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Environmental pedagogical aspects of light pollution

Doctoral (PhD) theses

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1. Introduction and relevance of the topic

Light pollution is a side-effect of human activities that are part of the environmental pollution process.

In contrast to air pollution or water pollution, the concept and impact of light pollution is less well known. Perhaps because of the fact that illuminated public spaces and light displays have become an essential part of an advanced, safe urban lifestyle, and we are used to sleeping in darkened rooms behind blinds. It never occurs to many of us how it could be otherwise, how light pollution affects our own lives, how it damages our environment. Little attention is paid to the fact that, of all the polluting activities of man, this is the problem that we could most easily and effectively solve.

The effects of artificial light at night have started to receive more attention in the last few decades, but the subject is still a relatively neglected area, especially in terms of legislation. According to recent studies, the amount of light emitted worldwide is increasing by about 6% per year (Hölker et al. 2010). It is important to stress that the 6% increase in light emissions is not justified by population or world economic output growth rates. However, as the efficiency of lighting equipment has improved, the energy demand for specific light output has decreased.

Increased night light can reduce melatonin production, which can cause sleep deprivation, fatigue, headaches, stress, anxiety and other health problems. Recent studies have shown a link between reduced melatonin levels and the risk of developing cancer (Falchi et al, 2011; Lamphar et al, 2022; Portnov et al, 2016, Bashiri et al, 2014). The negative effects of light pollution—indirectly or directly— affect virtually the entire ecosystem. Plants are a prime example, with their loss of pollination. Direct effects are seen in the populations of light-flying insects, bats, sea turtles and birds (Csörgits - Gyarmathy, 2006).

The risk is further increased by the disproportionate increase in the blue band of light, a critical spectral range for ecological and health reasons, as sodium lamps, which were previously almost the only light source, are replaced by white light sources.

My PhD research was aimed at promoting awareness and understanding of light pollution as an environmental problem among school students. The first step of the research was a content analysis of documents and textbooks that guide education in my country, to see how much the problem is being addressed by the education system in my country. In other words, how much chance does the average student (who makes no extra effort beyond going to school) have of becoming aware of the problem. The next question was the degree of actual knowledge that pupils have about the issue. The third was the extent to which pupils' also-knowledge could be enhanced through targeted knowledge transfer. Finally, in the fourth and fifth branches, two additional potential sources of knowledge were examined in terms of their potential usefulness in the acquisition of knowledge about light pollution. One of these two sources was national television and radio programmes, which I examined in terms of their frequency, duration and content. The other potential sources of knowledge are the Starry Sky Parks, where I examined whether there is a clear positive effect of the proximity of the Park. In other words whether adult residents in the municipality near the Park know more about the issue than in the control municipality far away from the Park.

2. Research objectives, research questions and hypotheses

Light pollution, as a newly identified environmental problem, does not yet have a long tradition in primary and secondary public education. Of the scientific issues that can be raised in this context, my thesis addresses the five that I formulate below in the form of questions and hypotheses. These five questions can be divided into two groups:

- examining the educational aspects of light pollution in school settings (questions 1-3)
- Examining the educational aspects of light pollution outside school (questions 4 to 5)

Note: the second question or hypothesis (examining pupils' knowledge about light pollution) belongs to the first group of questions only in that it was only the knowledge survey and the evaluation of the answers by school class that was examined:

- 1.) To what extent do the educational and developmental objectives for science subjects in the National Curriculum and the framework curricula include knowledge about light pollution and ways of developing knowledge that can be applied in everyday life?
- 2.) The dissemination of astronomy and its scientific and cultural values shall be considered as a core content to be included in educational activities. What new knowledge can be added to the subjects and how can the primary and secondary school curricula in science and geography be adapted to promote a better understanding of the causes and consequences of light pollution?
- 3) What methods can be used to promote the need for information on the subject?
- 4.) What content does the media convey on the subject of light pollution? How accurate is the scientific content of the sources?
- 5) Do the inhabitants of municipalities close to a starry sky park light up more and use more modern, healthier lighting equipment?

At the beginning of the research I formulated the following hypotheses:

H1: The National Core Curriculum (2020) and its framework curricula, as well as the textbooks approved in accordance with it, already include a sufficiently thorough and comprehensive discussion of the problem of light pollution.

H2: Secondary school students already have some knowledge of light pollution.

H3: A targeted, short educational programme can significantly increase students' awareness of light pollution.

H4: Nationally available television and radio channels currently have few, short and narrow programmes on light pollution.

H5: Adults living in a settlement with Starry Sky Parks have a higher level of awareness than those living in control settlements of similar population size in close proximity.

3. Research methods

I obtained results through exploratory and analytical studies using quantitative and qualitative methods. In the exploratory method, a written questionnaire was used. The analytical method involved quantitative research methodology and statistical analysis including a sample comparison. Data were processed using Excel and SPSS 10.0. In detail:

1) Light pollution in educational documents

At the beginning of the research, the National Curriculum was in force since 2012, but later the new central document was published in 2020, which made it necessary to compare the content of the two documents. In the comparative analysis, after searching for predefined keywords, I mapped the similarities and differences and gaps in the representation of light pollution. The analysis was based on the science subjects (science/natural sciences, biology, physics, geography, chemistry). I first examined the priority teaching and learning tasks and then looked for links between the National Curriculum subject area, environmental education and the theoretical knowledge of light pollution. The main themes per subject were taken from the National Curriculum, while the development tasks, knowledge and learning outcomes were taken from the framework curricula.

2) Explore prior knowledge on light pollution

The aim of the questionnaire surveys was to get a general idea of the content of the pilot curriculum and the prior knowledge of the students. The questionnaire consisted of multiple-choice, open-ended and closed-ended questions, grouped around five themes:

1. Knowledge about the effects of lighting: recognition of types of lamps, effects of night lighting on human organisms and animal activity.
2. Lighting habits at home, at school and at work, in public places.
3. How lighting conditions make people tired in their private lives: effects on restful sleep at night, lighting in public places, use of electronic devices.
4. Questions on the relationship with the sky: questions on the view of the sky, the emotional relationship with the sky, the knowledge and discovery of different celestial bodies and constellations.
5. Explore knowledge about astronomy, energy saving and light pollution.

After analysing the 132 responses received, information is now available to help us decide what should be given more and less emphasis in the development of the new curriculum on light pollution. The sample consists of responses from pupils in a secondary school in Eger.

3) The experimental curriculum and its impact on student performance

The experimental curriculum was designed to provide a systematic approach to the problem of light pollution, to explore cause and effect relationships, and to stimulate interest and a need for information. The pilot lessons were held in two schools in Eger, one in Budapest and one in Miskolc for a total of 198 students. The aim was to sensitise 13-18 year olds to the topic. Before the lessons, I assessed the students' knowledge of light pollution. After the lesson, the pupils completed another test. I created groups of tasks designed to measure their understanding of the cause and effect relationships and connections between the processes that cause light pollution (Group 1), their understanding of the systems theory (Group 2), their knowledge of appropriate lighting, the effects of artificial light sources on human health and their ability to recognise the signs of light pollution (Group 3).

At the pre- and post-assessment, so-called bridge tasks were left in both tests, thus ensuring that we can compare the results of the two tests, i.e. we can directly assess the students' knowledge growth. Also in both sets of tasks, pupils stated what was the first thing that came to mind when they heard the term 'light pollution'.

4) Media analysis

Electronic media is the main source of knowledge on many environmental issues. In the context of light pollution, I have therefore analysed the number and content of programmes on this topic on national radio and TV channels for the period October 2017 to September 2021. This study was made possible by the fact that the National Audiovisual Archive (NAVA) has been digitally recording Hungarian-produced programmes of Hungarian public service channels and commercial television stations with the highest coverage since 2006. Of these, I was able to include in the analysis 4 radio and 21 TV programmes that were freely available and reached from our University's network, i.e. on average one such programme was broadcast every two months. The average duration of the broadcasts was 8 minutes, the average time was increased by a few broadcasts of around 20 minutes, against a majority of much shorter broadcasts. In addition to recording technical data (which channel, when, for what duration), I focused on which of the four issues related to light pollution were addressed in each programme and, in aggregate, the frequency with which each of the impacts was substantively discussed in the thematic programmes. The four issues were (i) the favourable or unfavourable colour temperature of light sources, (ii) impact on humans, (iii) impact on fauna and flora, and (iv) loss of the view of the starry sky.

5) Adult population questionnaires

The questionnaire survey is based on questionnaire samples collected in two municipalities in the Bükk and Hajdúság. The aim of the study is to find out whether the inhabitants of the settlements that are close to the Starry Sky Park know more about lighting and whether they use more modern and healthier lighting devices. In these municipalities there are also public

information events. In the Beech, this is Répáshuta, for which the settlement of Cserépváralja was chosen as a control. In the Hajdúság, the target settlement with a Starry Sky Park is Hortobágy, and the control settlement is Újszentmargita. The aim was to find an equal number of respondents from each of the 5 age groups (19-30, 31-40, 41-50, 51-60 and over 60), but this was limited by the age distribution of the inhabitants of the settlements and the availability of residents, which was problematic even on weekend days (Table 1). The survey was conducted in the municipalities of the Bükk area in March-April 2019 and in the Hajdúság in November-2020 January 2019, with face-to-face interviews on Saturdays and Sundays. Responses of up to one person from each household were recorded. The questionnaire contained 21 open-ended and closed-ended multiple-choice questions in each municipality.

Table 1: Number and proportion of questionnaires completed in the surveyed municipalities as a proportion of the population

Target settlement			Control settlement		
Settlement	Number of replies	Response as a percentage of inhabitants	Settlement	Number of replies	Response as a percentage of inhabitants
Répáshuta	33	7,5%	Cserépváralja	30	7,3%
Hortobágy	41	2,8%	Újszentmargita	36	2,4%

4. Research responses, evaluation of hypotheses

H1: The National Core Curriculum (2020) and its framework curricula, as well as the textbooks approved in accordance with it, already include a sufficiently thorough and comprehensive discussion of the problem of light pollution.

The hypothesis was not confirmed. The specificity of the keyword document analysis is that at the beginning of the research, the National Curriculum, which entered into force in 2012, was in force, but in 2020 the newer central document with new content was published, which made it necessary to compare the content of the two documents. In the content analysis of the National Curriculum, the document that entered into force in 2012 contains 10 instances of terms related to light pollution: physics and environmental science 3-3, science and biology 2-2. A significant element is that light pollution appears in two cases in the document. In the National Curriculum2020, the previous 10 cases have been reduced to 7. 5 cases in physics and 2 in biology. In the 2020 edition, a major change has been made, as the term light pollution has been removed from the document. In none of the documents are the terms glare, melatonin hormone and circadian rhythm mentioned, while all three concepts are important factors in the effects of light pollution on the organisms. Physics is the subject with the most searched keywords in both documents. An important change occurred in 2020 with the introduction of the new National Curriculum. In the lower school, students only study the subject of environmental studies in the third and fourth grades, not in the first and second grades. In the 2012 edition of the National

Curriculum, the subject provides an excellent basis for understanding the consequences of light pollution: the deterioration of the view of the starry sky and the limitation of the possibility of orientation in the starry sky.

In the case of the framework curricula, light pollution appears as an environmental problem already during the description of the nature of nature damage and its scientific background (deforestation, air pollution, light pollution). During the textbook analyses, one paragraph from physics deals with light pollution in grades 7-8. In grade 9-10 a video talks about night lighting, but the root cause and the phenomenon of light pollution itself are not named. Attention is also drawn to the loss of the view of the starry sky in another lesson, where the term light pollution is already included in the explanation of the root cause. In geography, in grades 9-10, students deal with the phenomenon of light pollution for one assignment. It is worth noting that in order to solve these tasks, the students must obtain information about the operation of starry sky parks and the relationship between population density (urbanization) and light pollution.

During the analysis of the documents, I found that the energy and infrastructure topics of the subjects discuss the causes of light pollution. The topics concerning global problems outline the economic and social consequences caused by light pollution. And from the natural sciences side, students may be faced with harmful effects on the living world (including due to behavior patterns appearing in the students' age group).

Overall, concepts and phenomena closely related to the topic are mentioned in the analyzed documents, albeit with a small number of mentions. However, there is a lack of a unified structure of the topic, i.e. the exploration of the root causes and consequences of light pollution, as well as an understanding of the students' own role and solution options in light of these.

H2: Secondary school students already have some knowledge of light pollution.

The hypothesis was confirmed. I evaluated the knowledge of the high school students solely on the basis of the survey in Eger, because the pre-assessment prior to the teaching of the topic would have been influenced by the knowledge of what topic we will be dealing with. Although only 33% of the 132 high school students who filled out the online questionnaire named school as the source of their knowledge about light pollution, the answers to the types of questions mentioned below reflect significant awareness. The recognition of the type of individual light bulbs is almost perfect. According to the majority of the responding students, the improper use of lighting at night affects our health, although opinions differ on the severity of the effect. Almost 100% of families turn off the lights in rooms they are not currently in. When buying new light bulbs, the manufacturer, the price, and the energy saving class are the determining factors. Difficulty falling asleep is typical for 25% of respondents, 18% never experience this problem, while the majority, 57%, only rarely, in certain life situations. 52% of respondents often look at the starry sky, 44% rarely, and only 4% never.

H3: A targeted, short educational programme can significantly increase students' awareness of light pollution.

The hypothesis was confirmed. The effectiveness of the targeted training can be characterized by comparing the pre- and post-measurement.

I found that, as a result of the training, the recognition of the causes of light pollution and the acceptance of the fact that it burdens the environment strengthened. Condemnation of energy waste and related overconsumption has increased. They recognized the disturbing effects on the lives of plants, birds, insects and people with greater efficiency. Almost 70% of those filling in recognize the correct lighting methods. In the majority of pre- (72%) and post-surveys (93%) street lighting that does not fulfill its function and the artificial light sources connected to it are considered to increase light pollution. For the statements to be decided, according to which artificial night lighting transforms the night landscape of the surroundings of settlements, 95% of those who filled in the post-measurement thought it was a correct statement. 75% of respondents believe that the impact of night lighting on human health is true. 85% of respondents believe that artificial light sources affect the orientation of animals flying at night as false.

Based on the comparison of the measurements, the 3rd hypothesis was confirmed.

H4: Nationally available television and radio channels currently have few, short and narrow programmes on light pollution.

During the four years examined, the term light pollution appeared in the annotations of a total of 41 programs. There was less than one such program per month among the broadcasts of the six national TV channels and one radio channel. Within this, 14 TV and 3 radio broadcasts (17 conversations) dealt with the loss of the starry sky. The other three topics (the color of the light sources, the harmful effects on humans, and the fauna and flora) were only covered by fewer, 7, 8 and 9 broadcasts respectively. Unfortunately, these data confirmed hypothesis 4. At the same time, it is interesting that the loss of the sight of the starry sky was exposed in some conversations as the loss of folk culture connected to the starry sky.

H5: Adults living in a settlement with Starry Sky Parks have a higher level of awareness than those living in control settlements of similar population size in close proximity.

The hypothesis was not confirmed. Based on the answers received personally from 30-41 adult residents in two settlements with similar population numbers in the Bükk and Hortobágy regions, we found that in the Bükk region (near Répáshuta and Cserépváralja) our assumption was fulfilled that the residents of the settlement in the Dark Sky Park area they are more informed. In contrast, in the Hortobágy district (Hortobágy village and Újszentmargitá) the same assumption was not confirmed. In conclusion, the existence of Dark Sky Parks alone is not enough. Expanding knowledge requires specific information programs.

5. Application of results, further research options

In the course of the research, it was confirmed that the teaching material containing systematic and summary knowledge related to light pollution is suitable for understanding the connections, getting to know modern lighting techniques, recognizing improperly designed lighting methods, interpreting lighting technology information and making efforts and decisions aimed

at reducing energy-wasting activities. The completed teaching material can be used even without changes as a starting source for the teacher who uses it.

Taking into account the positive effects of the course material, I myself formulated additional goals for clarifying and retesting the auxiliary material. Additional opportunities will arise in three primary and secondary schools that indicated to me that they would be open to cooperation at my previous invitation.

I would visit these schools as a result of the further development of the current supporting material: using thematic walking trails and gamification in addition to the tools typical of the environmental education methodology (e.g. presentations, experiments, video viewing, museum visits, field trips, forest school).

Another goal is to expand the employment tasks that can also be seen in the appendix of the dissertation. Primarily creative, entertaining, experience-based tasks that use colorful and varied forms of work. It may also be possible to expand the target group, for example with children of preschool age. Although it is not mentioned in the dissertation, during the literature collection I also found kindergarten attitude-forming programs within the framework of a project week, where light was the central theme, but the children also dealt with the problem of light pollution.

In addition, time is also an important factor, as there are limited hours available for shaping attitudes. For this reason, after the revision, I will give a prominent role to the use in extracurricular school activities.

Summarizing the above, the completed curriculum can be used as an educational package in public education. However, in order for the topic of light pollution to become better known in public education, it would be important to include it in teacher training. Due to its complex nature, I consider the integration of the topic of light pollution into the teacher training of the "Z-specialisation" (natural science-related) to be the most useful.

6. Scientific publications related to the thesis points

2021

1.) Anna, Apró:

Fényszennyezés a természettudományos tárgyak tankönyveiben. In: Kolláth, Zoltán (szerk.) Savaria Természettudományi és Sporttudományi Közlemények 19.: Kutatási eredmények a fényszennyezéssel kapcsolatban Tematikus különszám. Szombathely, Magyarország: Gothard Jenő Csillagászati Egyesület (2021) 116 p. pp. 76-83., 8 p.

2.) Anna, Apró; János, Mika

Célzott képzés hatásainak vizsgálata közoktatási osztályokban. In: Kolláth, Zoltán (szerk.) Savaria Természettudományi és Sporttudományi Közlemények 19.: Kutatási eredmények a fényszennyezéssel kapcsolatban Tematikus különszám. Szombathely, Magyarország: Gothard Jenő Csillagászati Egyesület (2021) 116 p. pp. 84-90., 7 p.

3.) Anna, Apró; János, Mika:

Connections of the light pollution issue to the UN Sustainable Development Goals.
Acta Universitatis De Carolo Eszterházy Nominatae Sectio Biologiae/ Az Eszterházy Károly Egyetem Tudományos Közleményei. Tanulmányok a biológiai tudományok köréből 46. pp. 183-192., 10 p. (2021)

4.) János, Mika; Anna, Apró; Richárd, Novák:

A fényszennyezés lakossági ismeretének felmérése két-két bükk-vidéki és hajdúsági településen. In: Juhász Erika; Kozma Tamás; Tóth Péter (szerk.) Társadalmi innováció és tanulás a digitális korban. Budapest, Debrecen: Debreceni Egyetemi Kiadó, Magyar Nevelés- és Oktatáskutatók Egyesülete (HERA) pp. 383-397., 15 p. (2021)

5.) Anna, Apró; Erika Homoki; László, Sütő:

A fényszennyezés tudatosításának lehetőségei a tanárképzésben.
In: Juhász Erika; Kozma Tamás; Tóth Péter (szerk.) Társadalmi innováció és tanulás a digitális korban. Budapest, Debrecen: Debreceni Egyetemi Kiadó, Magyar Nevelés- és Oktatáskutatók Egyesülete (HERA) pp. 181-188., 8 p. (2021)

2020

6.) Anna, Apró; István, Pintér; Alex, Kertész; János, Mika:

A fényszennyezésre vonatkozó lakossági ismeretek kérdőíves felmérése két hajdúsági településen.

In: Bujdosó, Zoltán; Dinya, László; Csernák, József (szerk.) XVII. Nemzetközi Tudományos Napok [17th Scientific Days][XVII. Internationale Wissenschaftliche Tagung]: online konferencia [online conference][online Konferenz]: Környezeti, gazdasági és társadalmi kihívások 2020 után [Environmental, Economic and Social Challenges after 2020][Herausforderungen der Umwelt, Wirtschaft und Gesellschaft nach 2020]: Tanulmányok [Publications][Publicatione] Gyöngyös, Magyarország: Károly Róbert Kft. (2020) pp. 1242-1248., 7 p.

Anna, Apró:

Light pollution as environmental problem appearance in national core curriculum and in other educational documents. Journal of Applied Technical and Educational Sciences / Alkalmazott Műszaki és Pedagógiai tudományos folyóirat 10: 3. pp. 147-156., 10 p. (2020)

7.) János, Mika; Anna, Apró; László, Sütő; Szabolcs, Balogh; Mónika, Hankovszki; Alex, Kertész; Richárd, Novák; István, Pintér:

Measuring inhabitants' knowledge on technical features and physiological effects of light pollution. Journal of Applied Technical and Educational Sciences / Alkalmazott Műszaki és Pedagógiai tudományos folyóirat 10: 3. pp. 115-128., 14 p. (2020)

8.) János, Mika; Anna, Apró:

A fényszennyezés problémakörének kapcsolódása az ENSZ Fenntartható Fejlődési Céljaihoz. Elektrotechnika 4: 113. pp. 5-7., 3 p. (2020)

2019

9.) Anna, Apró; Richárd, Novák; Mónika, Hankovszki; Alex, Kertész; János, Mika:

A fényszennyezés műszaki jellemzőire és élettani hatásaira vonatkozó, lakossági ismeretek felmérése két településen. International Journal of Engineering and Management Sciences / Műszaki és Menedzsment Tudományi Közlemények 4: 4. pp. 155-161., 7 p. (2019)

2018

10.) Anna, Apró; János, Mika; Erika, Homoki; László, Sütő:

A fényszennyezés oktatási vonatkozásai a földrajz tantárgyban. In: Fazekas, István; Kiss, Emőke; Lázár, István (szerk.) Földrajzi tanulmányok 2018. Debrecen: MTA DAB Földtudományi Szakbizottság pp. 41-43., 3 p. (2018)

11.) Anna, Apró; Richárd, Novák:

A fényszennyezés megjelenése az oktatásban. In: Ollé János; Mika János (szerk.) Iskolakultúra és környezetpedagógia. Budapest: ELTE Eötvös Kiadó pp. 87-93., 7 p. (2018)

12.) Anna, Apró; Enikő, Kovács; András, Rázi; János, Mika:

A fényszennyezés, a megújuló energiák, a klímaváltozás és a fenntarthatóság környezetpedagógiai feldolgozása: hasonlóságok és egyediségek. In: Lázár István (szerk.) Környezet és energia: Hatékony termelés, tudatos felhasználás. Debrecen: MTA DAB Földtudományi Szakbizottság pp. 147-150., 3 p. (2018)

Scientific presentations directly related to research:

1. **Anna, Apró; Richárd, Novák:** A csillagoségbolt-parkok lehetőségei az oktatásban. XVII. Természet-, Műszaki- és Gazdaságtudományok Alkalmazása Nemzetközi Konferencia, Szombathely, 2018.
2. **Anna, Apró:** A fényszennyezés és az alvás közti kapcsolatok. HuCER Környezetpedagógia Konferencia, Székesfehérvár, 2018.
3. **Anna, Apró:** Szempontok a fényszennyezés oktatásához a tantervi szabályozás vonatkozásában. Társadalomföldrajzi folyamatok Kelet-Közép-Európában: problémák, tendenciák, irányzatok. Nemzetközi Földrajzi Konferencia. Beregszász (Kárpátalja, Ukrajna), 2020.
4. **Anna, Apró; Erika, Homoki; László, Sütő:** A fényszennyezés tudatosításának lehetőségei a tanárképzésben. HuCER Környezetpedagógia Konferencia, 2020.
5. **Anna, Apró; János, Mika; Richárd, Novák:** A fényszennyezés lakossági ismeretének felmérése két-két Bükk-vidéki és hajdúsági településen. HuCER Környezetpedagógia Konferencia, 2020.
6. **Anna, Apró:** A fényszennyezés oktatásának megközelítései. 14. Képzés és Gyakorlat Nemzetközi Neveléstudományi Konferencia, Kaposvár, 2021.

7. **Anna, Apró; János, Mika:** The light pollution and the UN Sustainable Development Goals (2016-2030). 7th International Conference On Artificial Light At Night, 2021.
8. **Anna, Apró:** A fényszennyezés tudatosítási lehetőségei nemzetközi környezetben. VI. Nemzetközi Interdiszciplináris Konferencián, 2021.
9. **Anna, Apró:** A fényszennyezés tudatosításának lehetőségei a Fenntarthatósági Témahéten. HuCER Környezetpedagógia Konferencia, 2021.
10. **Anna, Apró; Szabolcs, Balogh; Csaba, Patkós; László, Sütő:** Fényszennyezés terepi oktatási lehetőségei a természetjáró turistautakon. Fényszennyezés kutatási eredményei - Tudomány Heti Konferencia, Szombathely, 2021.

Other publications:

Anna, Apró:

Pedagógiai kutatások a földrajz felsőoktatásban.

EDU Szakképzés és Környezetpedagógia Elektronikus folyóirat 7:3. pp. 74-83., 10 p. (2017)

Anna, Apró; András, Rázi:

A környezeti tudatformálás lehetőségei az általános iskolában.

In: EDU 4:2. pp. 7-19., 13 p. (2014)

Anna, Apró; Árpád, Dávid:

Bioeróziós nyomok csontokon (Mecsek, Pécs, Danitz-puszta)

In: Bosnakoff Mariann; Dulai Alfréd; Vörös Attila; Pálffy József (szerk.) 16. Magyar Őslénytani Vándorgyűlés, Orfű: Program, előadáskivonatok, kirándulásvezető

Budapest, Magyarország: Magyarhoni Földtani Társulat pp. 7., 1 p. (2013)

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