preschools, it seems that there are more differences than there are similarities in the planning and delivery of education in eco-certified and non-eco-certified preschools. For instance, the principals reported that the eco-certified preschools prioritized ESD, and this they did by, for example, working with themes related to the environmental and social dimensions of sustainable development. These preschools seemed to focus on experimental work in which children take part actively, whereas non-eco-certified preschools seem to create opportunities for children to be out in nature. These findings are quite similar to other case studies (Davis, 2005; Lewis, Mansfield, & Baudains, 2010; Mackey, 2012), which indicates that the activities of eco-certified preschools focus on action for change by involving children in different activities. Studies (Borg, Winberg, & Vinterek, 2017; Corsaro, Molinary, & Brown Rosier, 2002) have shown that young children’s practical knowledge relates positively to their involvement in practical activities, and, therefore, it is

important that preschools create opportunities for young children to be engaged in practical activities. However, no studies have yet been carried out to evaluate the outcomes of eco-certified and non-eco-certified preschools at the national level in Sweden. Knowledge about such outcomes is crucial for both practitioners and policymakers to ensure 'evidence-based decisions and results-oriented programs' (UNESCO, 2016, p. 38).

5.2. Methods Discussion

This study has some limitations that need to be considered when its findings are being interpreted. The findings are based on what the principals said about the differences between eco-certified and non-eco-certified preschools, but no triangulation was used to verify the information. Since the study aimed to find out about the views principals had on ESD, it seemed appropriate to use a qualitative study design to answer the research questions. The semi-structured interviews allowed participants to have enough time to think about and reflect on the topic. Since the study included a limited number of participants, the findings should not be used to draw generalizations. Nevertheless, the findings are relevant and useful.

6. Conclusion and Implications for Research

The findings indicate that the principals viewed ESD to be important and essential for very young children despite the fact they consider ESD to be complex and challenging. They also viewed ESD to be especially challenging for preschool teachers who have yet to work with the concept of sustainable development. The principals also had different views on their role as leaders to set goals for the implementation of ESD activities in preschools. Most of them were aware of the environmental and social dimensions of sustainable development, but their awareness about economic dimension of sustainable development seemed limited. There is a need for more knowledge about all three dimensions of sustainable development so that the interconnectedness of these can be understood and implemented by the management of the whole preschool. The economic dimension of sustainable development has yet to be addressed, and as such it is unclear how this particular dimension can form a component in preschool education: the question is not only how the economic dimension can be included in preschool educational activities rather what can be integrated.

From the descriptions provided by principals, it would appear that the eco-certified preschools prioritized ESD in their daily educational practices more than non-eco-certified preschools did. Further, the eco-certified preschools seemed to include more experimental activities with

children using sustainable development themes than the non-eco-certified preschools. In terms of the reporting and documenting of educational tasks, the eco-certified preschools seemed to be systematic when it came to ESD.

Preschool staff and principals need to receive professional development in the field of ESD so that they can confidently implement it in their preschools. It is also important that a larger study be conducted that explores principals' attitudes, actions and commitments with regard to ESD since attitudes guide actions and behaviours. In higher education, it is crucial that student teachers graduate with the skills and competence required to work professionally with ESD in a way that includes the environmental, the social and the economic dimensions of sustainable development. To protect our one and only planet for present and future generations, everyone in society needs to take responsibility and to act for 'environmental integrity, economic viability and a just society' (UNESCO, 2019).

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school, funded by the Swedish Research Council. Professor Vinterek is a member of the Scientific Council of The Swedish Institute for Educational Research.

Appendix

Interview guide for principals

Education for Sustainable Development in Preschool

Participant

1. Preschool:	ID nr:
2. Municipality:	

Interview information

Date:	Interview started:	Interview ended:	Total time (minutes):
Interview status: ☐ Completed ☐ Partly completed. Reason: _____ ☐ Not started. Reason: _____ ☐ Audio recording			
Interviewed by:			

Background information

4. Principal's sex: ☐ Woman ☐ Man

5. Total number of teachers (with either teacher education, preschool teacher education or recreational pedagogical education qualification) at this preschool: _____

Total number of child minders at this preschool: _____

Total number of children at this preschool: _____

6. Certified preschool:

- ☐ Yes. Type of certification:
  - Environmental school, year: _____
  - Green flag, year: _____
  - Preschool for sustainable development, year: _____
  - Other: _____
- ☐ No

7. School location:

- ☐ Semi-urban (more than 200 inhabitants)
- ☐ Small town (more than 3 000 inhabitants)
- ☐ Medium town (more than 10 000 inhabitants)
- ☐ Large city (Stockholm, Gothenburg, Malmo)

8. How important is it for you that preschools work with environment and sustainable development?

- ☐ Very important
- ☐ Important
- ☐ Quite important
- ☐ Not so important
- ☐ Not at all important

Please motivate your answer:

_____

_____

_____

9. How are environmental and sustainable development activities prioritized at this preschool?

- ☐ Very important
- ☐ Important
- ☐ Quite important
- ☐ Not so important
- ☐ Not at all important

Please motivate your answer:

_____

_____

_____

10. How does this preschool work to develop children's interest and understanding of how people, nature and society influence each other?

_____

_____

_____

11. What differences have you noticed between eco- and non-eco-certified preschools with regard to pedagogical practices concerning sustainability issues?

_____

_____

12. Is there anything that you would like to add?

_____

_____

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Some Aspects of Teaching Species Diversity in and out of schools in Hungary

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Abstract

Nowadays young students are among the most significant target groups who need to gain experience from the world that currently exist around them in order to acquire knowledge about the up-to-date environmental and nature conservation matters, especially about the issue of biodiversity as the basis of our existence. But do we teach them what is around them in the science lessons? In many cases, the drastic decline in biodiversity might even result from that young generation does not always have access to sufficient and up-to-date information merely from textbooks. However, experience with the immediate environment and the active involvement of the wildlife provided by the schools would be irreplaceable. This article summarizes the results of a survey, which was filled up by 800 Hungarian science teachers. The results provide insight into their opinion and habits regarding going out to nature while teaching. The analysis extends to several diversity matters such as examining the school garden or trees nearby. The current article was written as part of a research on the effect of light pollution on wildlife, biodiversity in particular and supported by the project EFOP 3.6.2-16-2017-00014.

Keywords: teaching biodiversity; school yards; school gardens; natural science; Biology teachers; species diversity

1. *Introduction*

The three most acute components of the unsustainability problem areas these days are climate change, soil degradation and the rapid decline of biological diversity. (Mika & Pajtókné Tari, 2015) Although the third critical area, the biodiversity loss essentially results from overharvesting, poaching, the destruction and degradation of habitats, or climate change, (Slingenberg et al., 2009; Barnosky et al., 2011) some substantive causes in many instances may lie simply in the quality and content of the education in all types of schools and in higher education (Pénzesné 2017) as it is also decisive how the topic of biodiversity appears in the framework curricula in grades 10, 11, and 12 in secondary schools. (Nagy, 2018) Greater species diversity knowledge might ensure natural sustainability for all (Miteva et al., 2012) and so I was highly inspired to study the actual teaching methods related to this form of diversity In Hungary. Do teachers have a chance to organize learning in the natural environment? Do

they even make use of the possibility that is given? Basic questions like these were asked to draw an outline of the main aspects of raising awareness about the current species diversity teaching methods in Hungarian educational institutions. My hypothesis was that Biology teachers pay little attention to teaching species diversity outside the classroom.

2. *The Data and methods of the survey*

The main objective of this questionnaire was to examine the most significant aspects of Biology teaching today in Hungary. The survey was anonymous, and on-line. The link of survey was sent to the participants by the methodological group leader from an official database. Background data were the subjects taught by them, the number of years since they have been taught and the place where the respondents teach. The measurement was made with stratified random sampling, using google form. The questionnaire was short and easy to follow, with 30 questions. The first three and the last questions were open, while the rest were alternative closed-ended ones except for five questions, which were closed questions requiring rating. (Lengyelné, 2014) All relevant questions of the questionnaire are presented in the Results section below. Data were processed by Excel software. (Tóthné, 2013) and my basic hypothesis was that they pay little attention to teaching species diversity outside the classroom.

3. *The Results*

In the course of this analysis I got 800 answers in two months between May and June, 2017. A year earlier in 2016 the secondary vocational training in Hungary has drastically changed, which led to school type and name transformations. Hereinafter, I will use the names valid from 2016. The proportion of respondents surveyed by the types of the high school they teach is shown in Table 1.

Table 1. Respondent distribution by high school type, Hungary, 2016

Interviewed Biology teachers	%
Teaching in a secondary grammar school	17
Teaching in a secondary school	15
Teaching in a vocational school	1

It can be clearly seen that, primary school teachers sent the most answers (68%), while secondary schools (15%) and secondary grammar schools (17%) represented the secondary grading institutions in relatively high numbers.

The representative segmented sampling units were primary school (301) and high school Biology teachers (142) teachers respectively, altogether 443 items from the 800 items, 357 interviewees teach other natural science subjects (e.g. Physics or Chemistry) or the school level and type were uncertainly determinable. (Falus et al., 2004)

According to the answers of the two basic segmented categories, primary and secondary, education, the following questions were highlighted in the survey:

3.1. Question 3. How long have you been teaching science subjects?

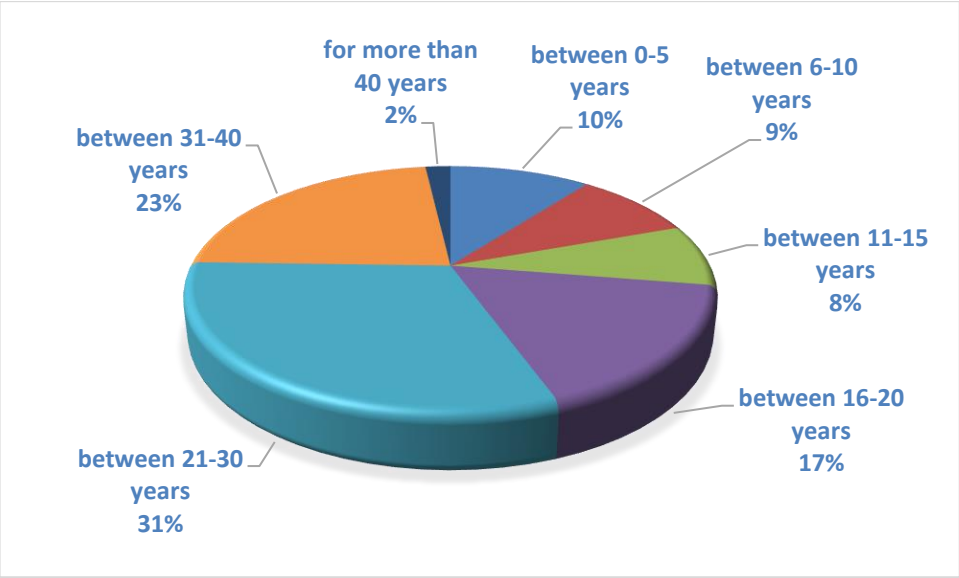

Fig. 1. The teaching experience of respondents. Answers to Question 3. *How long have you been teaching science subjects? (n=443)*

Figure 1 represents that the participants of the bulk sample are mostly experienced teachers who have been teaching basically for 21-30 years (31%) or 31-40 years (23%) and only some teachers stated that they had been teaching only for a few years.

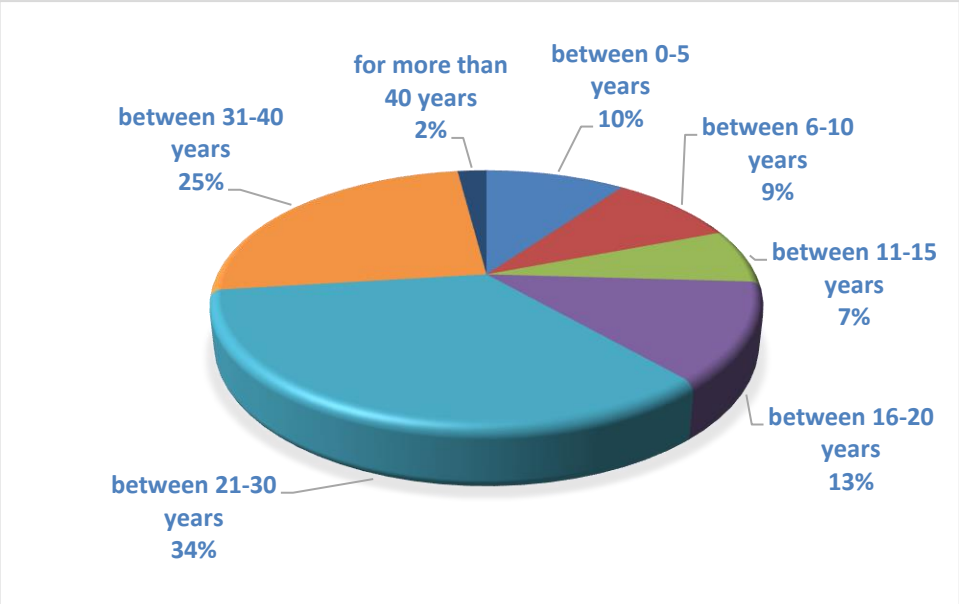

Fig. 2. The teaching experience of the Hungarian primary school teacher respondents. Answers to Question 3. *How long have you been teaching science subjects? (n=301)*

In primary education as Fig. 2. indicates, almost the same can be experienced, namely most teachers between the ages of 31-40 occur.

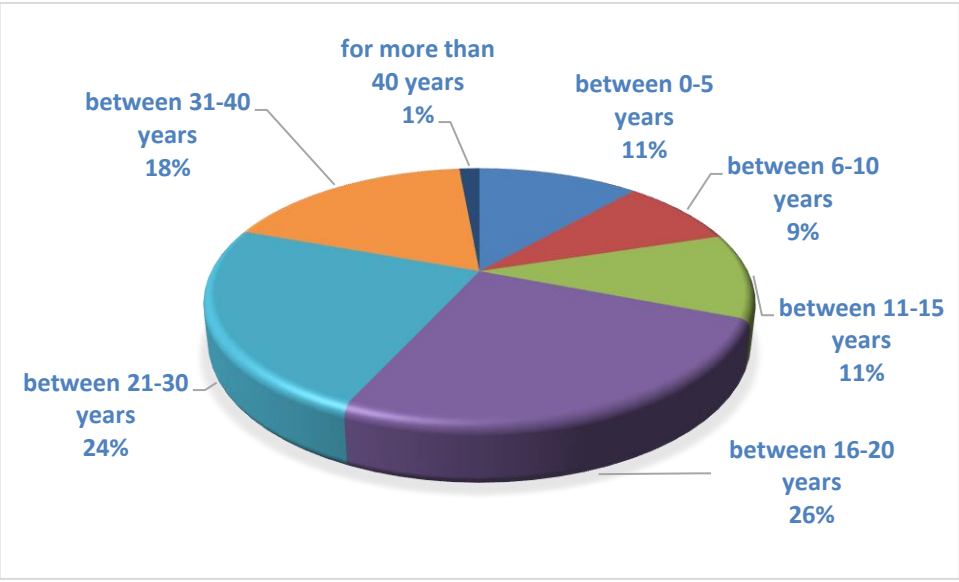

Fig. 3. The teaching experience of the Hungarian secondary school teacher respondents. Answers to Question 3. *How long have you been teaching science subjects? (n= 142)*

As Fig. 3. indicates in secondary education the rate seems a little bit different from primary education. Here the most respondents have less than 20 years of experience and the rate of those who have been teaching more than 40 years is only 1%.

3.2. Question 4. Does the institution where you teach have a yard? and Question 5. Are there science classes in the yard of the institution?

Table 2. Teachers' yard use during the science lessons (n=443)

Teachers whose institution has a yard	432
The number of teachers holding science classes in the school yard	241

Table 3. Yard use in primary schools during the science lessons (n=301)

Teachers whose institution has a yard	294
The number of teachers holding science classes in the school yard	181

Table 4. Yard use in secondary schools during the science lessons (n=142)

Teachers whose institution has a yard	138
The number of teachers holding science classes in the school yard	60

In general, 55,8% of the teachers, who have a school yard, do use it for scientific educational purposes, too (Table 2). 61,6% of Hungarian primary school teachers and 43,5% of secondary school teachers hold education activities there. In primary schools the percentage is higher but according to the chi-square test, there is no correlation between whether someone teaches in elementary school or not and whether he or she holds a class in the yard or not. (Chi-square test probability: 0.5676473656, Yates correction probability: 0.8151939962)

3.3. Question 6. Does the institution where you teach have a garden? and Question 7. Are there science classes in the garden of the institution?

Table 5. Teachers' garden use during the science lessons (n=443)

Teachers whose institution has a garden	138
The number of teachers holding science classes in the school yard	100

Table 6. Garden use in primary schools during the science lessons (n=301)

Teachers whose institution has a garden	97
The number of teachers holding science classes in the school garden	76

Table 7. Garden use in secondary schools during the science lessons (n=142)

Teachers whose institution has a garden	41
The number of teachers holding science classes in the school garden	24

Here, far fewer teachers stated that there was a garden, but a much higher proportion of the classes were held in the garden. So, where there is a garden, 72.5% of teachers hold science classes there. (Table 5)

3.4. Question 8. Is there an old tree around the institution where you teach? and Question 9. If there is an old tree around the institution, will it be visited for study purposes as part of science classes?

Table 8. Nearby-old-tree visiting during the science lessons (n=443)

There is an old tree nearby	284
The nearby old tree is visited for studying	182

Table 9. Nearby-old-tree visiting in primary schools during the science lessons (n=301)

There is an old tree nearby	194
The nearby old tree is visited for studying	140

Table 10. Nearby-old-tree visiting in secondary schools during the science lessons (n=142)

There is an old tree nearby	90
The nearby old tree is visited for studying	42

If there is an old tree around the institution where Hungarian teachers work 64,1% of the entire sample, 72,2% of the primary school participants and 46,7% of the secondary school teachers visit that for studying purposes as part of science classes. Here, as well, activity is highest in primary schools.

3.5. Question 10. Is there a bird feeder around the institution where you teach? and Question 11. If there is a bird feeder in the vicinity of the institution, is it visited for study purposes as part of science classes?

Table 11. Nearby bird feeder visiting during the science lessons (n=443)

There is a bird feeder nearby	329
The nearby bird feeder is visited for studying	253

Table 12. Nearby bird feeder visiting in primary schools during the science lessons (n=301)

There is a bird feeder nearby	250
The nearby old tree is visited for studying	212

Table 13. Nearby bird feeder visiting in secondary schools during the science lessons (n=142)

There is an old tree nearby	79
The nearby old tree is visited for studying	41

If there is a bird feeder around the institution where Hungarian teachers work 76,9% of the entire sample, 84,8% of the primary school participants and 51,9% of the secondary school members visit for studying purposes as part of science classes. Here, as well, activity is higher in primary schools.

3.6. Question 12. Is there a forest close to the institution? and Question 13. If there is a nearby forest, is it visited for studying purposes as part of the science classes?

Table 14. Nearby forest visiting during the science lessons (n=443)

There is a forest nearby	208
The nearby forest is visited for studying	153

Table 15. Nearby bird feeder visiting in primary schools during the science lessons (n=301)

There is a forest nearby	150
The nearby forest is visited for studying	113

Table 16. Nearby forest visiting in secondary schools during the science lessons (n=142)

There is a forest nearby	58
The nearby forest is visited for studying	40

If there is a forest around the institution where Hungarian Biology teachers work 73,6% of the entire sample, 75,3% of the primary school participants and 69% of the secondary school members visit that for studying purposes as part of science classes. Here, as well, activity is highest in primary schools, but the difference is less.

3.7. Question 14. Is there a park close to the institution? and Question 15. If there is a nearby park in the vicinity of the institution, is it visited for studying purposes as part of the science classes?

Table 17. Nearby park visiting during the science lessons (n=443)

There is a park nearby	297
The nearby park is visited for studying	208

Table 18. Nearby park visiting in primary schools during the science lessons (n=301)

There is a park nearby	190
The nearby park is visited for studying	142

Table 19. Nearby park visiting in secondary schools during the science lessons (n=142)

There is a park nearby	107
The nearby park is visited for studying	65

If there is a park around the institution where Hungarian teachers work 70% of the entire sample, 75,3% of the primary school participants, which is the same as forests, and 60,7% of the secondary school members visit for studying purposes as part of science classes. Here, as well, activity is higher in primary schools, but the difference is less.

3.8. Question 16. Do you consider the examples of living matters, used in science education, suitable?

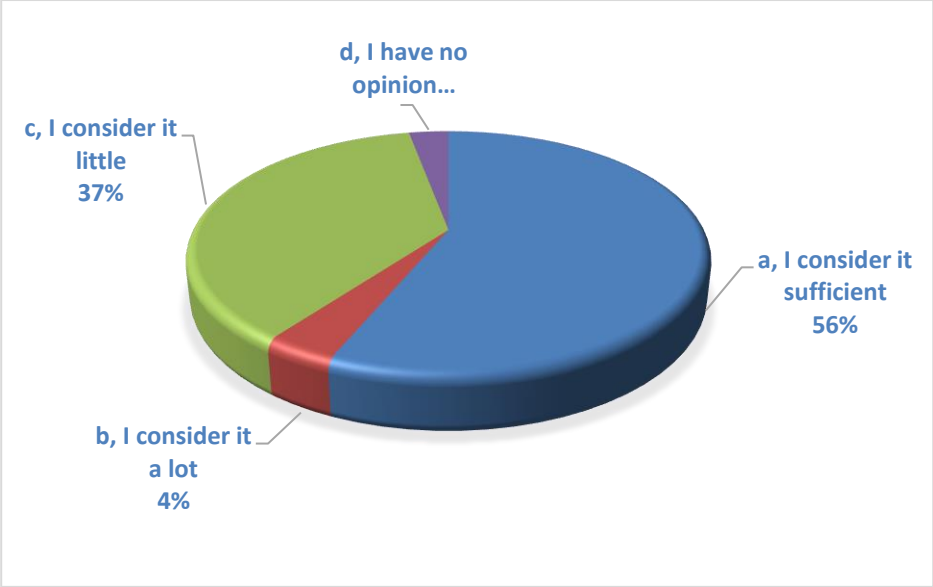

Fig. 4. The teaching experience of the Hungarian primary school teacher respondents. Answers to Question 16. *Do you consider the examples of living matters, used in science education, suitable? (n=443)*

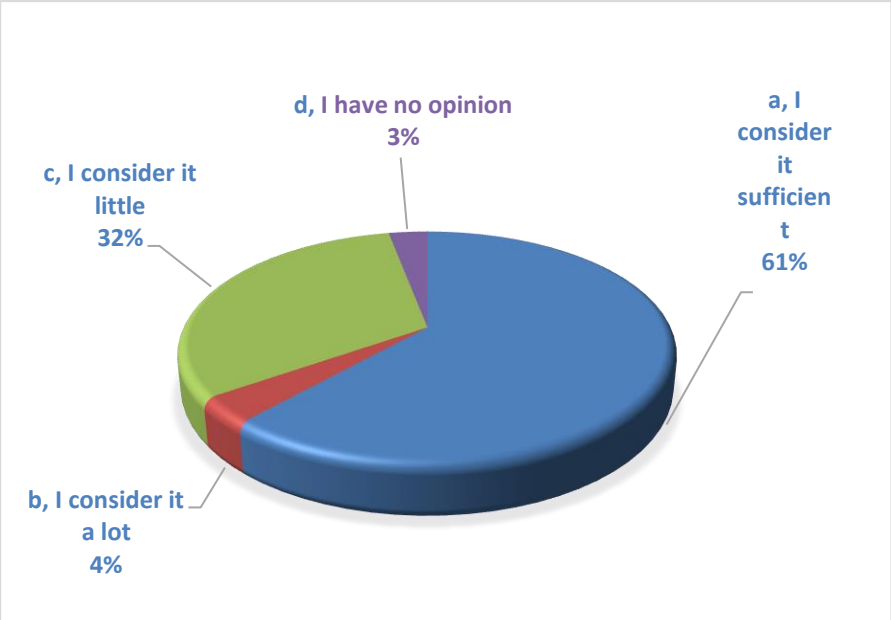

Fig. 5. The teaching experience of the Hungarian primary school teacher respondents. Answers to Question 16. *Do you consider the examples of living matters, used in science education, suitable? (n=301)*

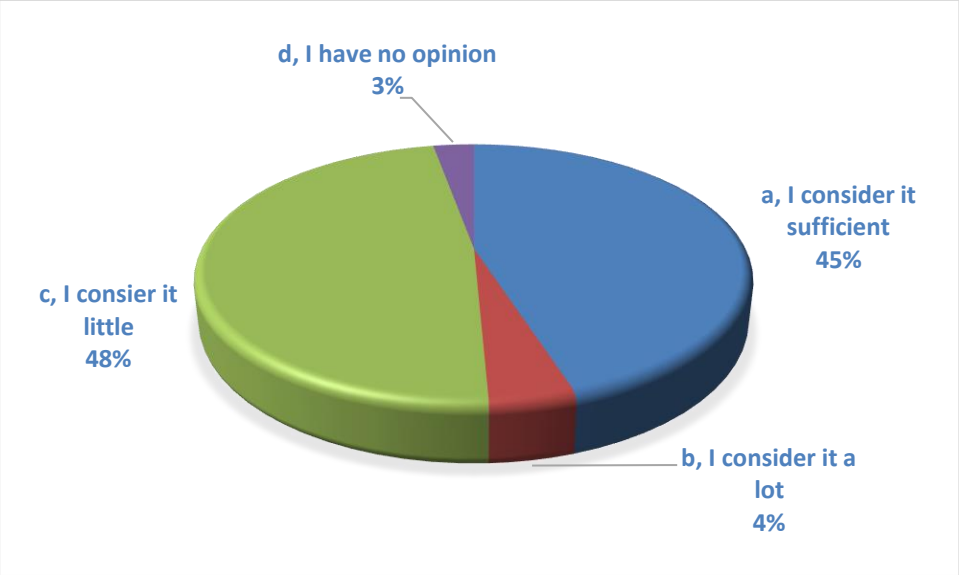

Fig. 6. The teaching experience of the Hungarian primary school teacher respondents. Answers to Question 16. *Do you consider the examples of living matters, used in science education, suitable? (n=142)*

None of the segmented groups consider the examples of living beings, used in science education too much (a lot 4% in both cases), both groups say that the examples are rather little (32% or 48%) or suitable (61% or 45%).

3.9. Question 23. Do you usually use living matter in the science lessons, or do you illustrate it with photos?

Table 20. use of living matter or presentation in a photograph (n=443)

Illustrate it with photos	255
Use living material in the science lessons	186

57,8% of the Hungarian teachers demonstrate the material with photos and 42,7% uses living matters.

4. *Conclusion*

"The air we breathe, the water we drink and the food we eat all rely on biodiversity, but right now it is in crisis – because of us. It is not surprising since "the presence of the living organisms determines our inner world and affects the smallest resonances of the surrounding environment." (Nagy, 2017) Seen like that, experts warn, humanity is currently burning "the library of life". But how can we stop it? (Carrington, 2018) Maybe sustainability education is the only way to solve this problem or obviously to survive. "Each higher organism is richer in information than a Caravaggio painting, a Bach fugue, or any other great work," wrote Professor Edward Osborne Wilson, often called the "father of biodiversity", in a seminal paper in 1985. (Wilson, 1985) But "do we give, or could we give the young generation enough to taste the real life of the actual world, attracting their attention to sustainability?" (Nagy, 2020) Or can we get enough information from our Biology textbooks about the living creatures? May the teachers have a chance to expand students' knowledge about different species diversity, the biodiversity?

My survey was conducted based on that. The surveyed population was the circle of Hungarian teachers, who were asked about their biodiversity, species diversity teaching methods and possibilities. A relatively wide population provided an opportunity for extensive analysis of the data due to the number of evaluable data in the sample and the reliability of the availability. Based on the data obtained for the sample, the following probability statements can be made:

Bringing pupils outside the classrooms for learning purposes is more popular in Hungarian primary schools than in secondary schools. If Science and Biology teachers they have a chance to go outside with the class, they tend to do it, even if it is a park or a nearby forest.

The same is true for nearby old trees and bird feeders, being the representatives of plant and animal species, they would need more of it because the examined Hungarian teachers added

some comments, too and these comments revealed that more illustration would be required under natural conditions.

Acknowledgement

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Appendix 1

A természetben történő oktatás fejlesztése

Kedves Kollégánk!

Az alábbi kérdőív kitöltésével segítse kutató munkánkat a természetben történő oktatás fejlesztése kapcsán.
Kérjük legkésőbb 2017. május 24-ig végezze el a kitöltést. Válaszait anonim módon kezeljük.

Üdvözlettel:
Az Eszterházy Károly Egyetem Neveléstudományi Doktori Iskolájának biodiverzitással, azon belül faji diverzitással foglalkozó kutatócsoportja

1. Hol tanít?

(Kérem adja meg a település nevét és azt, hogy milyen típusú iskolában tanít. pl. általános iskola, középiskola ... stb.)

Saját válasz

2. Milyen tantárgyakat tanít?

Saját válasz

3. Hány éve tanít természettudományos tantárgyat?

Saját válasz

4. Az intézmény, ahol tanít rendelkezik-e udvarral?

- ◯ Igen
- ◯ Nem

5. Tartanak-e természettudományos foglalkozásokat az intézmény udvarán?

- ◯ Igen
- ◯ Nem

6. Az intézmény ahol tanít rendelkezik-e kerttel?

- ◯ Igen
- ◯ Nem

7. Tartanak-e természettudományos foglalkozásokat az intézmény kertjében?

- ◯ Igen
- ◯ Nem

8. Van-e öreg fa az intézmény környékén ahol tanít?

- ◯ Van
- ◯ Nincs

9. Ha van öreg fa az intézmény környékén, a természettudományos órák keretein belül felkeresik-e azt tanulmányozás céljából?

- ◯ Igen
- ◯ Nem

10. Van-e madáretető az intézmény területén?

- ◯ Van
- ◯ Nincs

11. Ha van madáretető az intézmény környékén, a természettudományos órák keretein belül felkeresik-e azt tanulmányozás céljából?

- ◯ Igen
- ◯ Nem

12. Van-e az intézményhez közeli erdő?

- ◯ Van
- ◯ Nincs

13. Ha van közeli erdő az intézmény környékén, a természettudományos órák keretein belül felkeresik-e azt tanulmányozás céljából?

- ◯ Igen
- ◯ Nem

14. Van-e az intézményhez közel park?

- ◯ Van
- ◯ Nincs

15. Ha van park az intézmény környékén, a természettudományos órák keretein belül felkeresik-e azt tanulmányozás céljából?

- ◯ Igen
- ◯ Nem

16. Elégségesnek tartja-e az élőlény példákat, amiket a természettudományos oktatás során használunk?

- ◯ a) elégségesnek tartom
- ◯ b) soknak tartom
- ◯ c) kevésnek tartom
- ◯ d) nincs véleményem

17. Rangsorolja, hogy mely állatokat tanítja szívesen az alábbiak közül?

(1. érték: legszívesebben tanítja, 5. érték: legkevésbé tanítja szívesen)

	1.	2.	3.	4.	5.
egzotikus nagy ragadozókat	○	○	○	○	○
erdei ragadozókat	○	○	○	○	○
távoli tájak növényevő állatait	○	○	○	○	○
hazánk növényevő állatait	○	○	○	○	○
hazánk vizeinek állatait	○	○	○	○	○

18. Rangsorolja, mely növényeket tanítja szívesen az alábbiak közül?

(1. érték: legszívesebben tanítja, 5. érték: legkevésbé tanítja szívesen)

	1.	2.	3.	4.	5.
trópusi esőerdők növényei	○	○	○	○	○
tajga-tundra növényei	○	○	○	○	○
mediterrán tájak növényei	○	○	○	○	○
mérsékelt öv növénye	○	○	○	○	○
hazánk növényei	○	○	○	○	○

19. Milyen gyakran használja a biológia tanítása során mezőgazdaságban termesztett növények példáját?

- ◯ a) félévente egyszer
- ◯ b) félévente ötször
- ◯ c) minden esetben ha példát kell mondani rá
- ◯ d) egyszer sem

20. Milyen gyakran használja a biológia tanítása során a tenyésztett állatok példáját?

- ◯ a) félévente egyszer
- ◯ b) félévente ötször
- ◯ c) minden esetben ha példát kell mondani rá
- ◯ d) egyszer sem

21. Ha tanulmányi kirándulást szervezne fajok bemutatására, mi jutna eszébe a következő lehetőségek közül? Kérem rangsorolja!

(1. érték: leginkább, 7. érték: legkevésbé)

	1.	2.	3.	4.	5.	6.	7.
erdei séta	◯	◯	◯	◯	◯	◯	◯
múzeumi állatgyűjtemény	◯	◯	◯	◯	◯	◯	◯
állatfarm	◯	◯	◯	◯	◯	◯	◯
tanya	◯	◯	◯	◯	◯	◯	◯
udvarház	◯	◯	◯	◯	◯	◯	◯
vadaspark	◯	◯	◯	◯	◯	◯	◯
állatkert	◯	◯	◯	◯	◯	◯	◯

22. Szakmailag hogyan tartja hatékonyabbnak az állandó megfigyelést?

- ◯ a) egész évben egy konkrét helyen
- ◯ b) minden alkalommal máshol

23. Szokott-e élő anyagot használni a természettudományos órákon vagy inkább fotókon illusztrálja?

- a) Élő anyagot használok.
- b) Fotókon mutatom be.

24. Szokott-e a tanulóktól a tananyaghoz kapcsolódó, általuk gyűjtött saját mintákat kérni?

- a) Igen.
- b) Nem.

25. Szokott-e tanulók által készített gyűjteményeket kérni a természettudományos órákra?

- a) Igen.
- b) Nem.

26. A bekért tanulói gyűjteményeket önállóan szokta kiértékelni?

- a) Igen.
- b) Nem.

27. A bekért tanulói gyűjteményeket a tanulókkal szokta közösen kiértékelni?

- a) Igen.
- b) Nem.

28. A bekért tanulói gyűjteményeket a tanulók véleménye alapján szokta értékelni?

- a) Igen.
- b) Nem.

29. Szokta-e érdemjeggyel értékelni a tanulói gyűjteményeket?

- a) Igen.
- b) Nem.

30. A gyűjtemények értékelésekor rá szokott-e kérdezni, hogy honnan származnak a gyűjtemény elemei?

- a) Igen.
- b) Nem.

A kérdőívvel kapcsolatos észrevételeit ebben a pontban tudja jelezni. Köszönjük, hogy részt vett a kitöltésben.

Saját válasz

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Publications, target groups, methods and applications in the communication of biodiversity

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Abstract

One of the main goals of conservation biology is protection of biodiversity. Some important new tools to achieve this goal are science education and communication to the public, as well as communication of scientific research results for decision makers. Objectives of this study were (1) to investigate what are the main topics in science on communicating the concept of biodiversity, what are the best methods for communicating this concept and (2) to communicate the concept of biodiversity to local community. To obtain more accurate and systematic results, we were working with special settings and metadata of Google Scholar, Web of Science and Scopus. We have analysed the metadata of all the results and 30 highly cited articles, making citation networks using CitationGecko. The results of our analysis showed that we need metaphors, storytelling, strong emotions and framing techniques to reach the policy-makers and non-scientists. To strengthen the nature – people relationship we need local projects. We have started our local work in promoting the notion of biodiversity 2 years ago. Our innovative idea is to present and provide knowledge to local communities not only on diversity of species, but also an ecological diversity using interactive workshops. In this context we have developed a series of games in order to better know and understand our local and regional values.

Keywords: communicating biodiversity; science-communication; nature education; Cluj

1. Introduction

The term 'biodiversity' was introduced by Walter G. Rosen in 1986 on "*The National Forum on BioDiversity"* (Maclaurin & Sterelny, 2008). The concept of biodiversity generally refers to variability of life on Earth. In this paper we have used the phrases *taxon diversity* and *ecological diversity*, which were settled by Harper and Hawksworth (Harper & Hawksworth, 1994; Standovár & Primack B., 2001). The biodiversity loss has been recognized as a global problem since the conference in Rio de Janeiro in 1992, and all of the publications since then raise awareness that we need urgent changes both on the level of policy-making and individual action (Cardinale et al., 2012). Pál Juhász-Nagy has a simple explanation for why biodiversity loss is

a problem: „for the sake of development, we need a desirable diversity" (Juhász-Nagy, 1993). The main goal of conservation biology is to reduce biodiversity loss (Standovár & Primack B., 2001).

To implement in practice nature conservation activities, in some cases neither the deficit of experts, nor scientists are the problem, but the conflict of interest between local people, policy-makers and conservationists. These conflicts cannot be solved easily or fast, but some of them can be solved if the communication strategies will change (Casajus et al., 2018; Standovár & Primack B., 2001).

Nature education can be a tool for conservation biology to reach the target 1 (*"By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably."*) of strategic goal A (*"Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society."*) of the Aichi Biodiversity Targets (link1). The students are *"woefully lacking in basic ecological knowledge"*– this was the main conclusion of a paper, which analysed 110 papers about nature education in elementary and secondary school published between 1993-1999 (Rickinson, 2001). One of the main goals of nature education is to decrease "*environmental illiteracy*" (Bickford, Posa, Qie, Campos-Arceiz, & Kudavidanage, 2012). New words and concepts which we should use while planning nature education workshops are "*plant blindness*" (Wandersee & Schussler, 2012), "*nature deficit disorder*" (Louv, 2010), "*nature-based solutions*" (Walters, Janzen, & Maginnis, 2017), "*citizen science*" (Kullenberg & Kasperowski, 2016).

Based on the above-mentioned studies, we can affirm that new methods are needed: (1) in the science-communication of ecology, biology and conservation biology to the policy-makers, and (2) in nature education.

2. Objectives

The objectives of this study were: (1) to overview and evaluate the literature on "communicating biodiversity" in a structured and repeatable way and (2) to communicate the concept of biodiversity to the local community.

3. Methods

3.1. Methods of literature review

To ensure the repeatability of the literature review, we have used the search engines and configurations presented in Table 1.

Table 1. The search engines and configurations used for the literature review

No.	**Search engine**	**Expression searched**
A	Google Scholar	*"communicating biodiversity"* - the exact phrase in the title of the article, without patents and citations, between 1950 – 2018, language: English
B	Google Scholar	*"communicating biodiversity"*– the exact phrase anywhere in the article, without patents and citations, between 1950 – 2018, language: English
C	Web of Science	*"communicating biodiversity"* – the exact phrase in the title, abstract or the keywords, *"all databases"* option, between 1950-2018, language: English
D	Scopus	*"communicating biodiversity"* – the exact phrase, *"all fields"* option, all the years except 2019, language: English

In the case of all searches, we have chosen to highlight the results based on the following rules: 1) if the number of results were under 20 results we have highlighted all the results, (2) if the number of results were between 20-1000, then a) in the case of Google Scholar, we have organized the results based on relevancy and have chosen the first 10 results b) in the case of Scopus and Web of Science, we have organized the results based on citation and we have chosen the first 10 highly cited results.

We have made figures about some characteristics of results based on their metadata (fig.1, fig.2, fig.3, fig.4), used software: Mendeley, Zotero, R.

In the case of A, B and D searches (Table 1), we have made citation networks using CitationGecko software. We have ignored citation network of C search, as it didn't bring new information compared to the citation networks of A, B and D searches. The CitationGecko software uses the data from microsoft academic, open citations and crossref (Walker, 2018).

3.2. Methods of communicating biodiversity to local community

To communicate biodiversity, one of the easiest approaches is to organize events related to the International Day for Biological Diversity (22 May). In Cluj region the first celebration of Biodiversity Day was in 2005, and since then (between 2005-2017) it had been organized several times by different organizations. The main concept was to make a species list in different areas near Cluj, to present the taxon diversity (link2, link3, link4, link5, link6). Our approach from 2018 was to present ecological diversity, as well, with our *"Varietas delectat"* event, applying museum pedagogy and experiential education methodology (link7, link8). The diversity was presented based on the "Species of the Year" voted in Hungary and Romania (for the full species list what we have used on our workshops see Appendix A, Table A1).

The "Species of the Year" initiative works on the idea that there are some species selected by specialists to which the non-scientists can vote for, and the winner will be the Bird of the Year, for example, in a region or country. The target-group of this initiative are the citizens, not the policy-makers, the aim is to communicate information and correct misconceptions about the species (link9). This initiative is connected to target 1 from strategic goal A of Aichi Biodiversity Targets (link2).

4. Results and discussion

4.1. Results of literature review

4.1.1. The review of highlighted results

We have had 30 highlighted results as mentioned in chapter 3. For the list of publications and their detailed analyses, see Appendix B. Based on these publications, the four big topics which are present in the literature are:

(1) the importance of metaphors and framing techniques in communicating biodiversity to the policy-makers and to the citizens (Casajus et al., 2018; I Hellsten, 2002; Iina Hellsten, 2003; Hesselink et al., 2004; Koteyko, Thelwall, & Nerlich, 2010; Kusmanoff, 2017; Kusmanoff, Fidler, Gordon, & Bekessy, 2017; Larson, 2011; Ruiz-Mallén, 2016; Samuels, 2017; Stibbe, 2012; Väliverronen & Hellsten, 2002; Voss, King, & Bernhardt, 2015),

(2) for efficient communication to the citizens, we need emotion-connected knowledge, story-telling, presenting the local biodiversity, organizing nature education programs combined with arts, participatory communication (Bright, Barro, & Burtz, 2002; Casajus et al., 2018;

Chibememe, 2014; Jung & Streit, 2014; Myers A, 2003; Nöske & Zedda, 2014; Opermanis, Kalnins, & Aunins, 2015; Raven & Williams, 1997; SeppÄNen & VÄLiverronen, 2003; Väliverronen & Hellsten, 2002),

(3) for efficient communication to the policy-makers, we need simple figures (Angelstam et al., 2004; Fallding, 2004; Han et al., 2014; Turak, Regan, & Costello, 2017; Voss et al., 2015; Webby, Droser, & Paris, 2004),

(4) the offsetting schemes for companies (Hermansson, 2018; Quétier & Lavorel, 2011).

The focus of this paper and our practical application of it are related to the first two topics mentioned above.

The role of metaphors has been studied by Finnish researcher, Esa Väliverronen and Dutch researcher, Iina Hellsten. In the 60's, the environmental problems were presented as war: "the war against nature", "the battle over nature". These metaphors were the most widespread ones used at the time. From the 80's, new concepts and ideas have appeared, for example "sustainable development", "we need relation between nature and man", "the biodiversity as a cultural heritage" (Väliverronen & Hellsten, 2002). The "biodiversity as a cultural heritage" is the link between metaphors and framing techniques. Samuels thinks that we must have a cultural framing for biodiversity, otherwise people won't care about it (Samuels, 2017). In the topic of framing techniques, Kusmanoff is one of the main researchers, and one of his most interesting contribution is about the concept of "ecosystem services". For a long time, one huge critique against nature conservationists was that it does not have a monetary value for the biodiversity, and as an answer to this critique, the concept of "ecosystem services" was made. Kusmanoff says that "ecosystem services" is not efficient framing, because based on the "motivation crowding theory" the outer, monetary motivation destroys the inner motivation (Kusmanoff, 2017).

In the topic of communicating with the citizens, the common conclusion of publications was that we need to present the local natural values, because this motivates people to conservation biology actions. Beside this, the artistic component is also very important in its function of presenting the local values. The programs which have both intellectual and artistic components are the most efficient (Opermanis et al., 2015).

In the publication of Hesselink et. al (2004), the word "opinion-leaders" is presented as an important notion. When communicating science, the first step would be to find these opinion-leaders in a community and consult them about further steps (Hesselink et al., 2004).

Even if we were aware of the importance of the third and fourth topics, we didn't go in details, because they were not strongly related to our practical work in communicating biodiversity to the local community.

4.1.2. The results of metadata

The concept of biodiversity communication is present in the literature since 1993. In the case of A, C and D searches the number of publications was not higher in the relation of time, but in the case of B search we can see an increasing tendency (Figure 1). If we are looking to the metadata for searching science communication, we can see an increase in the number of publications and the number of citations, too (Figure 2).

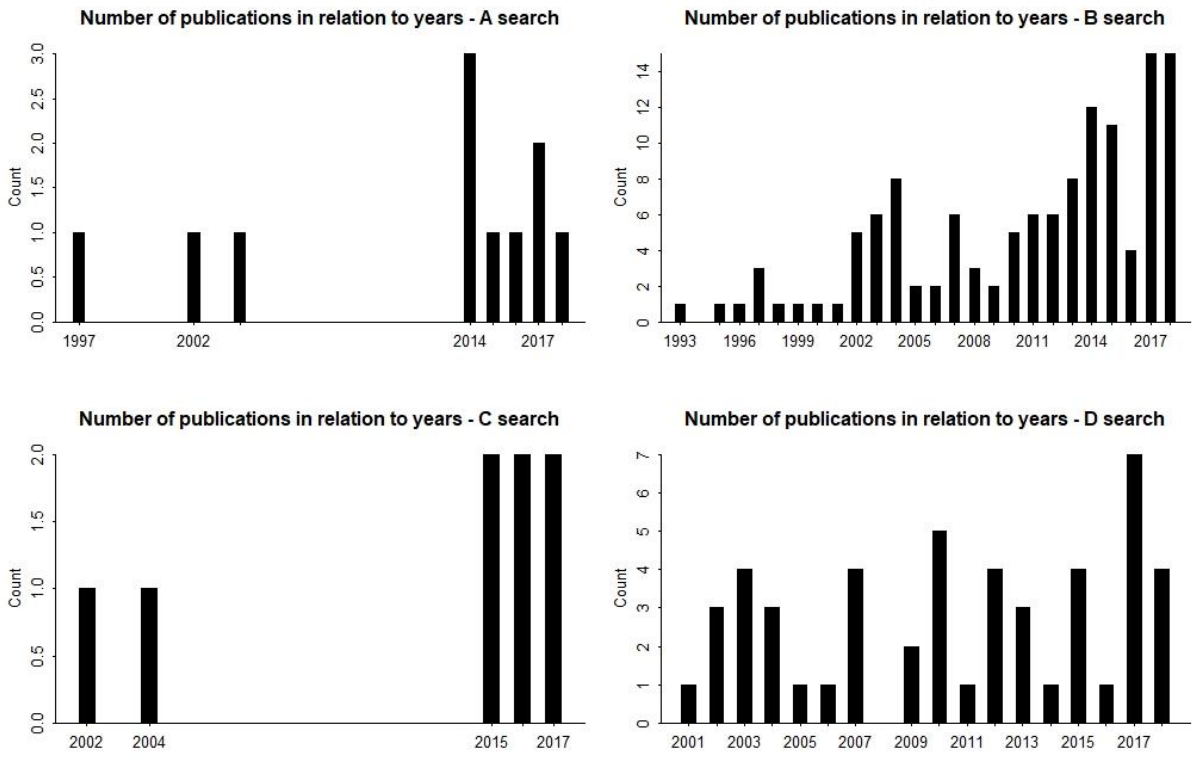

Figure 1. Number of publications per year for A, B, C and D searches (see Table 1)

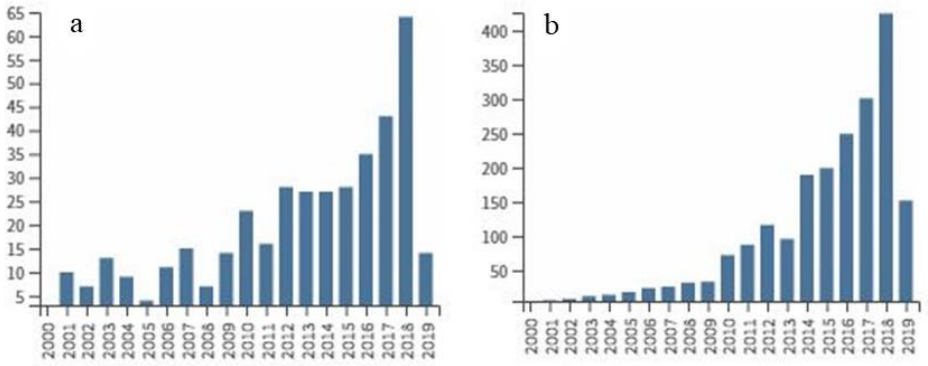

Figure 2. "Communicating science" phrase search in title, abstract and keywords: number of publications per year (a) and sum of times cited by year (b) (figure source: Web of Science)

Regarding to the number of type of publications we can say that a significant part of publications are articles, but to see the whole picture about communicating biodiversity, we cannot narrow the searches just for articles (figure 3).

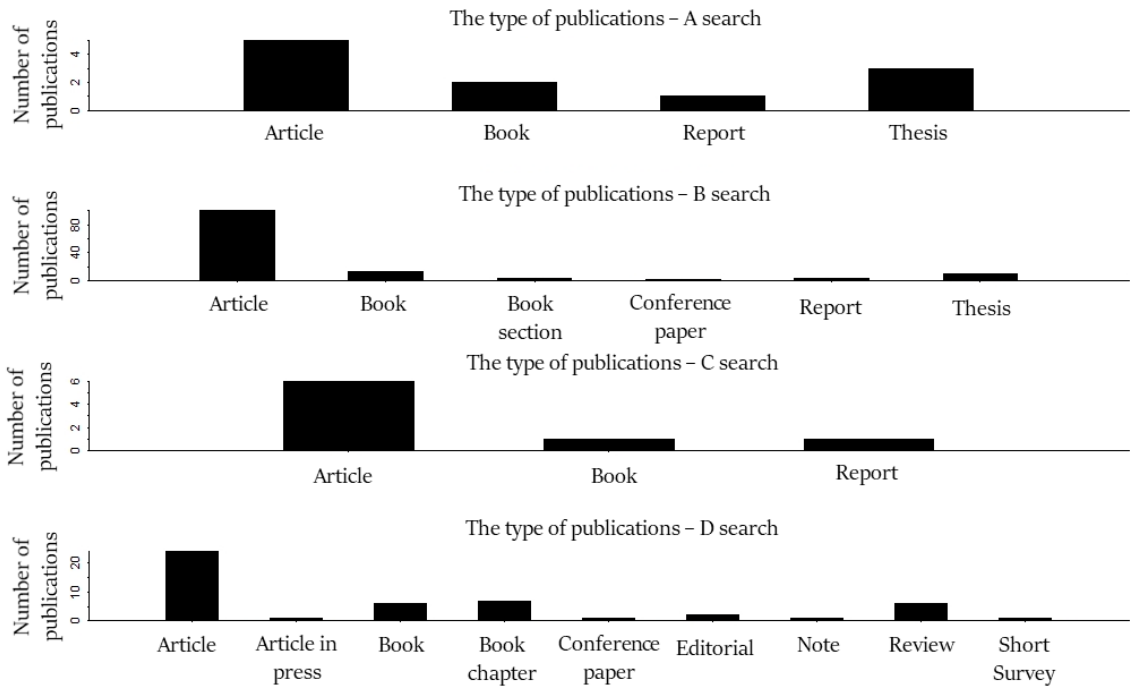

Figure 3. Number of publications in relation to type of publications

Social sciences and environmental sciences are the two main disciplines dealing with this topic (51%), but we cannot ignore agricultural sciences, arts and psychology (the remaining 49%) (figure 4).

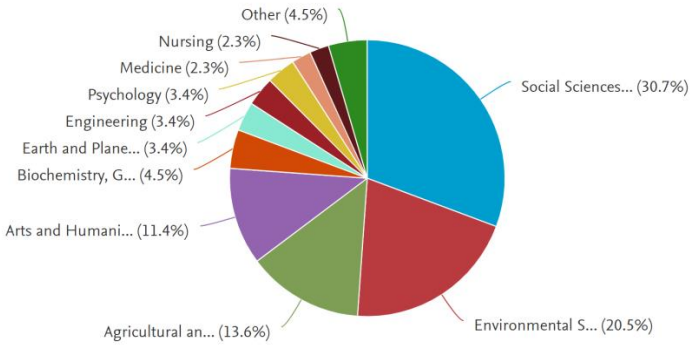

Figure 4. Disciplines in search D (source: Scopus)

4.1.3. Results of Citation Networks

A search: 11 results, 6 data (just the ones with DOI-number) on Citation Networks.

B search: 190 results, 69 data (just the ones with DOI-number) on Citation Networks

D search: 49 results, 38 (just the ones with DOI-number) data on Citation Networks.

We present here in detail the Citation Network of D search, because in that case we had the highest proportion of results with DOI-number (77.55 %). The Citation Networks for searches A and B can be consulted in Appendix C.

Analysing the network of papers cited by results of search D, one can observe one bigger sub-network (figure 5). It is advisable to use citation networks for the future literature reviews, to find related publications, which do not have the exact phrases in their title, abstract or keywords, but can be important. Above mentioned related publications are marked with red (figure 5). The sub-network's (figure 5b) topic is the communication strategy, regardless of the target audience. We have marked with green letters the publications which were highlighted results of the search D, and with red letters the publications which were highlighted in other results (figure 5).

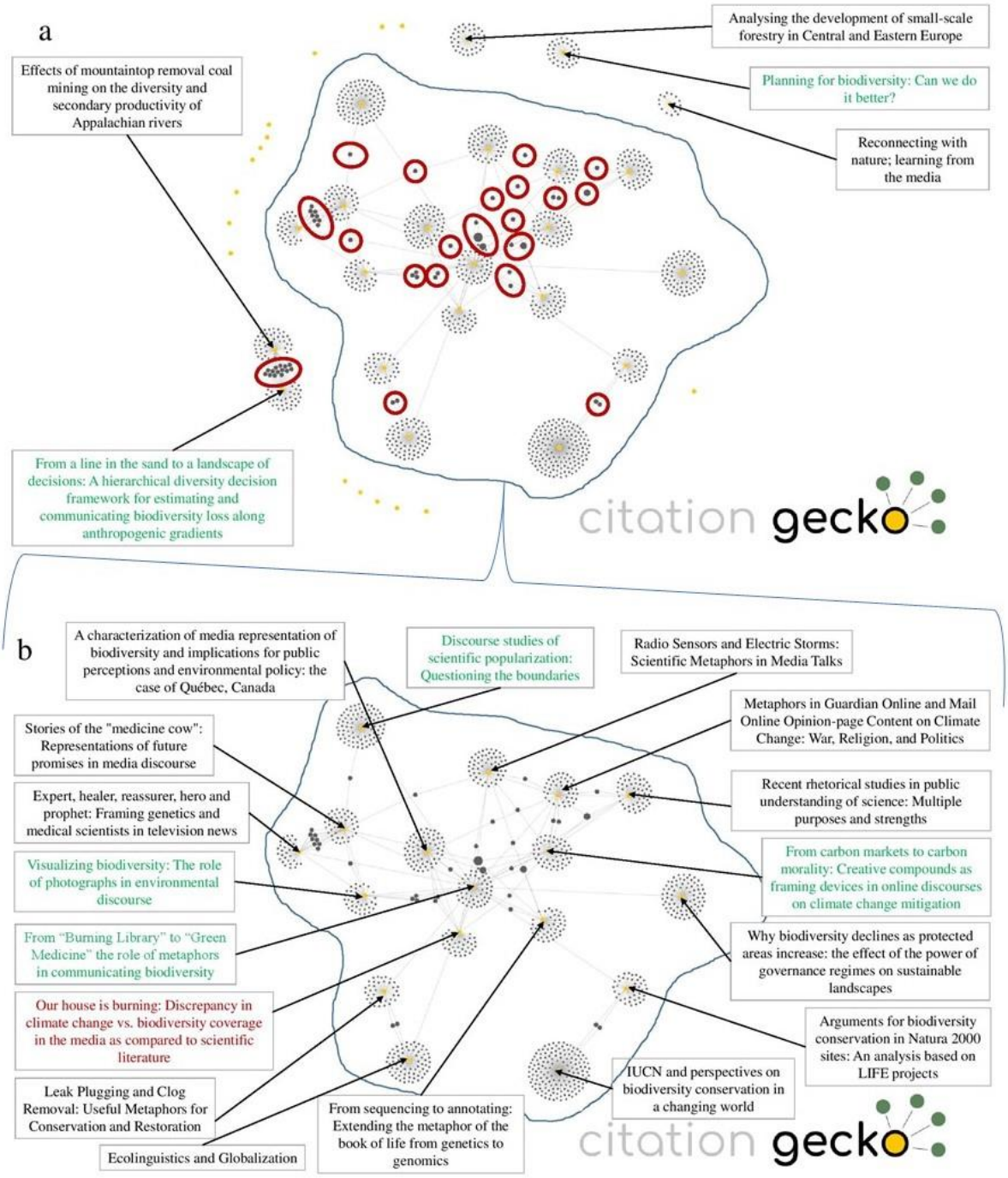

Figure 5. Citation Network 1 of search D; yellow dots – results of search D; **grey dots – papers cited by results of search D**; text-boxes: titles of papers which are hubs a) dots circled with red – papers cited by two or more by papers from the results of search D; b) subnetwork of Citation Network I

In case of search D there is a difference between Citation Network based on papers cited by the results (figure 5) and Citation Network based on papers citing the results (figure 6). At the second Citation Network we still have a sub-network but the hubs are different, mostly about metaphor topic (figure 5, figure 6).

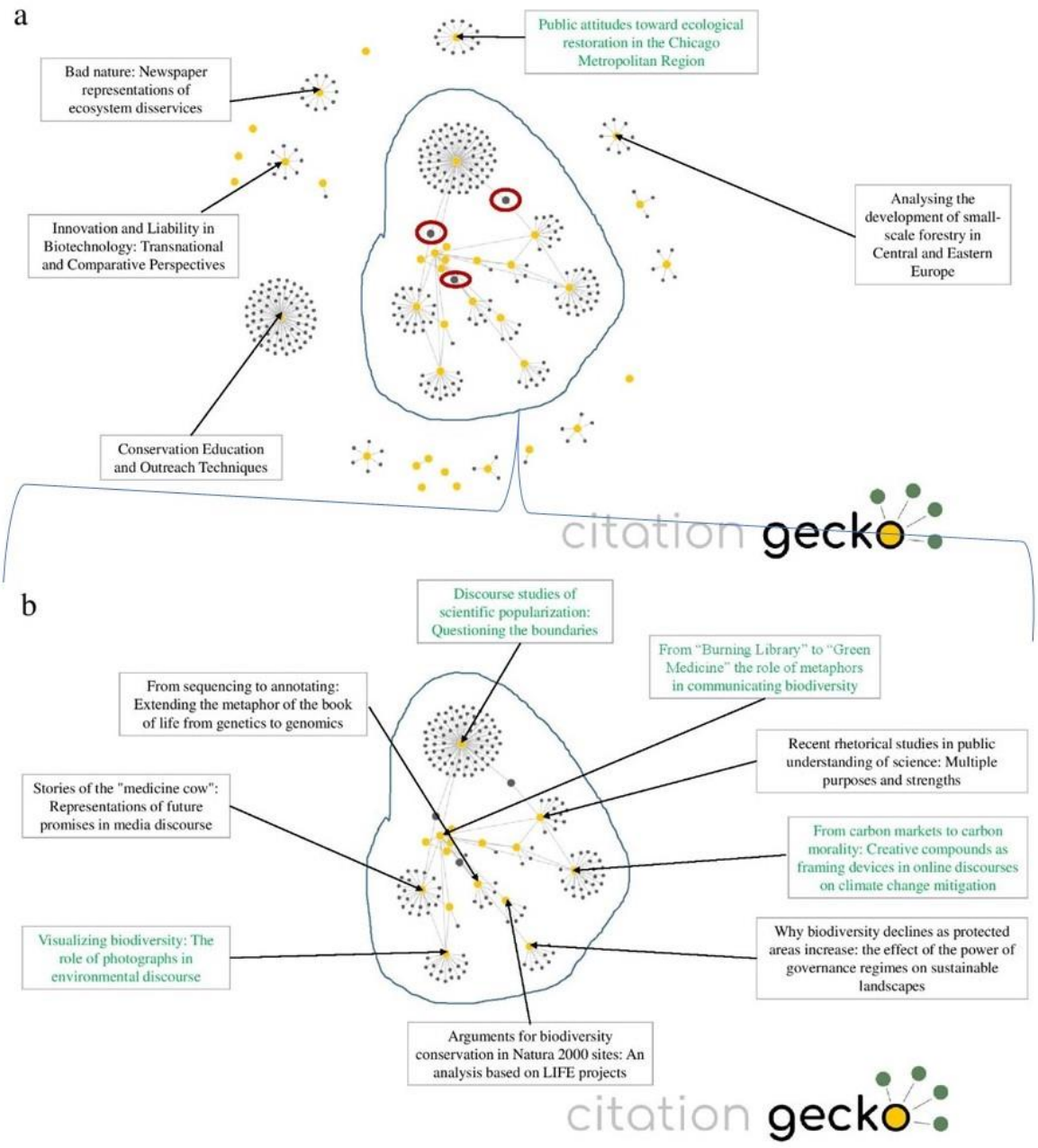

Figure 6. Citation Network 2 of search D; yellow dots – results of search D; **grey dots – papers citing the results of search D**; text-boxes: titles of papers which are hubs a) dots circled with red – papers citing two or more papers from search D; b) subnetwork of Citation Network 2

4.2. Application of theory into practice: nature education workshop and communicating biodiversity in local communities

During our workshops (figure 7), we work closely with the public and non-scientists. Based on literature and our own practical observations, we found that it is best to focus on activities where

participants can use most of their senses ("come in, see it, meddle it, shake it, feel it" – part of the 2018's workshop description). We have found that if is possible (in case of common species), it is preferable the use of the living organisms or part of these (in case of plants). Otherwise we strongly recommend the use of prepared materials. In lack of these, photos, drawings are useful in order to acquaint the participants with as many features of the species is possible. In addition to these we have used our hand-made mock-ups and interactive games.

Figure 7. The I. *"Varietas delectat"* event and part of our materials in May 26, 2018, photo: Szabó Csilla

After the celebration day (link7, link8), we brought the workshops to schools and kindergartens, and ultimately 120-150 children and 30-40 adults were attending our workshops. By having smaller groups each time, we have more time with one person and we can have a deeper conversation with participants. There is a higher chance to answer to their questions related to biology and ecology of the organisms concerned. If someone wants to organize nature education workshop or promote biodiversity, it is very important to have a deep knowledge in biology and ecology, because the visitors (especially children) are not always asking about the exact topic of the workshop that had been prepared beforehand.

We have created activities for all the species mentioned in Appendix A. We will present two from each year species in this paper.

4.2.1. Activites

The wild plant of the year 2018, *Gentiana pneumonanthe* is in the same genus as the *Gentiana asclepiadea*. The *Gentiana asclepiadea* appears on the Romanian banknote "1 RON", which is a banknote with little monetary value and thus widely known by adults and children as well. This banknote gave us the starting idea of this activity, where the players needed to pair the plants with the Romanian banknotes (figure 8). With the adults we had deeper conversations, for example about what is the state of nature conservation in Romania, why these are the first banknotes with the image of plants, about species names, etc. We have explained what is the meaning of the term "genus", and we were talking about taxonomy. We have a concept and the essence of the activity, but how we frame it, differs from one participant to the other.

Figure 8. The activity based on the Hungarian Plant of the Year 2018. Photo: Udvari Zita

A short video had been projected about the Hungarian Reptile of the Year 2018, *Zootoca vivipara,* from which the visitors could understand why the species has got the *vivipara* name. This activity also functioned as a break for people who did not wish to participate in other activities.

In 2019 our newest activity was a summary table about the Species of the Year, which had served as a good framework for the activities. We have linked one species with a specific object (figure 9). For example the *Hypericum perforatum* was linked with a bell, because one of its

Hungarian folk names is “bell-flower” (“csengővirág”), as shaking the dry fruits sounds like a bell.

Figure 9. The summary table at II. *“Varietas delectat”* event in 2019. Photo: Szabó Csilla

The activity about *Salamandra salamandra* put in practice the participative conversation theory. This game is a board game, where the players needed to ask questions of each other about the species highlighted during the event. The one who needed to answer could use every information in the event and could ask anyone, but not the other players about the problem. Some of us were players, too, so we could control the questions, to have some of them about fire-salamander, even if some of the children always had questions about the cheetah (the cheetah was presented at activity related to *Lynx lynx*, the Mammal of the Year 2019 in Hungary). The next level in this game was that the players needed to answer in 30 seconds. It was a good motivation for the kids to go fast to the other room and see the answers somewhere hanging on the wall or asking the leaders of the activities. This was a semi-structured activity: it was important that we did not have all the questions written, but we still had some questions prepared if the other players could not think of a new one. In addition, the game was home-made, invented by our ideas and the board we can use for numerous activities and topics (figure 6).

Figure 10. The board game for activity about fire-salamander (*Salamandra salamandra*). In the middle the life-sized fire-salamander. Hand-made by: Szabó Márta-Tünde, photo: Szabó Csilla

Based on the *Formica rufa* species group (insect of year 2019 in Romania), the *Ctenophora flaveolata* (Tipuloidea of the year 2019 in Romania) and *Rosalia alpina* (Insect of the Year 2019 in Hungary), we have presented the basic taxonomy of arthropods. For the *Formica rufa* we have made a mock-up with the components: head, thorax, petiole, abdomen (figure11). We talked with the visitors about what is the difference between insects and spiders, in which group can we put flies, wasps, ants or beetles. When talking about insects, in one of the classroom one kid said that the *Zerynthia polyxena* looks like an Indian-butterfly. This led us to the conclusion that if we leave space for this kind of associations, the visitors remember more of the information. Our practical experience is in consent with the literature: using metaphors while communicating biodiversity is indispensable.

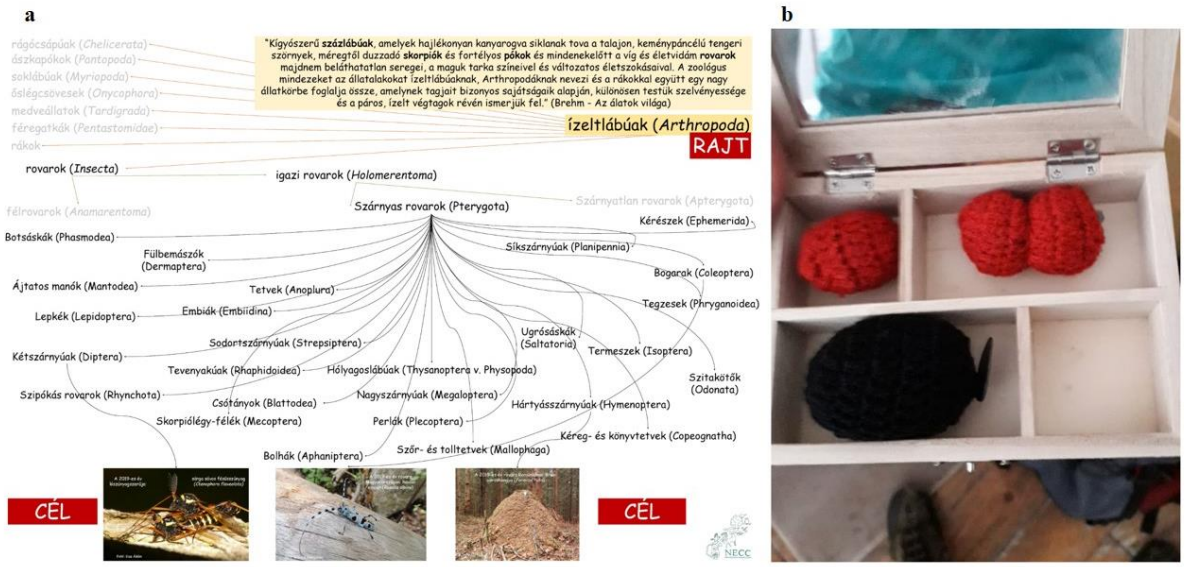

Figure 11. The materials of activities based on *Formica rufa* species group, *Rosalia alpina* and *Ctenophora flaveolata*; a – presentation of the basic taxonomy; b – mock-up for presenting *Formica rufa* and insect-morphology in general. Hand-made by Szabó Márta-Tünde, Szabó László and Szabó Csilla. Photo: Szabó Csilla.

5. Conclusions

The conclusions of the literature review about communicating biodiversity are the following: (1) the main topics found were the metaphors and the framing techniques, the measuring of loss of biodiversity and communicating results to the policy-makers, the offsetting schemes; (2) for efficient communication the right mode of framing is important: scientific, cultural, aesthetic; (3) it is important to: use metaphors; combine science with art; identify opinion-leaders in a community; use participative communication; promote the local natural values.

During our "*Varietas delectat"* workshops we have presented beside taxon diversity the ecological diversity as well. With our work we have been emphasizing the local nature values and urban biodiversity. Long-term positive effects of the workshops and the applied experiential pedagogy methods are at the moment hypothetical and should be tested later.

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Appendix A

Table A1. The species which have won the vote

Year and place	Species groups	Species
2018, Hungary	Bird	*Falco peregrinus*
2018, Hungary	Tree	*Fraxinus ornus*
2018, Hungary	Insect	*Anax imperator*
2018, Hungary	Fungi	*Hericium erinaceus*
2018, Hungary	Mammal	*Nannospalax leucodon*
2018, Hungary	Wild plant	*Gentiana pneumonanthe*
2018, Hungary	Reptile	*Zootoca vivipara*
2018, Hungary	Herb	*Lavandula angustifolia*
2018, Hungary	Fish	*Leuciscus aspius*
2018, Romania	Bat	*Rhinolophus mehelyi*
2018, Romania	Insect	*Phengaris teleius*
2019, Hungary	Bird	*Himantopus himantopus*
2019, Hungary	Mammal	*Lynx lynx*
2019, Hungary	Wild plant	*Doronicum hungaricum*
2019, Hungary	Fish	*Scardinius erythrophthalmus*
2019, Hungary	Insect	*Rosalia alpina*
2019, Hungary	Herb	*Hypericum perforatum*
2019, Hungary	Amphibian	*Salamandra salamandra*

2019, Hungary	Fungi	*Boletus aereus*
2019, Hungary	Tree	*Cerasus mahaleb*
2019, Hungary	Game species	*Perdix perdix*
2019, Romania	Bat	*Myotis bechsteinii*
2019, Romania	Insect	*Formica rufa species group*
2019, Romania	Diptera, Tipuloidea	*Ctenophora flaveolata*
2019, Romania	Bird	*Athene noctua*
2019, Europe	Tree	*Prunus dulcis*

Appendix B

Abbreviations: A1 - search A, 1. Result; doi-1: it has a DOI-number; doi-0: it doesn't have a DOI-number; sa – scientific article; phd – PhD thesis; b – book; p – poster at a conference; a – article; msc – master's thesis; bc – book chapter; ua – unpublished article.

1. *From "Burning Library" to "Green Medicine" the role of metaphors in communicating biodiversity* (Väliverronen & Hellsten, 2002) *(sa, doi-1, A1, B1, C1, D9).* Using metaphors is important, but there is no difference between positive and negative ones considering the success of implementation. To reach the target-audience it needs to evoke strong emotions.
2. *From a line in the sand to a landscape of decisions: a hierarchical diversity decision framework for estimating and communicating biodiversity loss along anthropogenic gradients* (Voss et al., 2015) *(sa, doi-1, A2, B6, C4, C9).* Communication between scientists and policy-makers: presenting the "HiDDeF – Hierarchical Diversity Decision Framework" which is a new method for measuring the diversity of aquatic invertebrates.
3. *Framing the Conservation Conversation: An investigation into framing techniques for communicating biodiversity conservation* (Kusmanoff, 2017) *(phd, doi-0, A3).* The conservationists should frame the message, in other disciplines this method is very popular and efficient. For example it matters if you frame the problem with hope or with

fear, there is a difference between saying that loss of biodiversity is a healthcare problem or something else.

4. *Biodiversity in World Heritage Cultural Landscapes: Possibilities and Problems for Communicating Climate Change and Mobilizing Mitigation* (Samuels, 2017) *(sa, doi-1, A4).* For the sake of efficient communication the problem of Climate Change should be framed as a cultural problem ("World Heritage Framework").
5. *Communicating biodiversity conservation to Forest Owners in East-Central Europe – Major Issues and Model Communication Strategies* (Hesselink et al., 2004) *(b, doi-0, A5).* To have efficient communication in a new community, the first step always should be to find the "opinion-leaders" and tell them first about the problems. In numerous projects there is no financial part for designing the communication strategies.
6. *Communicating biodiversity to young generations: examples from German urban areas* (Nöske & Zedda, 2014) *(p, doi-1, A6).* It emphasizes the role of education in science communication.
7. *Communicating Biodiversity and Wilderness to Urban People* (Jung & Streit, 2014) *(a, doi-0, A7).* There is a need in programs with local people as target-audience, instead of wealthy tourists. In some cases the nature areas are far from cities, from this reason it is important to present the urban biodiversity, too. There should be used two strategies in communicating biodiversity: one for the people who already have a connection with nature and one for the people who do not have any connection with nature.
8. *Communicating Biodiversity Offsetting in Sweden* (Hermansson, 2018) *(msc, doi-0, A8).* The main question of study is how can involve more companies into biodiversity offsetting scheme. The essential motive is the legal framework, if it is a law to do biodiversity offsetting, the companies will do it.
9. *Reaching the public: the challenge of communicating biodiversity* (Raven & Williams, 1997) *(bc, doi-1, A9).* The main conclusion of this paper is that local changes should be presented to people to understand the meaning of biodiversity concept.
10. *Communicating biodiversity conservation research Through dialogue and Mutual Learning in Rural and Indigenous Communities* (Ruiz-Mallén, 2016) *(sa, doi-1, A10, C8).* The conclusion of the article is that the communication between scientists and people is important, in developing countries usually this communication is from up to down, but it should be two-way communication, it is presented a project where they have used participatory communication.

11. *Communities managing commons for biodiversity conservation and the enhancement of their livelihoods and strategies for communicating resource management knowledge and skills in Sangwe Communal Lands* (Chibememe, 2014) *(ua, doi-0, A11).* It emphasizes the importance of presenting the local values combining science and art.
12. *Planning for biodiversity - Can we do it better?* (Fallding, 2004) *(sa, doi-1, B2).* It is about the connection between scientists and policy-makers in Australia. One of the main components of the urban planning should be biodiversity, but there are two problems with implementation: (1) the policy-makers are undereducated considering biodiversity concepts and (2) there is an information gap between scientists and policy-makers.
13. *Measuring and reporting biodiversity change* (Turak et al., 2017) *(sa, doi-1, B3, C3, C6).* It is about the connection between scientists and policy-makers, the conclusions are based on 11 studies. It is important to have a common measuring system to present the changes in biodiversity to the policy-makers. In one of the articles is presented a metaphor: the concept of EBV ("*Essential Biodiversity Value*"), which is very similar to *"Stock Market",* the policy-makers should make decisions based on EBV, like the investors make decisions based on Stock Market.
14. *Targets for boreal forest biodiversity conservation - a rationale for macroecological research and adaptive management* (Angelstam et al., 2004) *(sa, doi-0, B4).* There is a need to have a network, where conservationists and policy-makers can have a connection, to have efficient active conservation.
15. *Our house is burning: discrepancy in climate change vs. biodiversity coverage in the media as compared to scientific literature* (Casajus et al., 2018) *(sa, doi-1, B5).* To decrease the human impact on environment, we should have connections between policy-makers, scientists and media experts, because the way the media represents the information influences the political decisions. Between 1991 and 2016 in the USA, Canada and United Kingdom the media representation of climate change was eight times more than the media representation of biodiversity and this difference cannot be explained by the ratio-difference in scientific articles. The communication of climate-change to the public usually was connected to an event, in contrary to the communication of biodiversity. One of the reasons for this is, that the climate-change can be quantified and explained easier to the policymakers. Advices: organizing "Citizen Science Projects" and "reconnecting the people to the nature".
16. *A Biodiversity Indicators Dashboard: Addressing Challenges to Monitoring Progress towards the Aichi Biodiversity Targets Using Disaggregated Global Data* (Han et al.,

2014) *(sa, doi-1, B7).* The article is about the connection between scientists and policy-makers. They suggest to have an "operationalized online interface" to estimate and explain to policy-makers the impact on biodiversity.

17. *Assessing ecological equivalence in biodiversity offset schemes: Key issues and solutions* (Quétier & Lavorel, 2011) *(sa, doi-1, B8).* It is not strictly related to our topic, because it is about biodiversity offsetting schemes and their issues.
18. *The Politics of Metaphor: Biotechnology and Biodiversity in the Media* (I Hellsten, 2002) *(b, doi-0,B9).* This book's relevant information is the importance of metaphors, what we have mentioned already.
19. *Decline of 'biodiversity' in conservation policy discourse in Australia* (Kusmanoff et al., 2017) *(sa, doi-1, B10).* The study is about the representation of word "biodiversity" and "ecosystem services" between 1995 and 2015 in "3553 media releases Australian Government environment portfolio and 1064 media releases Australian Conservation Foundation". The usage of word biodiversity has decreased with time and the usage of ecosystem services has increased. The opinion of authors is that because of this the people may have lower connection and commitment to nature, because ecosystem services concept is a monetary one. In this point of view this is a very interesting article, because the concept of ecosystem services was invented to explain easier the value of biodiversity to economic experts.
20. *Final report of IGCP Project 410 (1997-2002) - The great Ordovician biodiversification event* (Webby et al., 2004) *(sa, doi-0, C2).* It is not strongly related to our topic, it was in the results, because there are some diversity measurements which can help to communicate the value of biodiversity to policymakers.
21. *Merging science and arts to communicate nature conservation* (Opermanis et al., 2015) *(sa, doi-1, C5).* They have started the "Nature Concert Hall" project, where they combined science with art. Based on their poll, the 56% of the visitors wouldn't have go to the event if there would be just the scientific component and after the event 80% of visitors said they have learnt something about biodiversity.
22. *Biodiversity and Education for Sustainable Development* (Barrico & Castro, 2016) *(b, doi-1, C7).* The book is about: invasion biology, sustainable development, online educational material, urban biodiversity. The main conclusion is that the society must be implicated to the conservation biology, one of the detailed projects which is strongly related to our project is presented at 10th highlighted result.

23. *Discourse studies of scientific popularization: Questioning the boundaries* (Myers A, 2003) *(sa, doi-1, D2).* The article's conclusion is that scientific communication should be a two-way communication. The public shouldn't be just a "blank slate" in the eyes of scientists.
24. *Metaphors for environmental sustainability: Redefining our relationship with nature* (Larson, 2011) *(b, doi-0, D3).* The science communicators should use metaphors to have more efficient communication.
25. *From carbon markets to carbon morality: Creative compounds as framing devices in online discourses on climate change mitigation* (Koteyko et al., 2010) *(sa, doi-1, D4).* The article is about comparing the framing techniques in the science communication of climate-change through the time: financial framing (1992-1999), lifestyle framing (1992-2004), attitude framing (2004-2008).
26. *Animals erased: Discourse, ecology, and reconnection with the natural world* (Stibbe, 2012) *(b, doi-0, D5).* The book is about why is important to have connection with nature, in principle focuses on animals – people relation and also has the conclusion that using metaphors can help in communication.
27. *Public attitudes toward ecological restoration in the Chicago Metropolitan Region* (Bright et al., 2002) *(sa, doi-1, D6).* The conclusion of article is that in the society there are negative and positive attitudes towards ecological restoration in the Chicago Metropolitan Region, and to have more positive attitudes it is a must to have proper nature education.
28. *Focus on metaphors: The case of "Frankenfood" on the web* (Iina Hellsten, 2003) *(sa, doi-0, D7).* It is not strongly related to our topic, because it is about the metaphor "frankenfood", which is about genetically modified food.
29. *Visualizing biodiversity: The role of photographs in environmental discourse* (SeppÄNen & VÄLiverronen, 2003) *(sa, doi-1, D8).* Using of photographs in communication of biodiversity is important because there can create more emotional connection than simple texts.
30. *On the frontier of science: An American rhetoric of exploration and exploitation* (Ceccarelli, 2013) *(b, doi-0, D10).* It is not strongly related to our topic, it is about the metaphor of *"The frontier of science"*.

Appendix C

Based on Citation Network1 of search A, the results are not citing to each other and they don't have common citations, we can say that they have separated topics, it is useful to read all of them (figure A1).

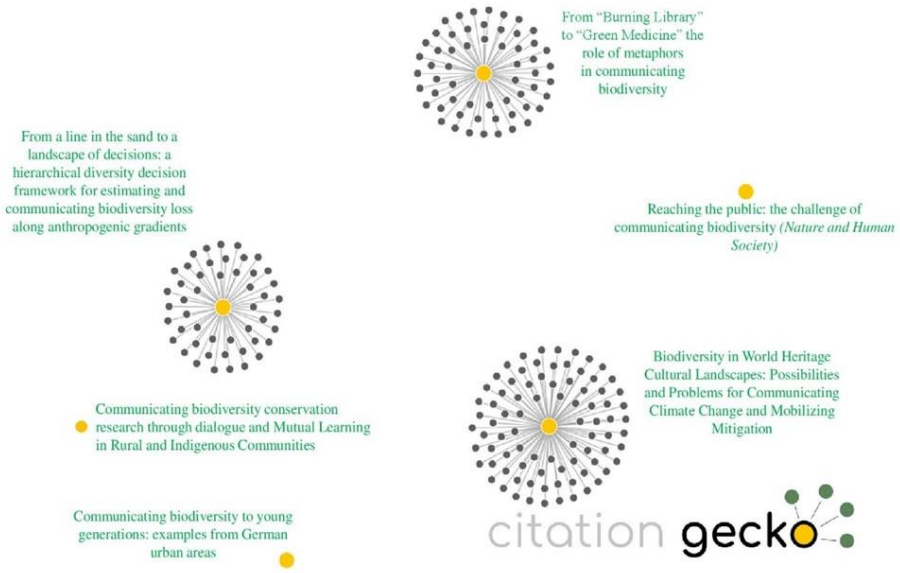
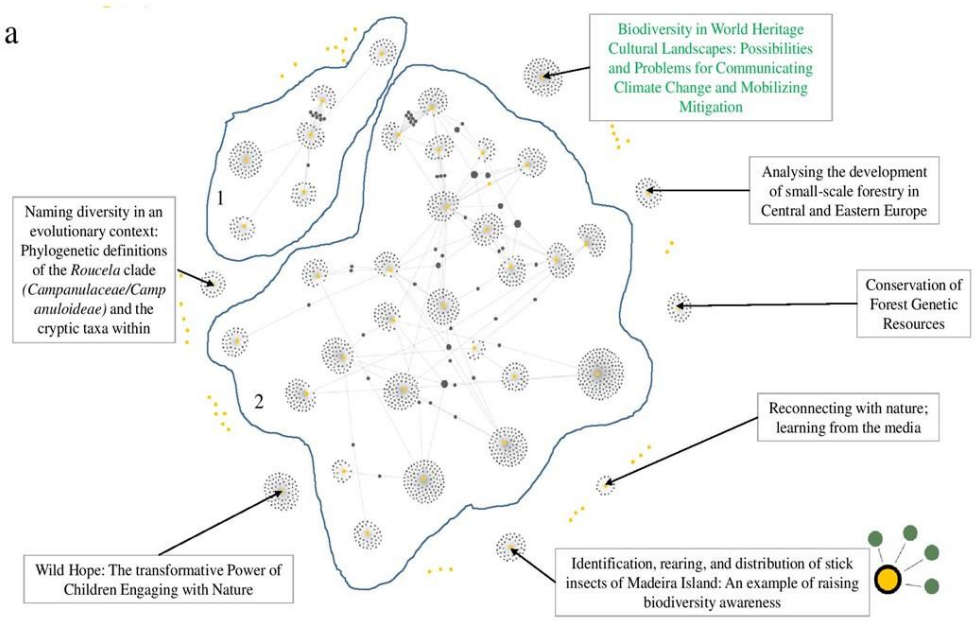


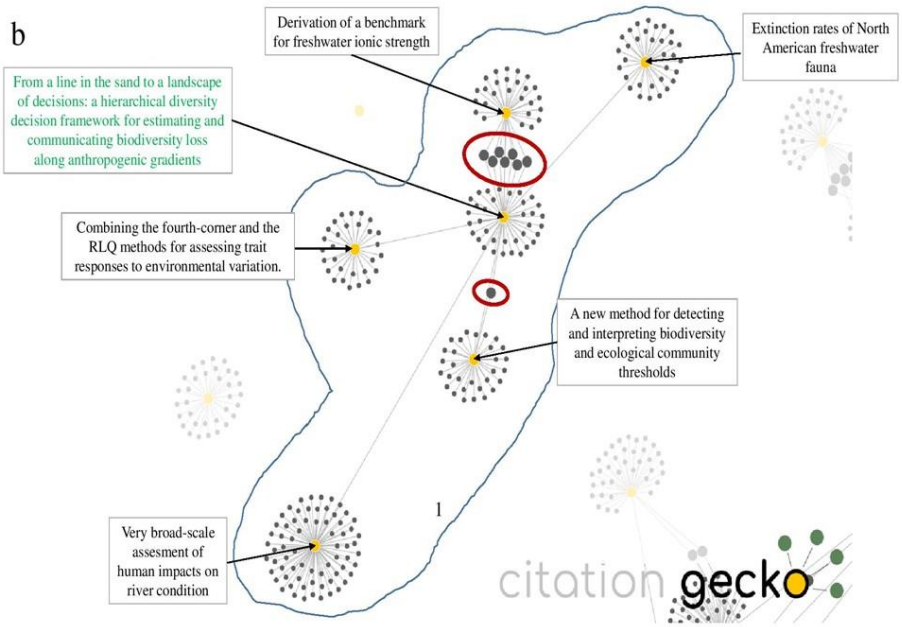
Figure A1. Citation Network 1 of search A; yellow dots – results of search A; **grey dots – papers cited by results of search A**; text-boxes: titles of papers from search A

Based on Citation Network 2 of search A, where the grey dots are the papers which are citing the results, the most important result is a paper which emphasizes that the metaphors are essential in communicating biodiversity, but it can be efficient using strong emotions (figure A2) (Väliverronen & Hellsten, 2002).

Figure A2. Citation Network 2 of search A; yellow dots – results of search A; **grey dots – papers citing to the results of search A**; text-boxes: titles of papers from search A

In case of search B from 190 results on Citation Networks there are 69 results, which had DOI-numbers (figure A3, figure A4). Based on Citation Network 1, where we can see papers cited by the results of search B, we identified 2 sub-networks and 7 hubs, which are outside of sub-networks. From 7 hubs we have marked with green letters which was in the highlighted results (figure A3 a). The first sub-networks topic is about measuring the biodiversity, we have marked with red circles publications which are important to read, but during advanced search we didn't find them (figure A3 b). The second sub-network is strongly related to our practical implementations, we have written the first 25 hubs title to the figure, with green what the search B found and with red what the search A, B or C found (figure A3 c). The publications which are important to read, but during advanced search we didn't find, we have marked with red circles (figure A3 d).


a
Biodiversity in World Heritage Cultural Landscapes: Possibilities and Problems for Communicating Climate Change and Mobilizing Mitigation
Analysing the development of small-scale forestry in Central and Eastern Europe
Naming diversity in an evolutionary context: Phylogenetic definitions of the *Roucela* clade *(Campanulaceae/Campanuloideae)* and the cryptic taxa within
Conservation of Forest Genetic Resources
1
2
Reconnecting with nature; learning from the media
Wild Hope: The transformative Power of Children Engaging with Nature
Identification, rearing, and distribution of stick insects of Madeira Island: An example of raising biodiversity awareness


b
Derivation of a benchmark for freshwater ionic strength
Extinction rates of North American freshwater fauna
From a line in the sand to a landscape of decisions: a hierarchical diversity decision framework for estimating and communicating biodiversity loss along anthropogenic gradients
Combining the fourth-corner and the RLQ methods for assessing trait responses to environmental variation.
A new method for detecting and interpreting biodiversity and ecological community thresholds
1
Very broad-scale assesment of human impacts on river condition
citation gecko

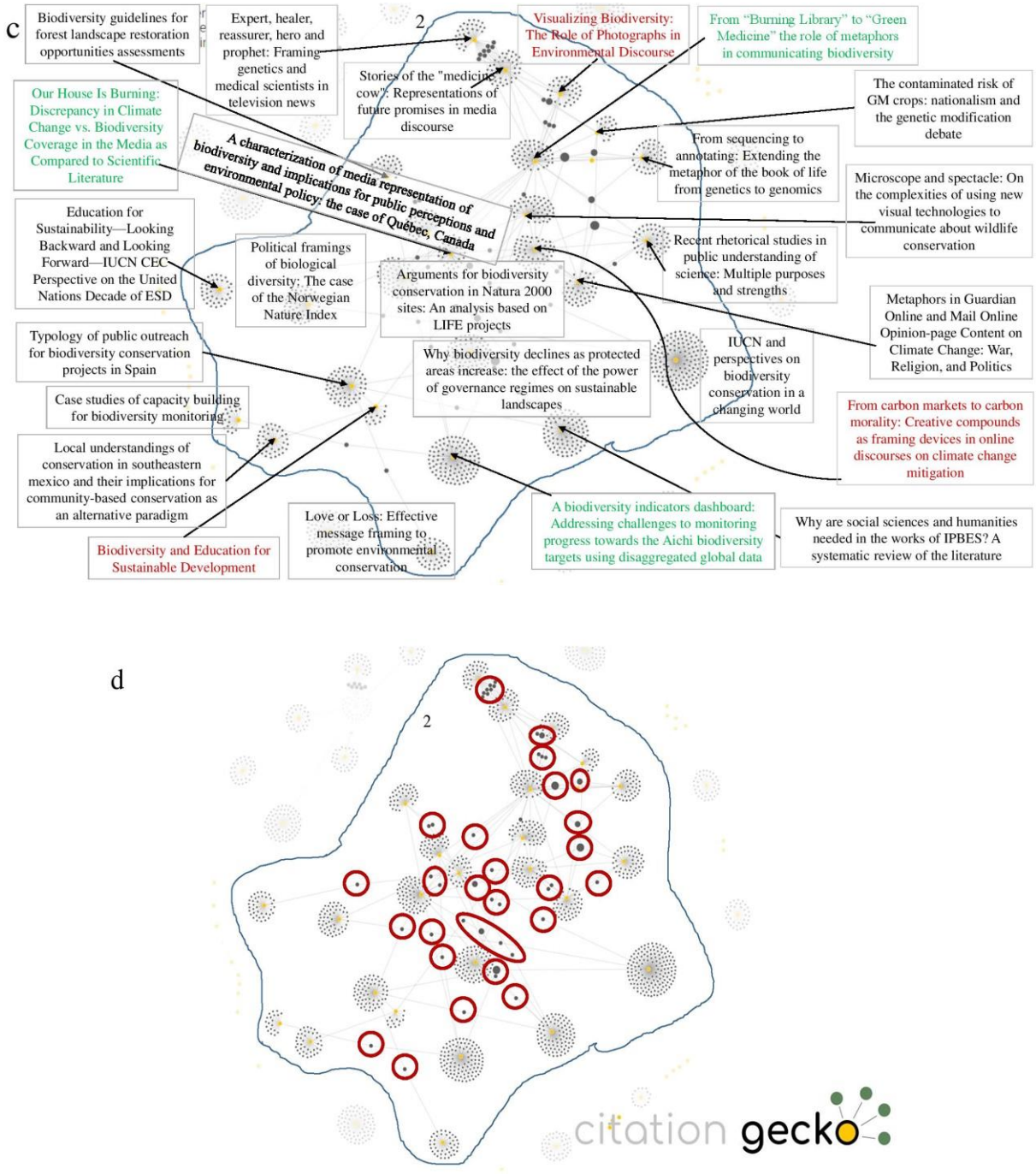


Figure A3. Citation Network 1 of search B. Yellow dots – results of search B, grey dots – papers cited by results of search B; dots circled with red - papers cited by two or more papers from search B; a – the whole network, b – 1. sub-network, c – 2. sub-network with titles, d –2. sub-network without titles

On Citation Network 2 of search B we have the same sub-networks (topic of metaphors and topic of measuring and communicating the biodiversity to the policy-makers), but the topic of measurements of biodiversity seems more important. We have marked with red circles publications which are important to read but the searches did not found it (figure A4).

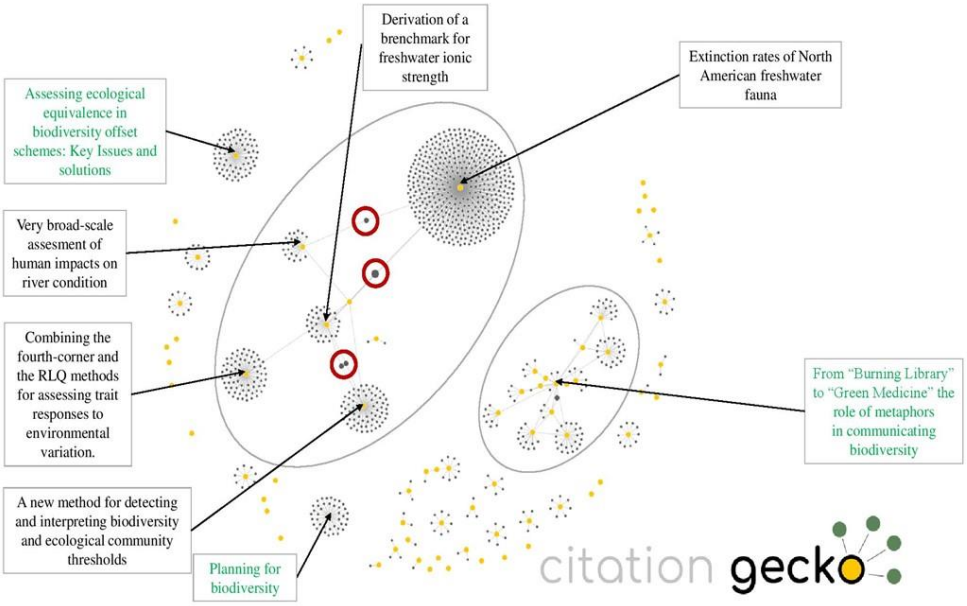


Figure A4. Citation Network 2 of search B. Yellow dots – results of search B, grey dots – papers citing to the results of search B; dots circled with red - papers citing two or more papers from search B;

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Polarized ecological traps at a mountain creek

A good practice in experiential environmental education

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Abstract

It is well-documented that highly and horizontally polarized light reflected from shiny dark artificial surfaces has adverse effects on positively polarotactic aquatic insects, including all insects, the larvae of which live in water. Such man-made surfaces may act as 'polarized ecological traps' for polarotactic insects, because they are inappropriate for the development of eggs laid by the deceived and attracted aquatic insects. We performed a field experiment on 27 May 2019 at a mountain creek and its anthropogenic environment to study this phenomenon. Our studies were carried out by Hungarian university students in a senior level biology teacher class. The methods and results can also be used in high and secondary schools. Our aim was to introduce students to the visual ecology of water insects, and help them to apply their knowledge the practice of environmental education.

Keywords: Asphalt road; Car paint work; Environmental education; Field experiment; Mayfly; Polarotaxis

1. Introduction

Totally linearly polarized light is composed of electromagnetic waves vibrating in a single plane. The light in which the waves with the same amplitude at a given wavelength vibrate in many planes is referred to as unpolarized (e. g., sun light). Unpolarized light can become partially polarized by reflection, refraction, and scattering. The photoreceptors in the human eye are not sensitive to polarization. Polarized filters are made of special materials, which are

capable of blocking one of the two planes of vibration of the electromagnetic waves. When unpolarized light is incident to such a filter, it emerges as totally linearly polarized. Light reflected by shiny non-metallic surfaces such as asphalt road and water is partially or totally linearly polarized, except when the light is incident perpendicular to the surface. A linearly polarizing filter can be used to observe this effect (as an analyzer) by rotating it while looking through. At certain directions, the reflected polarized light will be filtered, thus some parts of the image will be darker. Linearly polarizing filters block all light polarized at 90° to the filters' transmission axis. A polarizing filter with a proper direction of its transmission axis can attenuate most of the polarized light reflected from different surfaces (e.g. water surface, asphalt road, shiny black plastic sheet used in agriculture, bodywork of dark-coloured cars) (Fig. 1).

Fig. 1. Pictures on the left side (A, C, E) were taken through a linear polarizer with horizontal transmission axis, while pictures on the right side (B, D, F) were taken through a polarizer with vertical transmission axis. (A-B) Water surface. (C-D) Shiny dry black circular plastic sheets on a dry asphalt surface. (E-F) Red car (Suzuki Swift). Photographs taken by György Kriska (A-D) and Gábor Horváth (E-F)

It has been reported that various man-made shiny dark horizontal surfaces, such as oil lakes (Horváth et al. 1998), asphalt roads, black plastic sheets (Kriska et al. 1998, Egri et al. 2017, Egri et al. 2019), bodywork of black, red and dark-coloured cars (Kriska et al., 2006) and black gravestones (Horváth et al., 2007) can attract different aquatic insects (Coleoptera: water beetles, Heteroptera: aquatic bugs, Plecoptera: stoneflies, Trichoptera: caddis flies, Ephemeroptera: mayflies, Odonata: dragonflies). These visually deceived insects often swarm above, land on and oviposit onto these surfaces, because they are attracted by the high and horizontal polarization of reflected light. Since these insects detect water surfaces by the horizontal polarization of water-reflected light (Schwind, 1985; Horváth and Varjú, 2004; Horváth, 2014), they are lured to every source of horizontally polarized light. This behaviour is called positive polarotaxis.

Horváth et al. (2009) introduced the term "polarized light pollution" as a new kind of ecological photopollution. Under polarized light pollution they mean strongly (i.e. with high degrees of linear polarization) and horizontally polarized light reflected from smooth (shiny) artificial surfaces having adverse effects on polarotactic aquatic insects, including all insects, the larvae of which live in water (e.g., aquatic beetles and bugs, dragonflies, mayflies, caddis flies, stoneflies and tabanid flies).

Since, environmental education methods for studying this phenomenon were lacking, we developed in-door class work and a field experiment for students to fill this gap. Our regular training programme for biology teacher students at the university class focuses on three principal areas of skill development: ability of demonstration, organizing lessons and arrangement of laboratory and field experiments. In the scope of the first one of these skills teacher trainees get the mastery of the object-teaching elements (drawing on black-board, applying audio-visual aids). Organizing lessons means the ability to elaborate a detailed plan for a class and testing it in practice. To acquire this task, the students are asked to give a practice teaching for their own group members. This teaching practice are always discussed by the students and the lecturer. Within the framework of the third training programme area students get acquainted with the master strokes of biological experiments. Methodology of simple laboratory and field experiments (e. g., osmosis, examinations with a microscope or in a test-tube, biological qualification of freshwater etc.) is included in this programme. The subject of the present work was also included in the itinerary of this programme.

2. Methodology

A preliminary class work was performed at Eötvös University (Biological Institute, Budapest) on 6 May 2019 and to teach the theoretical bases of polarotaxis and to practice the use of linearly polarizing filters, and to identify freshwater invertebrates. Students looked for reflecting surfaces in the seminar room, and analyzed the reflected light by linearly polarizing filters. Living and preserved freshwater macroinvertebrates, especially insect larvae, were identified by a field guide (Kriska, 2013). The field guide contains detailed material on freshwater invertebrates in general, and on mayfly larvae in particular. Identification keys can be seen in vector diagrams on the odd pages of the book and invertebrate photographs appear on the even pages. The graphics of invertebrates are subtitled, in this way it is easier to identify the animals from the creek.

For the next class on 13 May 2019 the teacher trainees were requested to collect and study scientific papers dealing with visual ecology of insects. They were also asked to plan a research method suitable for revealing the effects of artificial shiny surfaces on the behaviour of insects. In order to facilitate this planning work, the students were informed about the scene of the field experiment: the study site is the bank of a typical reach of a mountain creek in Hungary, called Bükkös, from which mayflies emerge in large numbers. In the immediate vicinity (at a distance of 1–5 m) of the creek, an asphalt road ran among trees and bushes almost parallel to the water and in some places it crossed the stream over small bridges. The creek itself ran in a valley under trees and bushes, and it was usually completely shadowed by riparian vegetation, except where it was crossed by the road. The road ran in several metres higher than the creek, and above it the sky was open.

In the course of the next seminar in-door activity on 20 May 2019 a brain storming method was applied: students shared their ideas with each other under our guidance. This method was very useful to get to know more thoroughly our students' way of thinking. The processes of the field experiment were based on the proposals of the students.

The experiments were carried out on 27 May 2019 near the village of Dömörkapu located approximately 30 km away from Budapest, Hungary. Altogether twelve students were equally subdivided into three groups. The members of the first team collected insect larvae from the water and imagos in mid air by capturing them with hand-nets. The captured insect larvae were identified on the spot using an original field guide (Kriska, 2013), and imagos were referred later in the lab (Bauernfield and Humpesch, 2001). Our original field guide was evaluated

previously by students in different wetlands and in the lab of the university. The students of the first group have studied the mayfly swarming along the creek in natural conditions too.

The second team made experiments at the asphalt road. In the multiple-choice experiments, students laid different types of rectangular materials as test surfaces onto the asphalt road at different reaches of the creek where mayflies swarmed. The 1 m × 2 m test surfaces were placed 0.5 m apart. The test surfaces used were composed of shiny black plastic (polyethylene) sheet and matt black cloth. Due to depolarization by diffuse reflection a matt black cloth reflects light with much lower degrees of polarization than a shiny black plastic sheet. Occasionally, students counted the number of mayflies landing on and swarming immediately above (height no more than 0.1 m) a 0.1m × 0.1m region of the test surface during the mass-swarming for 30 s (Table 1).

Table 1. Number of mayflies landed on horizontal shiny black plastic sheet and a matt black cloth in the double-choice field experiment versus time. Data belonging to the shiny black plastic sheet (marked by *) are significantly larger than the corresponding data belonging to the matt black cloth (χ^2-test, $p < 0.001$). Time = local summer time = UTC + 2h.

		Number of mayflies landed	
Time (h)	Air temperature (°C)	Shiny black plastic	Matt black cloth
19:00	26	3	0
19:10	25.5	5	0
19:20	25	8	1
19:30	24	12	0
19:40	24	20	2
19:50	23	14	0
20:00	22.5	16	1
20:10	22	24	1
20:20	21	67	1
20:30	20	153	0
20:40	19	97	2
20:50	18	32	0
21:00	17	7	0
sum		458(*)	8

The position of the two test surfaces with respect to each other was changed randomly in order to avoid the possible influence of their position on the number of mayflies attracted. At the same time the persons of the third team worked at a parking lot near to the creek. They counted mayflies on the cars of different colours occasionally (Table 2).

Table 2. Number of mayflies landed on car roofs of different colours versus time. Samples were taken as described in the text. Time = local summer time = UTC + 2h.

	Number of mayflies		
Time (h)	Red car	Dark sienna car	White car
19:00	1	2	0
19:20	0	1	0
19:40	2	1	0
20:00	1	3	0
20:20	1	3	0
20:40	3	4	0
21:00	3	2	1
sum	11	16	1

The experiments were always carried out under clear skies. At the beginning of an experiment, the landscape was illuminated by direct light from the setting sun, and after sunset by skylight from above. During the experiments a person of the first team measured the water temperature, the air temperature immediately above the creek and the asphalt road. To compare the data pairs in Table 1, χ^2-test was performed by the computer program Statistica 6.1.

The experiences of the outdoor practice were also evaluated from a pedagogical point of view. Using the „buzz group" seminar technique we asked each student to write down any ideas they have how this method could be applied in their environmental teaching practice. Then they were asked to share their thoughts with a teammate for a couple of minutes. They were given some time to discuss and then we asked the question again – asking them for their suggestions.

3. Results

After the field experiment a class work was performed to share the experiences of our observations and to evaluate the collected data. Larvae of mayflies, caddis flies, stoneflies and beetles were collected by the students from the creek. The mayfly larvae belonged to three families: Baetidae, Ephemeridae and Heptageniidae (Fig. 2A, B, C). The captured adult mayflies were identified as *Baetis rhodani*, *Rhithrogena semicolorata*, *Epeorus silvicola*, and *Ephemera danica*.

The swarming of mayflies began at around sunset on 26 May 2019 at the creek. After the emergence of the mayflies from the mountain creek, the males gathered in several diffuse swarms in the air at a distance of approximately 4–5 m from the ground. First diffuse swarms appeared everywhere above the streamlet, asphalt road, and clearings in the vicinity of the emergence sites. Generally, these swarms developed in places where the sky was visible. Later, the swarms became nearer gradually to the ground, and more females flew through them in order to copulate with the males. After mating, the females returned to the streamlet or began

the egg-laying flight on the asphalt road, horizontal shiny black plastic sheet or roofs of dark-coloured cars.

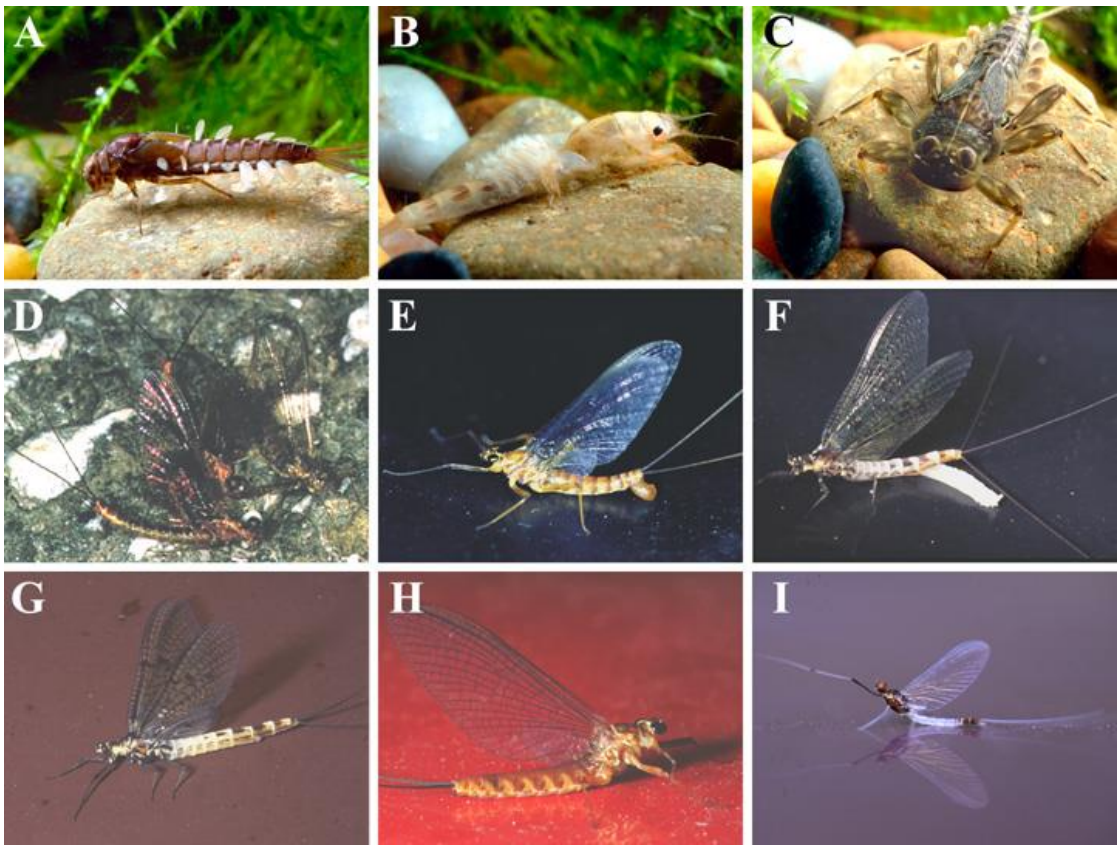

Fig. 2. (A-C) Mayfly larvae from the Bükkös creek. (A) Baetidae larva. (B) *Ephemera danica* larva. (C) *Ecdyonurus* sp. larva. (D-I) Mayfly imagoes on dry horizontal anthropogenic surfaces. (D) Copulating *Epeorus silvicola* mayflies on an asphalt road. (E-F) Egg-laying *Rhithrogena semicolorata* and *Ephemera danica* females on a shiny black plastic sheet. (G-I) Adult mayflies on cars. (G) Female *Ephemera danica* on the roof of a dark sienna car. (H) Heptageniidae imago on the roof of a red car. (I) Male *Baetis rhodani* on the windscreen of a red car (photographs taken by György Kriska).

During the egg-laying flight the females showed a typical flight pattern, which is similar to the nuptial dance of the swarming males. At the end of this flight the females landed on the highly and horizontally polarizing surfaces and laid their egg-batches (Fig. 2E-F). Only a few mayflies landed on the black plastic sheet at the beginning of swarming above the asphalt road (at approximately 19:00 h), but their number increased rapidly over time. At 20:30 h the reproductive activity reached its maximum on the plastic sheet (Table 1). The matt black cloth was not attractive to mayflies similarly to the light-coloured car roofs. Only a few mayflies landed on these surfaces (Table 1). The diffuse reflection from the rough surface of matt black

cloth in all possible directions results in depolarization (reducing p), because the reflected electromagnetic waves vibrate at many planes. Thus, matt black cloth does not attract flying imagos. The bodywork of cars reflects linearly polarized light, the direction and degree of polarization of which depend on the orientation and colour of the car surface. According to the rule of Umow (1905), the darker a reflector, the higher the degree of linear polarization p of reflected light. This is the reason for why light-coloured car roof did not attract polarotactic mayflies. Later, as the air temperature and intensity of ambient light decreased, the swarms were observed exclusively above the asphalt road where the air temperature was higher. In these swarms, both the males and females flew periodically up and down, displaying the species-specific nuptial dances, or flew parallel to the asphalt surface. They frequently touched the asphalt and car surfaces, or dropped onto them for a few seconds. When the air temperature decreased below 14–15 °C and the light intensity was low, mayfly swarming suddenly ceased, and the insects disappeared from asphalt and car surfaces. Then they landed on the leaves of neighbouring trees, bushes and grass in order to roost.

As a result of the pedagogical discussion the following teaching approaches were the most frequently mentioned: problem-based experiential learning and resource based tasks. A group of high school students work through a given problem gaining further information from the facilitator (practically from the biology teacher). The teacher provide the pupils with a range of resources (could be articles, quotations, tables of data, test results, photographs etc). Then the facilitator asks them to solve the problem or address a question using the provided resources. The outdoor trials will be held in small self-help group sessions run by students using the tutor as a resource.

4. Discussion

Our experiments demonstrate well that if mayflies can choose between a strongly and horizontally polarizing surface (e.g. asphalt road, horizontal shiny black plastic sheet or dark-coloured car roofs) and a weakly and not always horizontally polarizing one (e.g. matt black cloth, or brightly coloured car roof), they prefer the former. The smoother the surface, the higher the degree of linear polarization *p* of light reflected from it. Further, the darker a surface in a given spectral range, the higher the *p* of reflected light (Umow, 1905). Horizontal surfaces reflecting light with higher *p*-values are more attractive to polarotactic mayflies than less polarizing ones (Horváth et al., 1998). A similar phenomenon was observed for polarotactic aquatic beetles, water bugs and dragonflies (Horváth and Varjú, 2004; Horváth, 2014). Although the reflection-polarization characteristics of anthropogenic products depend on the

illumination conditions, shiny black horizontal surfaces (sunlit or shaded) reflect always horizontally polarized light (Horváth and Varjú, 2004; Horváth, 2014). Therefore, such reflectors can attract mayflies. Asphalt roads, horizontal shiny black plastic sheets and dark car roofs in parking lots mimic well the optical characteristics of dark waterbodies. They were observed to attract mayflies emerged from a mountain creek and preferentially breeding in small bodies of slow flowing water. Therefore, horizontal dark shiny anthropogenic products may elicit mayfly oviposition. One of the prerequisites of mayfly mating is to swarm above places where the sky is visible, because the females are usually detected visually and captured by the males from below (Brodskiy, 1973). The sky is generally open above asphalt roads and parking lots; thus, in this respect, these artificial products near the emergence site of mayflies provide a good swarming place. After mating, the polarotactic female mayflies return to water to lay their eggs. Hence, asphalt roads and parking lots are visually attractive on several levels to mayflies: the sky above them is visible, the strong and horizontal polarization of reflected light mimics a water surface, and they have a slightly higher temperature than the surrounding areas. Mayflies are endangered all over the world. An egg-batch of a female mayfly, e.g. contains 6000–9000 eggs (Kriska et al. 1998, Egri et al. 2017, Egri et al. 2019), and all the eggs laid onto car or asphalt surfaces inevitably perish. All these man-made substrata may constitute ecological traps (Schlaepfer et al., 2002), thus reducing the insect's individual fitness.

The naked human eye is practically not able to perceive the polarization of light. However, using a common liner polarizer, during our field experiments students could study the reflection-polarization characteristics of man-made objects and their adverse consequences for the survival of mayflies. The activities discussed in the present work improved considerably the environmental awareness of teacher trainees, and as they are easy to carry out, they can help students to extend their repertoire of methods applicable in the environmental education.

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Educate students in teacher training to sustainable consumption through the life cycle examination of an e-device

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Abstract

Sustainability is a highly complex, interdisciplinary field of education. Therefore, in the case of sustainability education in teacher training, it is especially important that students shall be able to see the natural, social and economic problems and challenges of sustainability, the possible solution of the problems and the causal relationships in a system. This is the only way to prepare them for providing children with quality education regarding sustainability education. In this study, our purpose is to demonstrate how the life cycle of smartphones as an e-product can contribute to an effective education of sustainability and the development of a complex approach of students. Besides, our purpose is to present the obtained results of a student survey related to smartphones. The questionnaire is supposed to answer the following questions: How do students appear in the consumer market as smartphone users? Whether the problem of planned and moral obsolescence appeared? What are their consumer attitudes towards smartphones? Is the device used in a conscious, environmentally-friendly way? Are students aware of the environmental, social and economic impacts of e-devices' life stages? The study presents the conclusions drawn from the results of the survey.

Keywords: sustainable consumption; smartphone; life cycle analysis

1. Introduction

When we would like to make sustainability education in teacher training more effective, it is worth taking into account the 2030's global educational framework developed by UNESCO (UNESCO, 2017; Könczey, 2017; Varga et Könczey, 2019). UNESCO is the Educational, Scientific and Cultural Organization of UN, which defines sustainability education goals for the 17 Sustainable Development Goals (SDGs) (SDG, 2015; Mika, 2017; Lükő, 2017). Fig. 1. shows the 17 sustainable development goals. It can be seen that it includes areas such as sustainable consumption and production, sustainable management of natural resources, climate change, poverty, gender and other inequalities, health, food security, infrastructure, as well as

peaceful and inclusive societies, etc. Goals related to the e-product lifecycle in a narrower or broader sense are highlighted in Fig. 1. UNESCO formulates unique educational goals for its 17 sustainable development goals in three main areas: cognitive, socio-emotional, and behavioural. In teacher training we try to keep in mind this complex three-pronged approach.

Fig. 1. The 17 sustainable development goals (SDGs). Goals related to the e-product lifecycle in a narrower or broader sense are highlighted.

https://www.bptargetneutral.com/us/how-we-work/choosing-our-projects/the-un-sustainable-development-goals/

It means that we do not deal with the environmental, socio and economic problem of sustainability on the level of knowledge alone, but we also emphasize personal connection to the topic; in this way can hope for a change in attitude. In addition, we believe it is important for students to be able to see sustainability challenges, problems, issues to be solved, and cause-and-effect relationships in a system, not out of context. We can only achieve students making their consumer habits more sustainable if they see their meaning and are aware of the wider impact of their lifestyles. We have already done many sustainability projects with our students in this approach, e.g. The „How others live" project (Hill et al., 2016b; Anthropolis, 2012). This complex vision can also be facilitated in the way presented in this study; that is, by examining the lifecycle of a product (Tamaska et al., 2001). When selecting the product to be examined, it was important an aspect that students were able to connect personally, that they had everyone's own, and that they had the opportunity to become involved mentally and emotionally during the analysis. This is how we chose the smartphone.

2. Aims and research questions

2.1. Aims

Our aim is to present that lifecycle examination of the smartphone as an e-product can contribute to effective sustainability education. Our goal is also to present a survey and the result of survey related to smartphones, filled by student.

The purpose of the questionnaire was to assess what kind of knowledge needs to be based on and to build upon, related to the lifecycle of a product and in which areas sensitization is of particular importance. Once we have a picture of this, we plan to develop and evaluate a product life cycle methodology with our students. In addition, we plan to assess whether consumer attitudes will change following the acquisition and sensitization of new knowledge. The research results and opinions are differ on the relationship between environmental knowledge and attitude. Some studies have found a positive (Campbell et al. 1999), however, other studies have found no positive correlation (DeChano, 2006). A very important aspect is the process and quality of the acquisition of knowledge. E.g. in frontal education we focus on acquiring lexical knowledge, so probably significant attitude change is not experienced. However, if a student acquires knowledge through the development of different competencies (like UNESCO defined key competences) and during this time experiences also a great deal of personal involvement, the expected change in attitude is significantly greater (UNESCO, 2017; Réti and Varga, 2008).

2.2. Research questions

- How do students appear in the consumer market as smartphone users? Whether the problem of planned and moral obsolescence appeared in students' thinking about smartphones?
- What are the students' consumer attitudes towards smartphone use? How conscious and energy saving are they in using the device?
- Are students aware of the environmental and social impacts of life stages of smartphones?

3. Theoretical background

3.1. Importance of education for sustainability in teacher training

When thinking about sustainability education in teacher training, it is important to keep in mind two main purposes. On the one hand, to educate students (future kindergarten teachers and primary school teachers) on sustainability, on the other hand, preparing them to be able to provide quality education in the field of sustainability. The following is a non-exhaustive list of concepts related to the evaluation of both mentioned goals, in accordance with key competences formulated by UNESCO (Hill et al., 2016a; UNESCO, 2017).

- Sensitization: developing a positive attitude and a realistic sustainable lifestyle through many positive personal experience.
- Adaptability: Develop a strategy for sustainability education, taking into account the current knowledge and attitudes of students.
- Thinking in a system: students will be able to see in a complex way the environmental, social and economic challenges, problems, issues to be solved, and causal relationships of sustainability. This will enable them to see and understand sustainability at global, local and individual levels and also recognize what they can do in practice for sustainability at local levels (community, school).
- Integration: As future teacher, it is important for students to realize that education for sustainability is essentially a part of any discipline, so integration into all subjects is required.
- Interiorization: the ideas of sustainability must become an integral part of the thinking of present and future teachers. Consequently, sustainable attitude and lifestyle and continuous self-improvement become an internal need.

- Multiplicative effect: students will lead and support the knowledge of many children about nature, and through the children they will also influence parents, so the role of teacher training will be strengthened.

3.2. The life cycle of a consumer product

Often, only one phase of a product's life (Ercan et al., 2016; Tamaska et al., 2001) is visible to us; namely, when we use it; the other phases remain hidden to us. This phase could be quite long, e.g. we use a piece of furniture for decades or could be extremely short, for example for a straw. However, the product has A pre-life, which comprises the raw material extraction, and various parts of the production process. Usually, little is known about these phases. The product has also an after-life; that is, it becomes waste or trash after use (Angyal et al., 2012). Many times we see this part only until we throw the product into the trash but we don't know where it goes from there. As Fig. 2. shows, each phase follows each other in a chain-like manner, so that the final phase is not closed into a loop with the initial one. That is why this type of production process is called open-chain production. Because of the linear nature of the process it would be more exact to use the term life chain or lifeway instead of life cycle, as it is in Hungarian, but since the English literature uses the term life cycle, we will follow it literally in this paper. At the same time, we emphasize that, unlike its name, it is a linear process and we would like to draw our students' attention to the problems that arise from it.

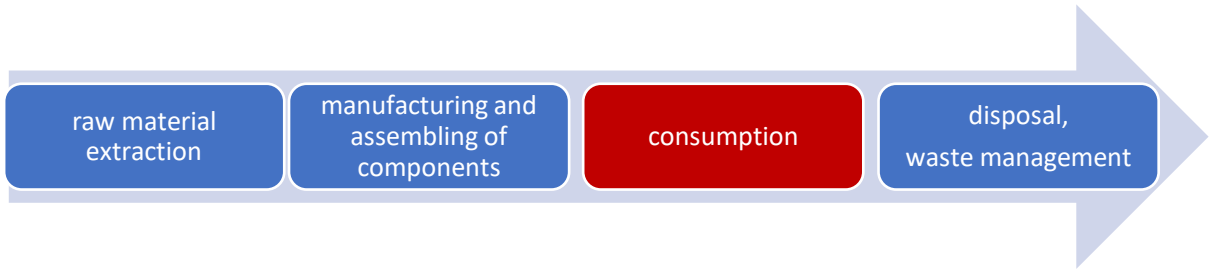


Fig. 2.
Life cycle phases of a product.

As a result of planned obsolescence (Reuss et Dannoritzer, 2017) product designed to go to waste, the reduction in the usage time of the product generates an increase in consumption. This increases the whole process, so the more often you change a product, the more will increase the raw material demand, production process, and waste and garbage. However, since these phases are not taking place before our eyes, it is possible that we do not think about it, and contribute to the cause of environmental and social damage unintentionally.

We believe that analyzing such a complex process along sustainability goals as the life cycle of a product, examining the environmental, social problems, and opportunities for change at each stage, helps our students to think systemically, recognizing causal relationships. However, it is also important for our students to be personally connected to the topic. For this reason, we chose the smartphone as a product. We assumed that all of the students (or almost all of them) have it and it is an integral part of their lives.

4. Methods

4.1. The smartphone life cycle analysis from pedagogical aspect

We collected sustainability (environmental, social and economic) problems associated with each phase of the life cycle, and made an overview of pedagogically important areas, and finally we prepared a summary of educational tasks. This is an important preparation phase for future research, where we plan to develop a methodology for processing the topic with students. This future methodological work is supported by the questionnaire, discussed in the next section.

4.2. Research method: survey

There are many fields of survey research on smartphone, eg. the use of applications (Havassy, 2016), the psychological effects of the smartphone, like the development of addiction (Aljomaa et al., 2016; Gligor et Mozos, (2019), Regarding the consumer's habits and attitudes, there are research results related with the replacement of the phone, the reasons behind the replacement, and end-of-life phones (Ylä-Mella, et al. 2015; Li et al., 2012), however, we do not know about research dealing with other phases of the life cycle. In our research, the aim of the survey as a conventional research method (Majoros 2011; Molnár 2010) is to obtain information about our students in the following areas: knowledge of smartphone life cycle, sustainability issues, consumer attitude, how consciously, environmentally friendly the device is used. The aim of the survey was also to raise the students' attention and focus it on the problem.

We hoped that the very act of filling the survey would have an attitude-shaping effect. The survey was completed by 498 students of the ELTE Faculty of Primary and Pre-school Education. The survey was included 20 questions, of both the open-ended and the close type (Majoros, 2011). The filling was done online so we didn't use a lot of paper and ink for printing. The questionnaire was filled out in Hungarian, the Appendix contains the translated English version.

5. The smartphone life cycle analysis from pedagogical aspect

5.1. Collection of sustainability problems associated with each life cycle phase

Although the whole life cycle is related to the product, each component (e.g. System on a chip/SoC, memory, display, camera, battery) has its own individual life path.

5.1.1. Phase 1. Raw material extraction

This includes raw materials required for the device and its components, as well as for packaging, protecting the device (e.g. screen protector, phone case).

Problems

- First point hard to access, rare raw materials (e.g. heavy metals, rare earth ores, cobalt, tantalum, lithium, gold, etc.) whose extraction results in severe ecosystem damage and destruction (e.g. deforestation) (MCS, 2020).
- Many of the required substances are hazardous to living organisms and the environment (e.g. heavy, and rare earth metals and their compounds) (Wu et al., 2016).

Because of the mentioned circumstances legal extraction has huge costs and a number of serious environmental, social, ethical, health problems and violations of the law occur as a result of shortcomings in the legislation. For example, illegal and dangerous mines and mining, child labor, exploitation, intimidation, armed conflict, smuggling of ore from mining, heavily contaminated mining areas (soil, air), posing a serious risk to public health.

5.1.2. Phase 2. Manufacturing and assembling of components

This phase includes the manufacture and assembly of individual components, which also raises a number of environmental and social problems. As well as raw materials harmful to many environments and health, additional harmful additives are added and toxic gases are released during production (Kang et al., 2018). Young or child laborers are employed in factories (i-slaves) for very low wages, 10-12 hours a day, in poor working and accommodation conditions. There is a very high rate of physical and mental illness among workers (depression, suicide, leukemia, cancer, etc.). Greenpeace and other human rights organizations carry out studies, reports to raise awareness and campaign on human rights issues during production, but because of their sensitive nature and the interests involved in production, "official" investigations and their publication are only rarely carried out.

5.1.3. Phase 3. Consumption

This phase is the shortest one with an average of 1.5-2 years of one smartphone being used (Baldé et al., 2017).

Relating to this phase, we should focus on and familiarize our students with the following issues:

- External costs (ISSC and UNESCO (2013) by which we pay a fraction of what the item actually costs.
- Second point planned obsolescence (Reuss et Dannoritzer, 2017) (product designed to go to waste) the consequences of this are *a,* the repair is not at all or only partially possible; *b,* it is impossible or only very expensive to get parts; *c*, in the case of parts failure the whole device becomes unusable (e.g. battery replacement); *d,* phone's operating system is slowing down
- Ethical obsolescence.
- It requires a lot of power (in the form of electric current).
- In the case of the smartphone, a psychological effect, addiction.

5.1.4. Phase 4. After-life of e-device, deposal, e-waste

Problems

E-devices (Baldé et al., 2017) no longer in use are shipped from Europe to Asia, Africa (e.g. Ghana, China, India) (EFFACE, 2015), so similarly to the raw material extraction and manufacturing processes, we do not have to deal with waste directly after use. Huge e-waste cemeteries are being created in those countries. People living there also try to extract the valuable, recyclable metals under inhumane conditions, which poses a serious environmental and health risk, as the e-waste and its combustion products contaminate the soil, water and air (toxic metals, combustion products, etc.). Only 20% of the e-waste generated all over the Globe was documented to be collected and recycled (Baldé et al., 2017; Rucevska et al., 2015) which corresponds to.

5.1.5. Phase 5. Extra phase: Transport, distribution

Transport accompanies the entire life cycle process, on land, by water, by air, starting with the transport of the mined raw materials to component factories. It is common for a component to be manufactured on several different continents so they can be transported to the assembly site.

The finished products are shipped all over the planet to distributors, shops. Finally, after a short period of use, e-waste goes to e-waste cemeteries. Students can follow a map, and can calculate the distance traveled.

5.2. Summary of educational tasks related to life cycle phases

The life cycle phases of raw material extraction, production and e-waste management (i.e., phases 1, 2, 4) are discussed together, while phase 3 (consumption) is dealt with separately.

The first, second, and fourth phases described above take place far away from us on other continents. The vast majority of problems occur there and exert influence also there, so our students feel much less about it, or may have never heard of it. So for these phases of producing a smartphone, other people are paying a high price for losing their natural environment, their peaceful life, their freedom, and maybe their basic human rights. In these phases, we emphasize that students have access to knowledge during sensitization, so we try to present the facts in such a way that they have the opportunity to be emotionally involved. Photographs, films (e.g. Complicit, http://www.complicitfilm.org/) that show the lives of people living in the areas concerned, the consequences of problems caused by mining, manufacturing and e-waste, provide an opportunity to do this. It means a lot if we do not generally talk about a problem, such as child labor, but relate a specific story, maybe show a person's face, or a personal life story is bound to it. Students may search for newspaper articles that are presented to each other (e.g. boy fell ill with leukemia during factory work). It is very important to note that the purpose is not to frighten but to induce responsible thinking and behavior through sensitization.

In phase 3, in the case of consumption, the primary goal is to become a (more) conscious consumer, which is fundamentally influenced by the knowledge of the topic and the emotional attitude.

Based on the generally valid aspects of conscious, sustainable consumption, we think about opportunities with a focus on the smartphone as a specific product. It is not our intention to try to dissuade students from using a smartphone, it would be a naive and pointless attempt. Our goal, however, is to see how much they can do, consciously thinking through their decisions and actions. Below are the re-things, consider the possible steps toward sustainability based on these:

- Rethink: Before you buy a phone, you should think carefully about what sustainability considerations you should take (e.g. buying from a manufacturer with more ethical life-cycle steps, such as a removable battery, etc.).
- Refuse: Rejecting such attractive offers as a higher category phone, or in the case of a sale (eg Black Friday). It can help a lot here if we explain to students how conscious the psychological influencing campaign is on the part of those who are making a profit. It is also worth influencing the students' self-esteem.
- Reduce: Consciously reduce the power consumption of smartphone, e.g. by selecting battery-saving mode, turning off wifi or mobilnet, or any other applications.
- Reuse: extend the life usage time of the phone by giving it away or selling it to a used phone dealer.
- Recycle: Disposal of the phone to the E-waste bin or specifically to the mobile phone bin will help recycle the phone's recyclable parts, materials (such as rare metals).
- Repair: Perhaps this is the least effective process as it is very rare that the smartphone may be worth repairing due to planned obsolescence.

In addition, a number of options are worth reflecting on and critically analyzing with students (such as buying a fairphone, signing petitions, etc.).

6. Result and conclusions of survey

The survey was filled by a total of 498 students. Young adults between the ages of 19 and 24, that is, members of generation Z (Mohr and Mohr, 2017), born of the digital age. The gender ratio among surveyed students, typically of our Faculty, is 3.6% male and 96.4% female, so from this point of view the sample does not represent the gender ratio in society and is not suitable for comparing the two genders relating to the topic.

The first set of questions measures how students appear in the “consumer market”. 99% of students have a smartphone, and the remaining 1% have a phone but not a smartphone. Only 2% of students have more than one phones. Fig. 3. shows how old they were when they got their first phone, and how old they think a child should be to be given a phone.

It can be seen that approx. one-fifth of them received or gave their child a phone between the ages of 6-9. Nearly half of the respondents received the phone between the ages of 10 and 12, while nearly two-thirds would buy one for a child of that age. So, if we were to project this to the entire Hungarian population, the members of today's Z and alpha generations, approx. 80%

would have had a telephone by the age of 12. Another Hungarian study (NMHH (2017) found that 71% of children have their own phones by the age of 12 (and further 9% use their parents or siblings phones). Considering that this data has been published more than two years ago and the number of children with phones has been increasing ever since the phones came on the market (Rideout, et al., 2010), the results of the two studies are similar.

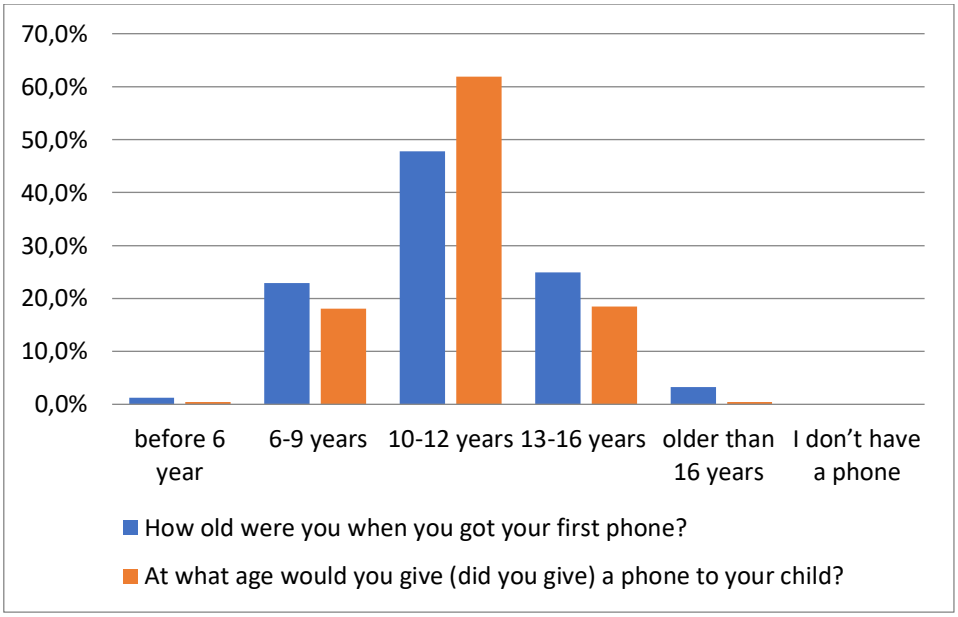


Fig. 3. The first time when students got their phone (red columns) and the first time when they would give one to their children (blue columns)

The following set of questions (Which phone / smartphone is your current phone, how long have you been using your current phone, and why have you replaced your previous phone) examines how the planned and moral obsolescence is displayed during phone use. Fig. 4. and Fig. 5. clearly show that phones are replaced very often. Based on these, we cannot yet determine whether planned or moral obsolescence dominates the cause of the replacement.

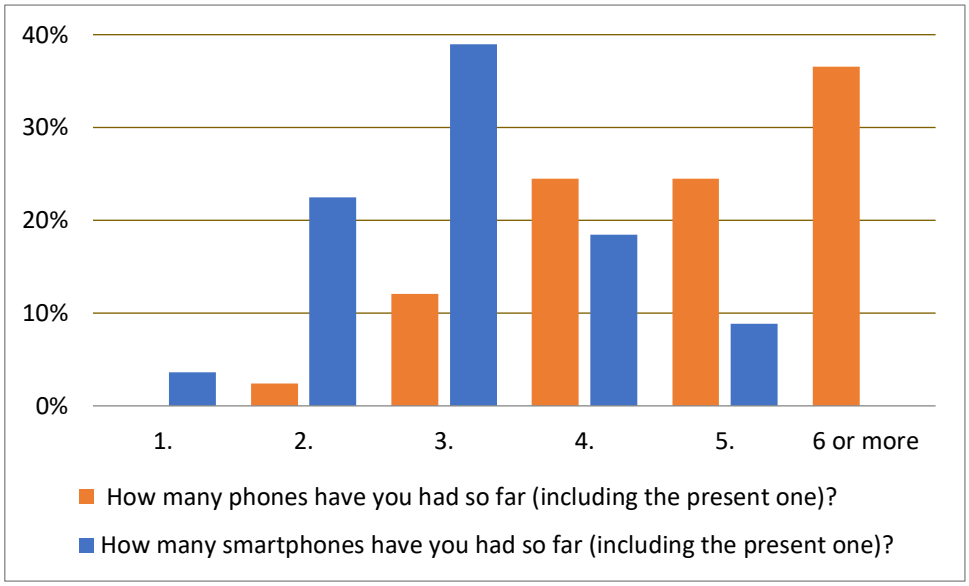


Fig. 4. Which phones (red columns) or smartphones (blue columns) are the current ones of students'

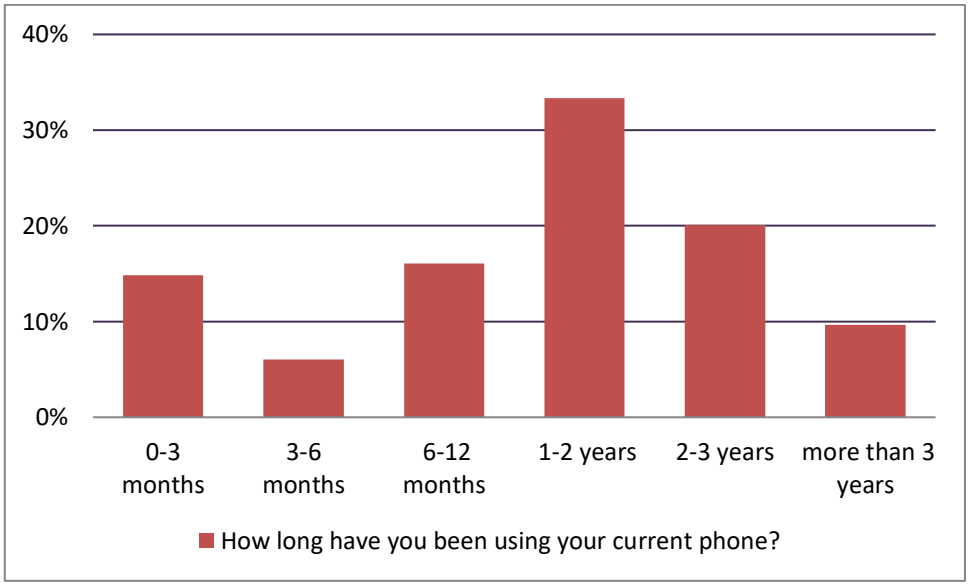


Fig. 5. How long have the students used their present phone

Fig. 6. shows also what the reason for replacing the phone was. The vast majority of the answers (84%) were "It went wrong." (41%) and "It was slow, there were no application running on it." (43%). From this it seems that the planned obsolescence is clearly dominant. The possible answers included "because I liked another one"; the affirmative answer to this shows ethical obsolescence: only 4% of them chose it. In a later question, asking about a phone case replacement similar reasons were given us yielding slightly higher percentages (often 10%, always 4.4%). This difference may be due to e.g. price difference between case and phone. Overall, the vast majority of students are not affected or only slightly affected by planned

obsolescence. With these questions, our goal was to make our students realize, by looking back, how often they switch phones. We presented these figures to a number of our students (about 10% of the students, 47 persons), who we had the opportunity to talk to during a course after their completing the questionnaire). Their typical reaction was "I never thought about how many phones I had destroyed in a short time."or "I've never counted it before." In our subjective opinion, based on the reactions of the students, they are somewhat aware of the frequent switching of devices, but this kind of awareness and confrontation with the facts still astounded them.

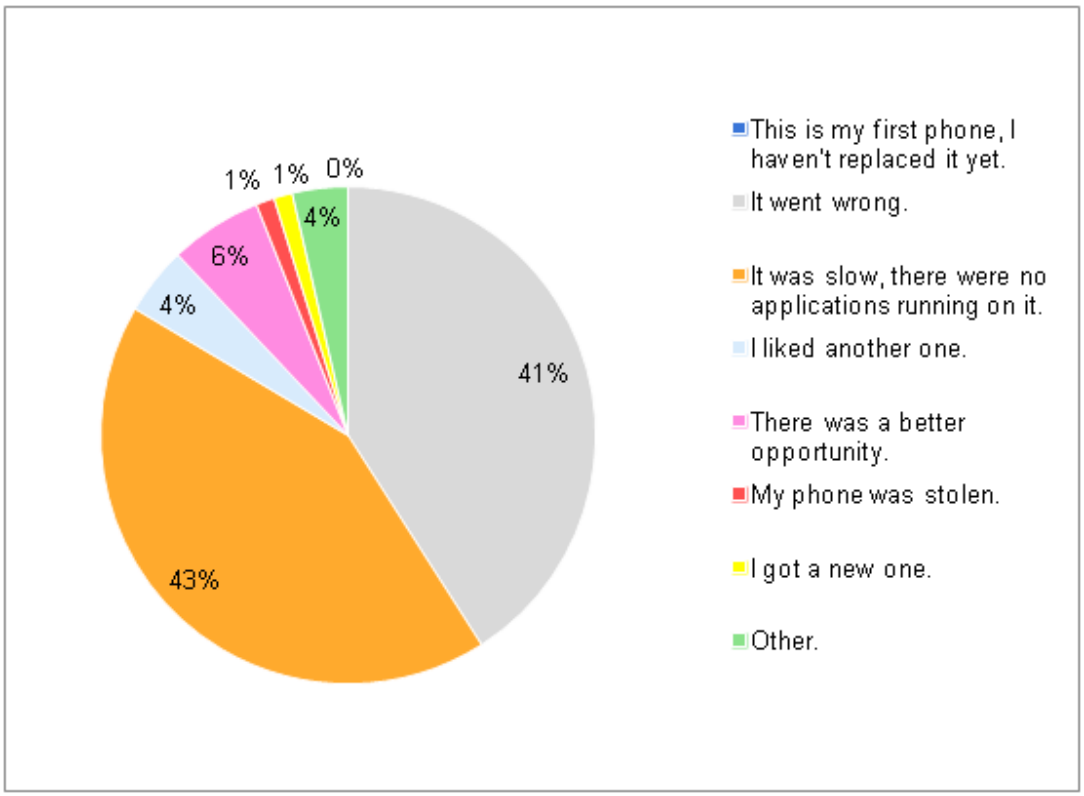


Fig. 6. The reason for students replacing their phone

The next set of questions explored the students' habits of using the phone (how much they save the battery, how much they pay attention to energy efficient use and how much they protects their phone). Students could answer a question on a four-point scale (never, sometimes, often, always).

96% of students do not or only rarely turn off the phone at night, compared to the 36% for those who mute their phonrs for the night (Figs 7 a,b.). We suppose that behind these figures there is an underlying students' need for round-the-clock availability.

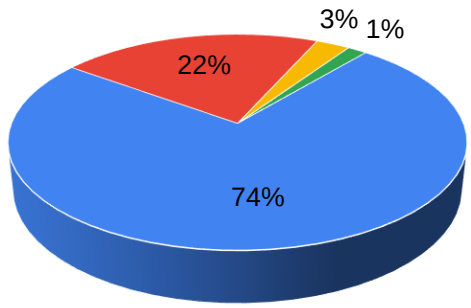
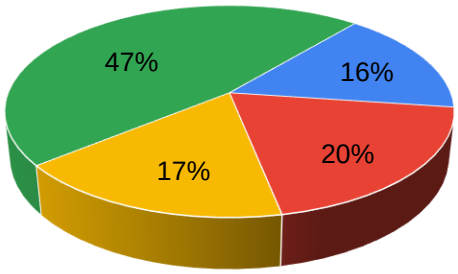
I turn the phone off at night.	I mute the phone at night.
	

Fig. 7 a. (left). Students turn their phone off at night, and 7.b. (right). Students mute their phone at night. Colour code never sometimes often always

Most (56%) do not use battery-saving mode or use it only occasionally. 47% of them do not or only occasionally turn off Wi-Fi or mobilnet, even though they do not use it (Figs. 8 a,b.).

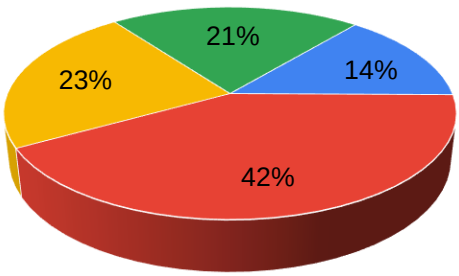
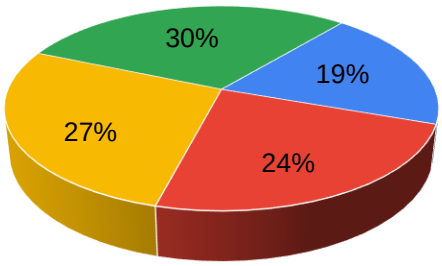
I'm using battery-saving mode	When I don't need internet, I turn the wifi or the mobil net off.
	

Fig. 8 a. (left). Students are using battery-saving mode, and 8.b. (right). When students don't need the internet, they turn the wifi or the mobil net off. Colour code:
never sometimes often always

Much more attention is being paid to the protection of the telephone in use (Figures 9 a, b). There is a very high proportion of students protecting the screen with foil or the phone itself with case. The use of phone cases or foil raises an interesting ambivalence in terms of environmental protection. It is worth discussing and arguing with students that produce a case

or foil is considered to be more harmful for the environment (so it is not worth protecting the phone for a short period of time), or changing the phone due to damage.

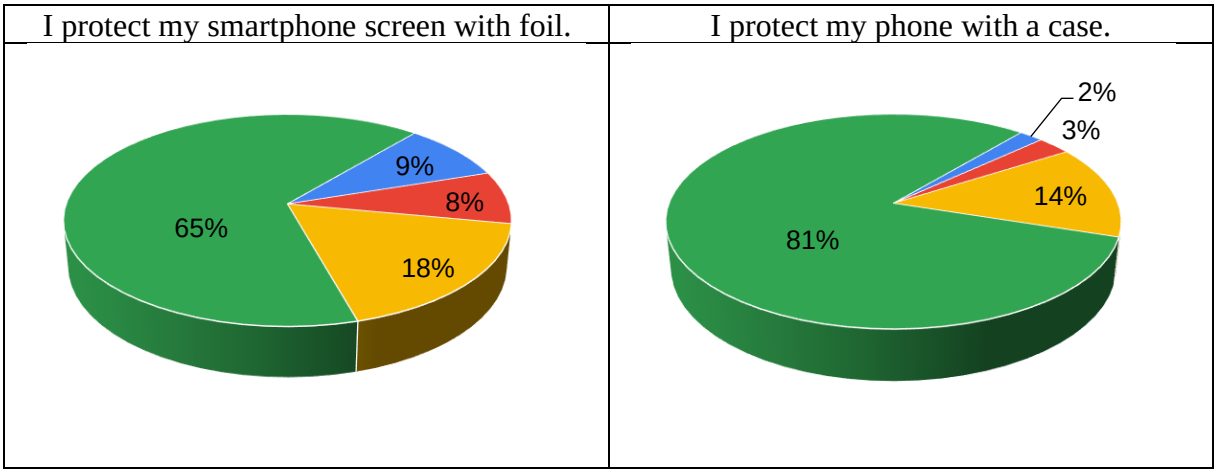


Fig. 9. Students protect their phone with foil (a, left), and with a case (b. right). Colour code: never sometimes often always

Summarizing the results, we find that students are less environmentally conscious in their use of the telephone. Although they protect it, they do not pay attention to energy conservation. From this we can conclude that mainly the high price of the phone is the reason behind the protection of the phone. We asked the students what they do with the phone that they no longer use (Fig 10). Nearly 30% of students chose the option of reuse (giving away or selling on).

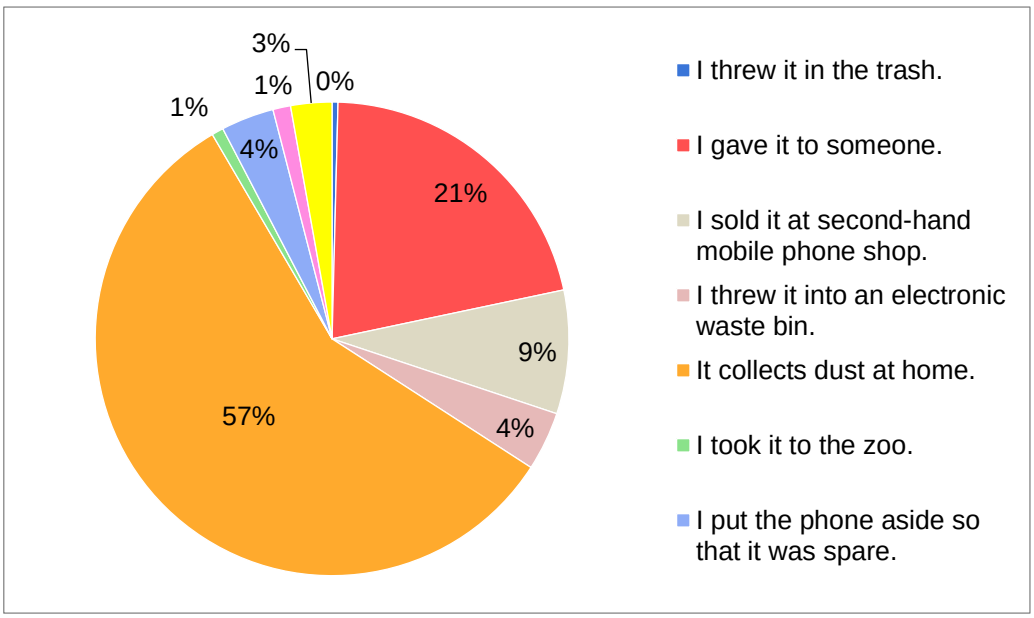


Fig. 10. The students do with the phone which they no longer use

Recycling can be realized by disposing of smartphones in the electronic waste bin, with only 4% of students opting for it. Our Faculty plan to join the "Pass it back bro" campaign

(http://janegoodall.hu/mobilkampany.html), where we plan to apply for phone collection boxes and draw the students' attention to the option.

There are boxes like this in the Budapest Zoo and Botanic Garden, so the answer "I took it to the zoo" probably refers to this. Numerous students (57.4%) wrote that their phones are getting dusty at home, so we trust that more students will bring them.

The last set of questions focused on students' knowledge and understanding of the life cycle of smartphones.

The table 1. shows what students have answered to the question of what raw materials are needed for a smartphone. 11.6% of students said they did not know. Our question was specifically about raw materials, but students did not distinguish raw materials from other manufactured materials (e.g. glass, plastic).

Table 1. According to students raw materials are needed for a smartphone

Students' answers		**value of% answers given**
I do not know.		11.6%
plastic		32.1%
glass		24.1%
sand		2.0%
petroleum		4.4%
carbon		2.4%
mentions metal	metal in general	41.4%
	specific metal mentioned	41.3%
ore	coltan	2.4%
	bauxite	0.4%

We found that 18.5% of the students could name one 19.7% two, and 51% three or more materials. Plastic, 32.1%, glass, 24.2% and metals were the most abundant, but sand, oil and coltan, bauxite as ores were also mentioned. When creating the survey, it is worth mentioning the metals separately. 82.7% responded that smartphones contain metal. 41.4% described it with “metal” accuracy only, and 41.3% listed specific metals. Individual metals are mentioned in the following percentages: aluminum 20.9%, gold 15.7%, copper 12.9%, lithium 10.8%, tin 10.4%, tantalum 8.8%, iron 5, 6%, cobalt 4.4% silver 3.2%, nickel, lead 2-2%, platinum 1.6%. Evaluating the answers, we can say that most of the materials in the phone, including most of

the different metals, came up in the answers. However, on the one hand, the individual components are found in very few responses, with a small percentage; on the other hand, half of the students could not, or could only name 1-2 materials. All in all, there is therefore a great need to develop this knowledge.

To the question of where the raw materials named by the students came from (table 2.). More than the half of the students (25.7%+28,9%) have some information about the topic, they can name a continent or a country. 30.9% of respondents were unable to name any raw material field and 7.6% believe that the raw materials required for cellphone production can be obtained anywhere on earth. Based on this, it seems that this part of the students are not aware that certain materials are found in very few places on earth, and, in addition, are in very small quantities.

Table 2. According to students where the raw materials named by the students came from

students' answers	value of% answers given
I do not know.	30.9%
Wherever.	7.6%
They can name a continent.	25.7%
They can name a country.	28.9%
Other.	6.8%

Some students, 2.4% generally described the extraction site as "poor" or Third World, with 25.7% responding with continental accuracy (Africa, Asia, South America, Europe) and 28.9% responding with country accuracy (e.g. Argentina, Chile, China, Bolivia, Australia, Democratic Republic of the Congo). According to the answers in the "other" category (6.8%), raw materials can be found in mountains, mines, and under ground. We cannot determine whether the student was simply superficial about the question or lacked the more precise knowledge to give a more specific answer.

The answers to the raw material extraction problem are given in Table 3. A very large percentage, 45.8% said they did not know. A total of 21.7% mentioned social problems (eg child labor, unpaid labor, inhumane working conditions, exposure to hazardous substances), while 44.9% mentioned environmental problems (e.g. endangering African chimpanzee habitats, over-mining, finite resources).

Table 3. According to students the problems related to extracting raw materials for mobile phones

students' answers		**value of% answers given**
I do not know.		45.8%
social	health	6.8%
	exploitation	14.9%
environmental	contamination	29.3%
	exploitation	15.3%
difficulties in extraction		3.2%

So students are more aware of the impact on the environment, than the social, e.g. human rights issues. It is interesting that in the case of social problems, exploitation is mentioned by approx. twice as many students (14.9%) as is health problem (6.8%).

The answers to the question regarding problems related to the manufacture of the smartphone are given in Table 4.

Table 4. According to students problems related to the manufacture of the smartphone

Do you know any problems or difficulties encountered during producing your smartphone? If yes, please name them.	
students' answers	**value of% answers given**
I do not know.	56.2%
social health	6.0%
social exploitation	14.5%
environmental	19.3%
planned obsolescence	3.2%
overproduction	1.2%

Unfortunately, the ratio of those who do not know the answer is even higher (56.2%). 20.5% mentioned a social problem (very similarly to the previous question), while 19.3% mentioned an environmental problem.

Overall, we can say that students' knowledge of the life cycle of the smartphone needs improvement at every stage. Our goal is not specifically to give students a full understanding of the smartphone life cycle, but rather to shape their broader global aspect and approach. Smartphones are a very good subject for this because almost all sustainability education goals are outlined and system thinking can be developed very well. We consider it important for students to be aware of the environmental, social processes, problems and their local and global impacts while living in Europe, which are far from us in space and time.

7. Conclusion

In our study, we outlined the life cycle of an e-product, the smartphone, from raw material extraction to waste processing. We discussed the sustainability of education related natural, social and economic problems in each phase. We believe that our study can be applied well in education, both to provide a basis for knowledge, to develop systemic thinking through the discovery of causal relationships, and to sensitize to problems that are global or away from us. The survey revealed, as expected, that almost all students had a smartphone that has become an integral part of their lives, making it a suitable tool for conducting a life cycle examination with this product. The aim of the survey was also to focus the students' attention on the topic and thus to start the attitude-forming. The phenomenon of planned obsolescence is also very clear with regard to the frequent replacement of mobile phones and the reasons behind it. Moral obsolescence is less pronounced on smartphones, which may be due to the high price of the product. In terms of consumer attitudes, we found that students are conscious of the protection of the phone, which may be due to the material value of the phone. On the contrary, energy-conscious use is much less prominent, and they do not pay attention to unnecessary power consumption. Their knowledge of life cycle phases is quite limited in both environmental and social terms. Knowing this, as a continuation of the research, our goal is to determine, based on our experience, what areas we should focus on for the future to build our students' competence (e.g. knowledge, critical thinking, global understanding, social decision-making) and sensitize them to environmental and social problems. This is not only important for shaping a responsible sustainable attitude of students, but also because of the multiplier effect of the future teacher. We also plan to develop a project methodology for mobile phone life cycle phases that can be adapted to any product.

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Appendix

Smartphone survey

1. Your gender

   male female

2. Your age:

   …….years

3. Choose which of the following is true of you.
   a. I don't have a mobile phone
   b. I have mobile phone but it is not a smartphone
   c. I have smartphone
   d. I have several phones, including smartphones
4. Choose which of the following is true of you.
   a. I got the phone.
   b. I bought the phone in one sum.
   c. The phone was bought for a down payment or on credit.
   d. I bought the phone for installment / loan.

5. How many phones have you had so far (including the present one)?

   1. 2. 3. 4. 5. 6 or more

6. How many smartphones have you had so far (including the present one)?

   1. 2. 3. 4. 5. 6 or more

7. How long have you been using your current phone?
   a. for 0-3 months
   b. for 3-6 months
   c. for 6-12 months
   d. for 1-2 years

e. for 2-3 years
f. for more than 3 years
g. I have no phone

8. How old were you when you got your first phone?
    a. before I was 6 years old
    b. between 6-9 years old
    c. between 10-12 years old
    d. between 13-16 years old
    e. older than 16 years old
    f. I don’t have a mobile phone
9. Why did you get your first phone?
10. At what age would you give (did you give) a phone to your child?
11. Do you have a smart watch or fitness bracelet?

    yes no

12. Why did you replace your previous phone?
    a. this is my first phone, I haven't replaced it yet.
    b. because it went wrong.
    c. because it was slow, there were no applications running on it.
    d. because I liked another one.
    e. because there was a better opportunity.
    f. other:
13. What did you do with your previous phone?
    a. I threw it in the trash.
    b. I gave it to someone.
    c. I sold it at second-hand mobile phone shop.
    d. I threw it into an electronic waste bin.
    e. It collects dust at home.
    f. Other:

14. Evaluate on a four-point scale how much of the following statements are true for you.

	never	sometimes	often	always
I turn the phone off at night.				
I mute the phone at night.				
I'm using battery-saving mode				
When I don't need internet, I turn the wifi or the mobil net off.				
I protect my smartphone screen with foil.				
I protect my phone with a case.				
I'll replace my phone if I find another one I like even better.				

15. List the raw materials needed to make your mobile phone!
16. Please list, from what part of the world the raw materials come from, (Those you mentioned in the previous question above)?
17. Do you know any problems or difficulties related to the extraction of raw materials? If yes, please name them.
18. Do you know any problems or difficulties encountered during producing your smartphone? If yes, please name them.
19. What do you think, what problems arise during the recycling of used smartphones?
20. Would you mind stop using your cell phone for 24 hours?

yes no