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Awareness of planetary boundaries as a starting point for sustainable development: An example of the use of the ecological footprint in education

Abstract: Public awareness of planetary boundaries is crucially important for moving towards sustainable development and, thus, is an essential component of education for sustainable development. A requirement for sustainable development is that socioeconomic progress be achieved within the environment's carrying capacity, which in recent decades humanity has exceeded through depletion of natural resources and pollution of the environment. Calculations of the ecological footprint as a synthetic measure of environmental impacts, which online calculators have made available to the general public, clearly indicate how the planetary capacity for regeneration has been exceeded. In research undertaken with geography students at the University of Ljubljana in Slovenia, we used the online ecological footprint calculator to make selected learning content more accessible through calculation of one's own personal ecological footprint and experimentation with the possibilities of reducing it in different consumption categories. Simultaneously, we also evaluated the acquisition of practical experience with the calculator of the ecological footprint and its suitability for use in schools. Users of the online calculator recognised its important contribution to education for sustainable development and its user-friendliness, which they viewed as particularly advisable in the last triad of primary school and in secondary school, while they found that there is room for improvement mostly in terms of specific proposals for changing habits and motivating users to introduce these changes into everyday life.

Keywords: ecological footprint, calculator, education for sustainable development, sustainable consumption, Slovenia

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Introduction

Human society depends on the planet's ecosystem services to ensure our survival, health, well-being and security (Constanza et al. 1997; Constanza et al. 2014; Millennium Ecosystem Assessment 2005). Through depletion of natural resources and pollution of various components of the environment, these ecosystem services increasingly have been degraded or lost (Constanza et al. 2014) because possibilities for regenerating them are limited. The debate over the impossibility of endless growth on a planet with limited resources, space and self-cleaning capacity has been going on for half a century, since the publication of the report »The Limits to Growth« (Meadows et al. 1972). The concept of sustainable development, devised over the past three decades, also draws attention to limitations on the use of environmental resources, depending on the organisation of society, the state of its technology and the biosphere's ability to absorb the consequences of human activities (Our Common Future 1987). Expectations and efforts to achieve socioeconomic progress within the environment's carrying capacity in the 21st century have focussed on sustainable development (Hoekstra and Wiedmann 2014; Moldan et al. 2012; Sachs 2015; Steffen et al. 2015), as many studies and authors have warned that environmental impacts already are exceeding regional and planetary capacity (Global Environment Outlook 2019; Hoekstra and Wiedmann 2014; Millennium Ecosystem Assessment 2005; Sachs 2015; Steffen et al. 2018; The European Environment – State and Outlook 2020 2019), which mainly is reflected in environmental problems such as climate change, biodiversity loss, air and water pollution, desertification and similar.

Public awareness of planetary boundaries is crucial to make progress towards sustainable development and, thus, is an essential component of education for sustainable development. Fernández et al. (2016) emphasised that awareness of environmental problems, their causes and possible solutions is a prerequisite for responsible sustainable behaviour, but that individuals must be convinced that their contributions are important. Several studies (Bülbul et al. 2020; Du et al. 2018; Kollmuss and Agyeman 2002; Zsóka 2008) found a significant gap between knowledge and awareness on one hand and more environmentally friendly behaviour on the other, i.e., knowledge and awareness are important, but by no means are

sufficient preconditions for action towards sustainable development. Among the approaches that effectively raise awareness of the gap between consumption and availability of natural resources on the planet, and that we are exceeding planetary boundaries, is calculating ecological footprint (Fernández et al. 2016; Wiedmann and Barrett 2010).

The ecological footprint's significance for public awareness and education

Increases in the socioeconomic well-being of the world's growing population historically have been accompanied by increasing impacts on natural resources and ecosystem services, particularly since the Industrial Revolution. In recent decades, the growth of these impacts also has been monitored quantitatively using the ecological footprint developed as a synthetic measure by Rees and Wackernagel in the 1990s (Rees 1992; Wackernagel and Rees 1996). For the past two decades, its methodology and calculations have been overseen by the Global Footprint Network. The ecological footprint calculates the extent of the biosphere's regenerative capacity and the ecosystem services needed to conduct human activities. It makes these calculations in terms of the area of biologically productive land and water needed to produce all the resources we consume, support our infrastructure and absorb the waste produced. The area is converted into global hectares (gha), which are hectares with average global productivity (Borucke et al. 2013; Galli et al. 2016; Global Footprint Network 2021). Despite many methodological limitations (Galli et al. 2016), experts believe that the ecological footprint is a powerful communication tool that strengthens public awareness and education (Fernández et al. 2016; O'Neill et al. 2018; Wiedmann and Barrett 2010), particularly because of the clear comparison between the biocapacity available annually in a particular country or region, or the planet as a whole, and the ecological footprint as actual consumption by inhabitants of the same area.

According to the Global Footprint Network's (2021) latest calculations, the average global ecological footprint in 2017 was 2.8 gha per capita, exceeding the planet's available biocapacity (1.6 gha per capita) by a factor of 1.7. In Slovenia, the ecological footprint of 4.9 gha per capita in 2017 substantially exceeded the Slovenian territory's available biocapacity (2.2 gha per capita), as well as that of the world. Thus, if every nation in the world generated the same level of consumption as Slovenia, the biocapacity of three planets would be needed to meet this planet's needs. Thus, exceeding the ecological footprint beyond biocapacity directly highlights unsustainable practices (depletion of natural resources and pollution) that strain planetary capacity in the form of what is termed the ecological deficit. The ecological deficit also draws attention to the environmental impact in other parts of the world caused by an individual's consumption of imported energy, raw materials and goods. To raise awareness and promote education, the possibility of comparing the average ecological footprint of people in different countries and parts of the world is welcome, as is analysis of the ecological footprint's structure at the level of the individual.

Ecological footprint calculator

In the years following the popularisation of ecological and other footprint types, several nongovernmental organisations (NGOs) (e.g., Global Footprint Network and the World Wildlife Foundation) and government agencies have set up online calculators (Franz and Papyrakis 2011) to allow individuals to calculate their environmental impacts. The most widely used one is the Global Footprint Network's ecological footprint calculator (What is Your Ecological Footprint? 2021), which employs national ecological footprint calculations for this purpose, so that the size of an individual's footprint can be broken down by both land-use category needed to meet daily needs (built-up land, forests for forest products, cropland, grazing land, fishing grounds and forest land to sequester CO₂ emissions from burning fossil fuels) and by consumption categories (food, housing, mobility and goods and services) in which the footprint is produced (Footprint Calculator FAQs 2021). The online calculator adjusts the results to the individual entering data on their lifestyle and consumption using 18 basic questions and 30 detailed questions from all five consumption categories,¹ with the results provided at the end. For all questions, a slider can be used to select answers on a scale from the minimum to the maximum values, making answering easy and the results more accurate than choosing from predefined size classes. For example, with an individual who states that they consume twice as much beef as the national average, the online calculator would take twice the national average of the beef footprint into account in the final ecological footprint, while for a vegetarian, no footprint would be generated from this item.

The online calculator presents the results for an individual's ecological footprint in five different ways. In addition to the ecological footprint based on land use and consumption categories, as described above, it also calculates the number of planets required to support the consumption of the world's population if everyone lived like the person whose footprint was calculated. It also calculates the day of the year when the world's population with this footprint would use up the planet's biocapacity and all the natural resources that the planet can regenerate and provide in one calendar year (Earth Overshoot Day). For example, in 2021, based on the average global ecological footprint per capita, Earth Overshoot Day was 29 July, while an ecological footprint of 6.8 gha per capita would move it to 28 March and require 4.2 planets' biocapacity to meet our needs (Global Footprint Network 2021). Furthermore, the results present carbon dioxide emissions (CO₂ in tons per capita per year), i.e., the share of the carbon footprint in a person's ecological footprint, which averages about 60% (Vintar Mally et al. 2021). After answering questions and learning more about their personal results, an individual also can react to the findings, and the online tool encourages them to examine data on their own country

¹ The questions concern consumption frequency of food of animal origin, the use of unprocessed and locally produced food, housing characteristics (construction type, building materials, energy efficiency and energy use), household size and appliances, renewable energy supply, amount and type of waste produced (frequency of purchase and replacement of particular types of goods), and waste management and mobility habits (distances traveled, means of transport used, fuel consumption in vehicles used, use of public transport, etc.).

and foreign countries, and provides concrete suggestions on how they can reduce their footprint in particular consumption areas.

The online calculator is available for use in Slovene as of March 2021 through the international Sustainaware project and is valuable for use in the Slovenian education system and to raise public awareness. The translation and adaptation of the Global Footprint Network calculator (Kakšen je tvoj ekološki odtis 2021; Slovenski kalkulator ekološkega odtisa 2021) for the Slovenian context provides more comprehensive education on humans' effects on the environment and sustainable development. Previously, two useful education tools commonly were employed – the NGO Umanotera's carbon footprint calculator (Izračunaj svoj ogljični odtis 2021) and the Eco-School project's CO₂ calculator for educational purposes (Ekošola meri odtis CO₂ 2020) – but both are limited in scope, as they rely only on measuring carbon footprint, which is only one component of the ecological footprint. The former focusses more on the carbon footprint from energy use and the latter on the carbon footprint in classrooms and schools, and less on individuals' daily behaviour. This gap can be filled by using an ecological footprint calculator, the advantage of which is not only an emphasis on the individual, but also the possibility of analysing their various impacts and comparing them with calculations for the entire country of residence.

Research problem

In recent years, the online ecological footprint calculator has been used successfully in higher education with various projects (Collins et al. 2018; Collins et al. 2020; Fernández et al. 2016; Galli 2020), and during the 2020-2021 academic year, we tested its English version with students in the University of Ljubljana's Department of Geography, Faculty of Arts. We tried to make selected learning content more accessible to students by calculating their personal ecological footprint and experimenting with various specific options that aim to reduce it. The main research objective was to evaluate the acquisition of practical experience with the online tool, spontaneously during the course of work and systematically at the end of the academic year through a questionnaire. Our assumption was that the assessment of the online calculator's suitability for school use would increase with education level, and we simultaneously posed the following basic research questions:

- To what extent and in which consumption categories are students willing to change their behaviour to reduce their ecological footprint?
- Which advantages of using an online ecological footprint calculator stand out the most?
- Which way of presenting the results from the ecological footprint is the most memorable and clearest in the long run?
- At what education levels would the use of an online calculator be recommended?

Research methodology

Research method

In this study, we used a descriptive method of empirical research and quantitatively processed the numerical data collected using the online ecological footprint calculator and a questionnaire.

Sample

All 54 first-cycle students enrolled in the third year of geography participated in the study. During the winter semester 2020-2021, they attended classes for the subject Environmental Geography and will be trained at the second level of study in greater numbers as geography teachers. In the introductory analysis of the ecological footprint results, based on data obtained using the online calculator, we only included results from the 46 students who entered all data sets in the spreadsheet (see Step 2 in the Procedure) and from those in which no discrepancies were found in the totals of the ecological footprint categories.

	Questionnaire participants		Participants enrolled in the course	
	Number	Share (%)	Number	Share (%)
Women	25	60.9	30	55.6
Men	12	29.3	24	44.4
Gender not disclosed	4	9.8	0	0.0
Total	41	100.0	54	100.0

Table 1: Survey respondents' characteristics

Altogether, 41 of the 54 invited students, or 75.9%, completed the questionnaire (see Step 5 in the Procedure), of which four participants provided incomplete answers. Among the participants, 25 female and 12 male students provided gender data, differing significantly from the gender structure of those enrolled in the course (Table 1). When interpreting the results, it also should be considered that this is a very homogeneous group in terms of age and study discipline, i.e., not at all representative of the general population, so the answers cannot be generalised to other fields of study or population groups. Geography students learn about various topics in the field of sustainable development and environmental protection throughout their studies, so their views are not necessarily influenced predominantly by knowledge and competencies acquired via the subject Environmental Geography.

Procedure

The whole process of learning about the concept of ecological footprint, calculating it, identifying ways to reduce environmental impacts and evaluating the online calculator's usability took place in five steps, which, during the introductory stages, partially followed the materials from the EUSTEPS project (Galli 2020; Galli et al. 2020). This was followed by in-depth learning in accordance with the environmental geography curriculum:

1. We introduced the concept of sustainable development, the importance of indicators of sustainable development and the concept of ecological footprint to students. We acquainted them with the methodology for calculating ecological footprint, as well as the advantages and disadvantages of this indicator, as well as the ecological footprint calculator. Before performing the second step (i.e., answering questions in the international version of the online calculator), we reminded them of certain national specifics that need to be considered to help ensure more accurate calculations (e.g., average share of electricity from renewable energy sources in Slovenia, average motor vehicle fuel consumption, clarifying the understanding of questions relating to locally grown food, etc.). Considering that the 2020-2021 academic year took place entirely in the context of the COVID-19 pandemic – which has been a significant factor since mid-March 2020, but probably only temporarily, and has changed some habits that represent a major contribution to the ecological footprint, such as reductions in commuting and leisure travel – the students were instructed to take into account the data for a typical year before the pandemic and the location where they spend most of their time to obtain realistic results from their answers.
2. The students used the online calculator on their own to calculate their ecological footprint under normal conditions, then entered all the results into a common online spreadsheet (Google Sheets). The calculation of the ecological footprint then was repeated, taking into account any adjustments to daily activities they would be willing to introduce to reduce their footprint (e.g., fewer car or plane trips, less meat in their diet, fewer purchases of clothing, more waste separation, etc.). The results from the repeat calculations also were entered into the online spreadsheet.
3. The collection, editing and analysis of ecological footprint calculations was followed by the presentation of results and discussions to evaluate the overall results (i.e., the ecological footprint's size) and the contribution of individual consumption categories and daily activities. Special attention was paid to examining the possibility of reducing the ecological footprint as a whole, as well as identifying specific actions that could reduce environmental impact.
4. Whole-class evaluation of the results was followed by preparation of more specific proposals for reducing the ecological footprint in groups. Each group chose one of the consumption categories (i.e., food, housing, mobility,

goods and services) and examined it in more detail through the study of literature and the search for Slovenian and international examples of good practice. Particular emphasis in preparing the presentation of selected proposals to reduce the ecological footprint was placed on the use of an approach that would encourage peers to change everyday practices (e.g., interactive presentations with the inclusion of original video material).

5. Eight months after the course ended, students were invited to evaluate various aspects of the ecological footprint calculator's usefulness critically and their willingness to change habits that would help reduce the ecological footprint in a questionnaire.

Data collection, instrument and data processing

The participating students entered the data on the calculated size and structure of their ecological footprint into joint tables. The first data set was related to normal situations, and the second to calculations after the introduction of changes that they viewed as acceptable.

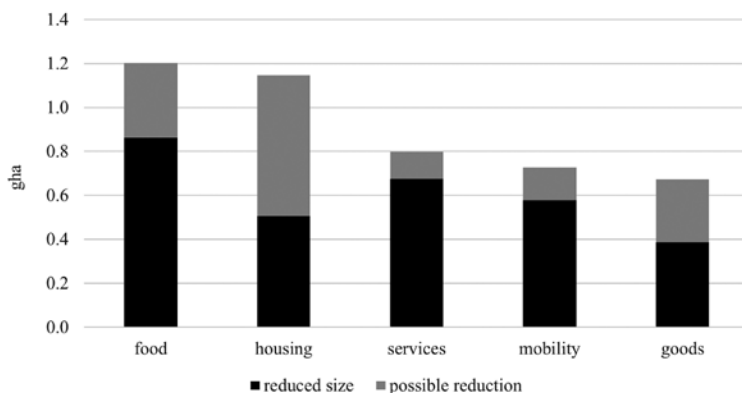
Data on the ecological footprint calculator's usability were collected using a questionnaire, with invitations sent out to students to complete it at the end of July 2021, plus three more reminders sent to them until the end of the survey in early September 2021 to ensure the best possible response. Thus, the survey was available for six weeks. At the time of the survey, an average of about eight months passed since completion of the course and two months more since use of the online calculator. The survey was conducted entirely online, using the 1KA tool. The questionnaire comprised three sections, partly following related research abroad (Collins et al. 2018; Collins et al. 2020), that were adapted partly to Slovenian conditions, work methods and research purposes.

With the first set of questions, we gauged students' willingness to change their behaviour to reduce their ecological footprint and ease impacts on the environment in the areas of food, housing, mobility, goods and services. For the first question, they noted areas in which they were willing to change their behaviour significantly, and for the second question, areas in which they were unwilling to do so. The second set of questions concerned opinions on the use of the online calculator, calculated values of the ecological footprint, information obtained and incentives to reduce environmental impacts. In this set, the students agreed or disagreed with given statements using a five-point Likert scale that also was used to evaluate the ecological footprint calculator's usability in the third set, in which the statements referred to the online calculator's ease of use, its use at different education levels or for different target groups (schoolchildren, older students, friends and relatives) and in education for sustainable development in general. The last part referred to the memorability and clarity of different ways of presenting the results from the ecological footprint (i.e., the size of their ecological footprint in gha, their dates for Earth Overshoot Day, the number of planets needed for their footprint and the amount of annual emissions of CO₂ in tons that their footprint generated).

The analysis included data on the size and structure of the ecological footprint for 46 students who entered sufficiently accurate data in all required categories. Both data sets (i.e., for normal situations and after the introduction of changes) were analysed separately, then the results were compared. In the analysis of the survey results, we included all the answers received from all 41 respondents who completed the questionnaire.

Results and discussion

Using an online calculator, geography students calculated the initial size of their ecological footprint to study its structure and possible ways of reducing their impact on the environment, in which knowledge about the ecological footprint's structure, according to particular consumption categories, is particularly useful. Their average ecological footprint was 4.55 gha per person, about 7% less than the average Slovenian resident's footprint, at 4.89 gha (Vintar Mally et al. 2021). Food (26.4%) and housing (25.2%) comprised the largest shares among the consumption categories. The remaining three categories contributed significantly less to the overall ecological footprint: services (17.5%); mobility (16.0%); and goods (14.8%). These percentages are comparable to the latest data on Slovenia's ecological footprint structure (Vintar Mally et al. 2021), with larger differences only in food, in which the share for geography students was 9.1 percentage points higher, while in mobility, it was 5.9 percentage points lower than the national average.

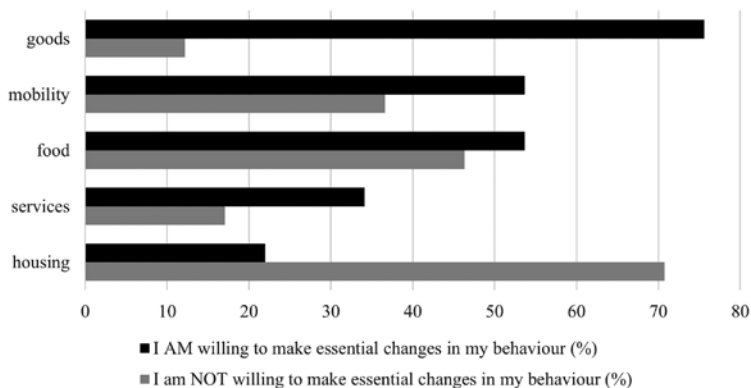


Graph 1: Values for geography students' ecological footprint by consumption category

Note: The full column represents the initial ecological footprint calculation's value (i.e., the ecological footprint under normal conditions), and the black part represents the second ecological footprint calculation's value (i.e., the ecological footprint after the introduction of changes that students deemed acceptable), with the difference (in grey) representing a possible reduction in the footprint.

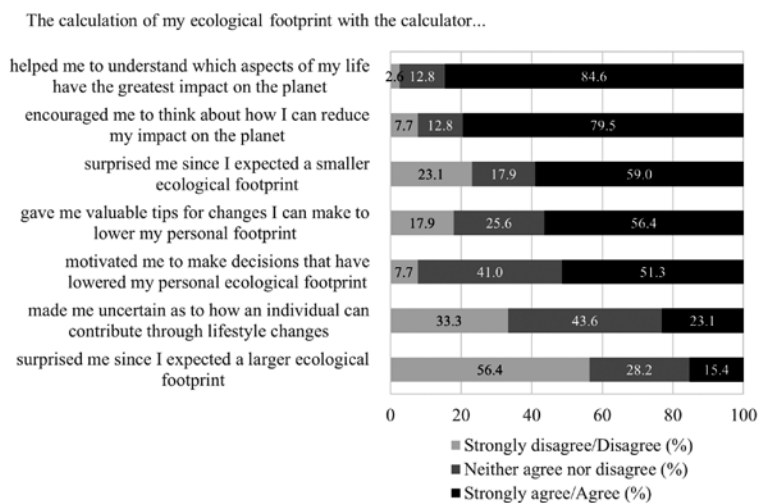
The repetition of the ecological footprint's calculation, taking into account all the adjustments to daily activities that students would be willing to make to reduce

their footprint, indicated (Graph 1) that this could reduce the ecological footprint by an average of 33.8% (from 4.55 to 3.01 gha). The largest decreases were in the categories of housing (55.8%) and goods (42.6%), which are interesting mainly from the perspective of comparisons with survey answers, in which they expressed the least willingness to make changes related to housing. We conclude that when using the calculator, they took into account all the changes that they thought possible, but did not take into account these changes' feasibility.



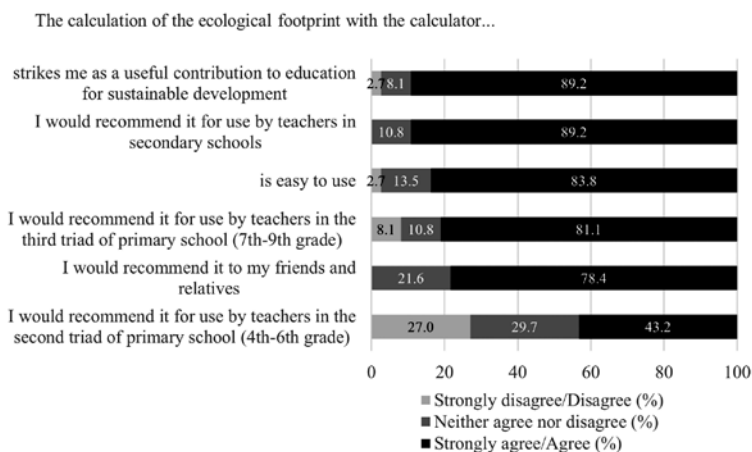
Graph 2: Willingness to change behaviour to reduce environmental impacts.

In the questionnaire, more than eight months after the original calculations, we asked students, by consumption categories, whether they were or were not willing to change their behaviour significantly to reduce environmental impacts (Graph 2). Three-quarters (75.6%) of respondents were willing to change their behaviour when shopping for goods, and more than half (53.7%) with mobility and food. The lowest willingness to change was in the category of housing (22.0%), in which unwillingness to change is the most pronounced (70.7%), likely related to the fact that students do not have many opportunities to change their places of residence, usually dormitories, rented apartments or shared households with parents. As a result, the small possibility of influence also was highlighted in the comments. The second highest level of unwillingness to change was recorded in the category of food (46.3%), which was the only category in which all respondents took a position. We can conclude that the respondents have the most developed opinions regarding this category, or the most emotional attitudes towards it. However, the response was lowest in the category of services (the sum of positive and negative answers was 51.2%), at least partly because this category was the least-elaborated among the online calculator items and, thus, was less well known. Altogether, 4.9% of the respondents were unwilling to change their behaviour significantly in any category, while 7.3% were prepared to make significant changes in all areas to help reduce environmental impacts and problems.



Graph 3: Agreement with statements regarding ecological footprint calculations using the online calculator.

The second part of the questionnaire comprised seven statements on calculation of the ecological footprint using an online calculator, in which geography students agreed or disagreed with items using a five-point Likert scale (Graph 3). They conveyed the most unequivocal agreement with statements that the calculation helped them understand which aspects of everyday life make the greatest impact on the planet (84.6% agreed or strongly agreed) and that it encouraged them to think about ways to reduce these impacts (79.5% agreed or strongly agreed). The majority also agreed that the online calculator gave them valuable tips on possible changes to reduce their personal ecological footprint (56.4%) and motivated them to make such decisions (51.3%). From the results, we also can see that several months after using the ecological footprint calculator, about half the students said they changed their habits – beyond just becoming aware of their negative impact on the environment. Considerably more gained the necessary knowledge and mindset about the ecological footprint's structure, which is also a good starting point for possible later decisions. Low rates of disagreement with these statements also are encouraging. The share of undecideds (43.6%) was the highest with respect to the statement that the calculation of the ecological footprint left them uncertain about concrete solutions in the form of lifestyle changes. For statements regarding expected size of their personal ecological footprint, 59.0% expected a smaller ecological footprint and 15.4% a larger one. The share of undecideds was 17.9% and 28.2%, respectively. Most were surprised by the results from the calculations, as they did not have a good idea of the extent of their impact on the environment, even though they were acquainted previously with the footprint concept itself and the average values per capita in the world and in Slovenia.

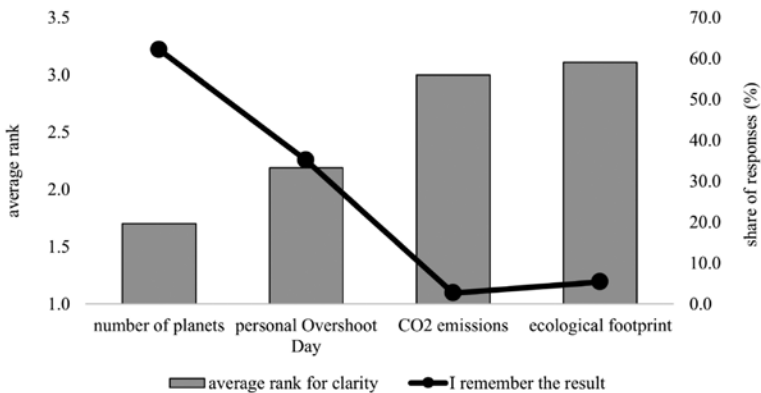


Graph 4: Agreement with statements about the ecological footprint calculator's usefulness.

Before providing the extent to which they agreed with statements about the ecological footprint calculator's usefulness for selected target groups in education for sustainable development, students were asked in the questionnaire to take into account not only their own experience, but also the fact that after the winter semester, an online version of the calculator in Slovene became available. The results indicate (Graph 4) that the respondents were the most sceptical about the calculator's usefulness with the youngest group that they were asked about – students in the second triad of primary school – as only 43.2% explicitly would recommend that teachers use the calculator at this level (agreed or strongly agreed). As education level increased, so did the extent of agreement to recommend using the ecological footprint calculator (81.1% agreement for the third triad of primary school and 89.2% agreement for secondary school). The results confirmed the assumption that tool suitability for school use increases with education level, as it requires relatively solid awareness of one's own actions, housing characteristics and other aspects of everyday life (e.g., car use and grocery shopping). It should be emphasised that the calculator also requires thorough consideration with older students to obtain accurate calculations, so the teacher must explain some difficult questions' content first. Slovenian teachers can use various Slovene-language materials (Kaj je ekološki odtis 2018; Kmet Zupančič 2021; Vintar Mally et al. 2021). It also makes sense for students to enter data into the calculator at home, where they can ask parents or guardians about certain aspects of household consumption. The surveyed students also pointed out these aspects in the comments, where individuals also expressed support for using the calculator with students in the first triad, which was not included in the questionnaire, as they believed that it could start raising children's awareness of the importance of reducing environmental impacts. Nine out of 10 respondents thought that the ecological footprint calculator was an important contribution to education for sustainable development, with only slightly less (83.8%) agreeing that this tool is easy to use. Slightly more restraint can be

seen in recommending the calculator to friends and relatives, but 78.4% of the respondents still would do so, while the rest were undecided.

Among the ecological footprint's benefits for education for sustainable development and for awareness-raising in general, how the results are presented must be highlighted first. In basic calculations, these are expressed in surface area units (global hectares), and more recently, for communication purposes, mainly in number of planets, dates for Earth Overshoot Day and CO₂ emissions. All the aforementioned ways of presenting the results are useful for teaching, as each brings a new aspect to the discussion. We compared them on the basis of the survey results, considering aspects of learning, memorability and clarity. For the first question, we asked which ways of presenting the ecological footprint results would students remember more than eight months after the calculation (Graph 5). Altogether, 73.0% of respondents remembered at least one result. Most remembered the result given in number of planets (62.2%), with more than a third remembering their dates for Earth Overshoot Day (35.1%), but only one and two respondents (2.7% and 5.4%) recalled data on CO₂ emissions and ecological footprint, respectively.



Graph 5: Memorability and clarity in how results are displayed.

In the second question, the respondents ranked ways of presenting results from the most (Rank 1) to the least (Rank 4) clearly, with 62.2% of the respondents ranking number of planets first, while 56.8% ranked dates for Overshoot Day second. These two ways of presenting the results were ranked in the top two places in 75.7% (Overshoot Day) and 81.1% (number of planets) of cases. Most smaller percentages were registered for ecological footprint in global hectares (18.9%) and CO₂ emissions (24.3%). Average ranking also clearly demonstrates distribution, which ranks how results are presented, i.e., number of planets (1.7), personal Overshoot Day (2.2), CO₂ emissions (3.0) and ecological footprint (3.1). We recommend providing results in this order in primary and secondary school, with special emphasis placed on number of planets at lower education levels.

Conclusions

Similar to the results from studies in other countries (Collins et al. 2018; Collins et al. 2020; Fernández et al. 2016), in our case as well, the ecological footprint and its calculation using an online calculator proved to be a useful tool for understanding how human activities' impact on the environment has exceeded the planet and its ecosystems' carrying capacity. Most users appreciate the ecological footprint calculator's ease of use, its contribution to education for sustainable development and how it raises public awareness on how to reduce environmental pressures. However, there is room for improvement in terms of the need to expand and enhance proposals for making changes in everyday habits, as well as motivating users to introduce these changes into everyday life. Our research also has indicated a marked discrepancy between students understanding and being aware of the problem on one hand, and making specific changes in their lives on the other. Nevertheless, eight months after using the tool, about half the students in the study stated that their ecological footprint score motivated them to make changes in their lives to reduce their personal ecological footprint. The highest willingness concerned purchases of goods and services, while the lowest willingness concerned changing or adjusting housing circumstances.

Based on the results presented here and knowledge of how the ecological footprint calculator works and its use in practice, we conclude that it is a suitable tool for education from the second triad of primary school onward, and that suitability of use increases with education level. At all levels, the teacher's role is very important in explaining the calculator's significance and the specific features of calculations, while it also makes sense to perform calculations at home, where parents, guardians or other household members can help answer questions about certain aspects of consumption. In this way, awareness also can be spread further to the general public. The number of planets and the date of Overshoot Day proved to be the clearest ways of presenting the results from ecological footprint calculations, serving as a useful guideline for the most understandable teaching on environmental impacts. However, other ways (ecological footprint in gha and CO₂ emissions), though more difficult to remember, should not be neglected because they are important to the original understanding of the ecological footprint concept. For the first triad of primary school, the calculator would need to be adapted and simplified, i.e., at this stage, other ways are more advisable for raising awareness and educating children about sustainable development to improve human well-being without exceeding the planet's environmental carrying capacity.

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ZAVEDANJE O PLANETARNIH OMEJITVAH KOT IZHODIŠČE TRAJNOSTNEGA RAZVOJA: PRIMER UPORABE EKOLOŠKEGA ODTISA V IZOBRAŽEVANJU

Povzetek: Zavedanje planetarnih omejitev je ključno za delovanje v smeri trajnostnega razvoja in posledično nujni del vzgoje in izobraževanja za trajnostni razvoj. Paradigma trajnostnega razvoja zahteva, da se socialno-ekonomski napredek dosega v okviru nosilnih zmogljivosti okolja, ki pa jih v zadnjih desetletjih človeštvo presega z izčrpavanjem naravnih virov in onesnaževanjem okolja. Na preseganje planetarnih zmogljivosti obnavljanja nazorno opozarjajo tudi izračuni ekološkega odtisa kot sintezne mere pritiskov na okolje, ki so prek spletnih kalkulatorjev postali dosegljivi širši javnosti. V raziskavi s študentkami in študenti geografije na Univerzi v Ljubljani smo uporabili spletni kalkulator ekološkega odtisa, da bi jim približali izbrane učne vsebine z izračunavanjem osebnega ekološkega odtisa in preigravanjem možnosti za njegovo zmanjšanje v različnih kategorijah potrošnje, sočasno pa smo vrednotili tudi praktične izkušnje s kalkulatorjem ekološkega odtisa in njegovo primernost za šolsko rabo. Uporabniki spletnemu kalkulatorju priznavajo pomemben prispevek k izobraževanju za trajnostni razvoj in enostavnost uporabe, ki sem jim zdi priporočljiva predvsem v zadnji triadi osnovne šole in v srednji šoli, medtem ko je največ izboljšav možnih pri konkretnih predlogih za spremembe navad in motiviranju za njihovo uvajanje v vsakodnevno življenje.

Ključne besede: ekološki odtis, kalkulator, izobraževanje za trajnostni razvoj, trajnostna potrošnja, Slovenija

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