

# **SOLVING THE WASTE PROBLEM BY MODERNIZING THE SECONDARY EDUCATION**

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## **Abstract**

*By to Directive 2008/98/EC on waste, which is the basic EU waste management legislation, waste means any substance or object, which the holder discards, intends, or is required to discard. Unfortunately, we are currently linking waste to the global problems of humanity. Every year around 2 billion tonnes of municipal waste is collected worldwide. This amount will increase every year due to the growth of global population. Environmental education is one of the basic preventive tools of environmental protection. The basis of the submitted paper is to point out the possibilities of modernization of Environmental education through selected ICT tools in the topic of Waste in the teaching process. The aim of the paper is to introduce available mobile applications (Trash Out, Green Daily, Czech Zero Waste) to teachers and pupils of lower secondary education with the possibility of their application within the Environmental education. The result of this work is a model of environmental education for lower secondary education, which interconnects mobile learning, interdisciplinary learning, project-based learning and outdoor education in order to modernize and streamline the teaching of waste issues and make this issue more attractive to pupils. The content of education, which the model proposed by us, mediates, consists of 3 consecutive levels. Through them, pupils gradually become acquainted with the specific waste problem found in their immediate environment. Subsequently, they will become acquainted with the possible solutions (corrections) of this problem and also with the ways of preventing it.*

## **Keywords**

*Waste, Environmental education, Outdoor education, Mobile learning, Project-based learning, Information and communication technologies, Illegal dumping, Separation, Zero waste*

## **INTRODUCTION**

Waste. We all know this word and when mentioned, we all imagine something unnecessary that is no longer needed, and we want to get rid of it. By to Directive 2008/98/EC on waste, which is the basic EU waste management legislation, waste means any substance or object which the holder discards or intends or is required to discard. Unfortunately, we are currently linking waste to the global problems of humanity.

Every year around 2 billion tonnes of municipal waste is collected worldwide (data from 2016). This amount will increase every year due to the growth of global population.

By 2050 mankind is expected to have produced up to 3.40 billion tons of waste (<http://datatopics.worldbank.org/what-a-waste/>). On a global scale, we most often encounter the problem of plastic waste that accumulates in the oceans and eventually disintegrates into small particles known as microplastics (Tibbetts, 2015; Gross, 2015). These can be caught by hundreds of different organisms and can also affect human health through the food chain. Floating residues tend to accumulate in large ocean vortices (gyre), such as the Great Pacific Garbage Patch. According to WWF (2019), up to 80% of oceanic plastics are estimated to come from land-based sources, therefore not only the seaside countries are responsible for plastics in the oceans. Example being the Danube River, according to Lechner et al. (2014), through which 4.2 tonnes of plastic waste enters the Black Sea every day.

Plastics are not the only type of waste currently emerging as a global environmental problem. Other problematic types of waste include electrical waste (e-waste), which is produced in staggering quantities. Alabaster et al. (2013) and Heacock et al. (2016) consider e-waste the greatest threat to the environment. Grant et al. (2013) assess e-waste as dangerous not only for the environment but also for human health, because it contains a few hazardous components such as lead (Pb), mercury (Hg) and chromium (Cr). Food waste is also often mentioned worldwide. Approximately 1.3 billion groceries are wasted worldwide each year (FAO, 2013). According to Melikoglu et al. (2013), more than 95% of food waste ends up in landfills where it is converted into methane, carbon dioxide and other greenhouse gases under anaerobic conditions. Food waste therefore also has a catastrophic impact on the climate change. Recently because of the so-called Fast Fashion, a global problem related to textile and clothing waste is emerging. It is estimated that between 1996 and 2012, the amount of clothing bought per person in the EU increased by 40%, while in 2015 EU citizens bought 6.4 million tonnes of new clothing (12.66 kg per person) (<https://www.eea.europa.eu/>). More than half of the garments are not recycled and end up in mixed municipal waste and then sent to an incinerator or landfill after they are discarded.

Most commonly, municipal waste is disposed of by landfilling or incineration. However, in many parts of the Slovak Republic (SR), we can encounter illegal waste in illegal dumps. They consist mainly of municipal mixed waste from households, construction and bulky waste. The number of illegal dumps in the SR is estimated at 6000 – 8000. Such landfills pose a great risk to the environment and, of course, to human health (Boltížiar et al., 2016), causing not only aesthetic but also hygienic problems and waste of raw materials that could be recycled. Tasaki et al. (2007) consider raising waste disposal charges as one of the reasons for illegal landfills due to stricter waste treatment regulations in order to better protection of the environment.

To tackle the global waste problem, it is necessary to spend a lot of money and resources to improve the waste situation. At the same time, it is important to consider other means necessary to prevent more unnecessary waste to be generated. The basic preventive tools of environmental protection include environmental education. Its goal is the assessment of an environmental issue and any feasible solutions it may have; in that assessment problems are analysed systematically, not only as a theory of reality but also as an action strategy to be undertaken (Magnus et al., 1997).

Under the current educational conditions within the State Educational, the Program “Environmental Education” is a mandatory part of education and is implemented as a

cross-cutting topic. Through it, it is possible to point out the seriousness of the waste issue and to influence pupils so that they get "engaged in activities aimed at protecting and improving the environment and actively participating in the elimination of environmental pollution" (<http://www.statpedu.sk>). We believe that further education, knowledgeable and spreading of information on waste education is not only needed, but also necessary.

The basis of the submitted paper is to point out the possibilities of modernization of environmental education through selected ICT tools in the topic of Waste in the teaching process. The aim of the paper is to introduce available mobile applications to teachers and pupils of lower secondary education with the possibility of their application within the environmental education.

## METHODS

In our view, modernization of environmental education concerns three interconnected areas: *modernizing of the content of education, modernizing of the education process and modernization of the teaching aids and didactic technology.*

### *Modernizing of the content of education*

The issue of waste as a topic of environmental education can be demonstrated to pupils through the following basic areas: what is waste, types of waste, waste characteristics, history of waste origin, place of waste origin, how we handle waste, environmental problems related to waste, prevention and minimization of production of waste.

However, this content does not remain on a global, theoretical and impersonal level. It is linked to the pupils' daily lives and the environment that surrounds them directly. Pupils themselves discover the seriousness of the waste problem by mapping illegal landfills or littering (Earll et al., 2000; Valiente et al., 2020) and looking for solutions to address and prevent these problems.

### *Modernizing of the education process*

We propose to use a combination of the following teaching approaches to implement the Waste issue in the teaching process within the secondary education:

- *Interdisciplinary learning* – Rowntree (1982) defines an interdisciplinary approach as an approach in which two or more disciplines come together, preferably in such a way that they interact. Interdisciplinary education according to Ivanitskaya et al. (2002) is characterized by the integration of multidisciplinary knowledge into the central theme in our case it is the issue of waste.
- *Project-based learning* – is a comprehensive perspective focused on teaching by engaging students in investigation. Within this framework, students pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analysing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artefacts (Blumenfeld et al., 1991).
- *Outdoor education* – is known as a method of developing knowledge, skills and attitudes concerning the world in which we live. It is an expression of the place where teaching takes place, but also of the topic to be taught (Ford, 1986).

The purpose of the outdoor activities is to give pupils out-of-classroom educational experiences involving direct contact with various environments. These experiences are intended to give pupils in-depth knowledge of environmental issues and to develop their self-confidence, environmental sensitivity, action skills, responsible action in nature, and their social relationships (Palmberg, Kuru, 2000).

### *Modernization of the teaching aids and didactic technology*

The implementation of new technologies and practices into education currently represents the greatest support for the development of learner's cognitive and intellectual abilities (Balogh, Kucharik, 2019; Balogh, Koprda, 2014). Information and communication technology (ICT) is a key tool for the modernization of teaching aids and didactic technology. Stoffová (1998) considers computing, telecommunications, transmission, and organizational technology used for information processing to be ICT. It also includes software and organizational arrangements. Smittek (1998) explains ICT as methods, procedures and methods for collecting, storing, processing, verifying, evaluating, selecting, distributing and timely delivering the necessary information.

In our case, we mainly included mobile learning in the ICT group, which includes the use of mobile or wireless devices for learning purposes. Typical examples of devices used in mobile learning are mobile phones, smartphones, handheld computers, tablet computers, laptops or personal multimedia players (Kukulka-Hulme, Traxler, 2005).

The main applications that we use within our proposed mobile learning to teach the topic Waste include:

- *TrashOut* – is an environmental project that aims to locate all illegal dumps around the world. Since 2012, the Ministry of the Environment of the Slovak Republic (<http://www.minzp.sk>) has published on its website a new way of reporting the occurrence of illegal landfills in nature using the TrashOut mobile application (TrashOut, n.f.). TrashOut is a mobile application that is free to download for Android and iOS not only in Slovak, but also in other languages (Fig. 1). It was based on a worldwide initiative to locate and eliminate illegal landfills (<https://www.trashout.ngo/>). This form is considered very simple and effective. The main functions of the application are: easy reporting of illegal dumps, map of illegal dumps, anonymous reporting of illegal dumps, all check-ins can be synced, badges earned for activity and sign in with Facebook or email.
- *Green Daily* – free and downloadable application for both Android and iOS in Slovak language (EKOrast, o.z.) (Fig. 2). Since the system of sorting common waste is not uniform in Slovakia, the waste producer's application navigates to what colour of the waste bin it belongs in its municipality or city e.g. can, paper, glass, etc. At the same time, this simple application will offer the user the possibility to find the nearest place for the collection of specific waste in each municipality or town, such as medicines, electrical waste, old batteries, kitchen oil or construction waste. The application includes useful information and contact details for collection yards and other establishments or shops that take care of specific waste and ensure its consistent recycling. The application also includes a learning window that explains to the user why he should sort the waste and some interesting information. The application was prepared by a civic association as one of the projects for the public, companies, children, and youth in the field of environmental protection.

• *Czech Zero Waste* – is a free mobile application in Czech language created by girls who blog about life without waste (Czech Zero Waste) (Fig. 3). The application guides the user to meet the 40-day waste-free challenge. Every day, the user is given a new challenge that prompts him to live with less waste. Since checking the current status of the trash can, the user has moved on to perform day-to-day tasks, such as a shopping bag, a water bottle, less paper, a food bag, a waste-free drugstore, leaflets, food waste, etc. Each task explains its purpose and meaning. The user can document the fulfilment of tasks by photographing them and then sharing them on social networks. If a user fails to complete a task or it does not suit them on a given day, it is possible to postpone it and return to it later. Zero waste is a lifestyle that aims to reduce or prevent the amount of waste we produce under the five basic 5R rules: R - Refuse, R - Reduce, R - Reuse, R - Recycle, R - Rot (<http://www.zerowasteslovakia.sk/>).



Figure 1: Free mobile application TrashOut for Android and iOS



Figure 2: Free mobile application Green Daily for Android and iOS

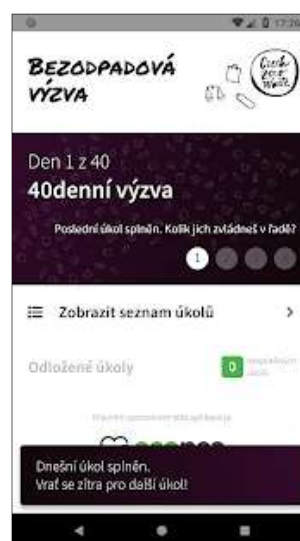


Figure 3: Free mobile application Czech Zero Waste for Android and iOS

Other ICTs that can be integrated into the training model we propose include GPS and GIS. We discussed them in more detail in our previous published papers (Zigová et al., 2018; Pucherová et al., 2019).

## RESULTS

The result of this work is a model of environmental education for lower secondary education, which interconnects mobile learning, interdisciplinary learning, project-based learning and outdoor education in order to modernize and streamline the teaching of waste issues and make this issue more attractive to pupils.

The content of education, which the model we propose mediates, consists of three successive levels. Through them, pupils gradually become acquainted with the specific

waste problem found in their immediate environment. Subsequently, they will become acquainted with the possible solutions (corrections) of this problem and also with the ways of preventing it.

Waste issues are a part of the education since the kindergartens. Pupils in lower secondary education, therefore, have a certain level of knowledge and habits. However, before execution of the model it is necessary to repeat the previously learned knowledge and habits. This level is shown in Fig. 4 as "level 0" and is represented by the key question: What do we know about waste and the problems that waste causes?

*Level 1* – presents an analysis of the problem that waste poses directly in our communities and in close proximity. Attention is paid to illegal waste dumps and littering. This level is executed through outdoor education and represents the beginning of the work of pupil groups on their projects (within the project teaching). Pupils map illegal landfills directly in the field, using their mobile phones or tablets and using TrashOut to record individual landfills (Fig. 4).

After mapping the area, the result of this level is to report the occurrence of illegal dumping to the appropriate municipal or city authority or using the TrashOut a mobile application to generate an e-mail with all the necessary data. Subsequently, the data is also sent to the Ministry of Environment of SR or the relevant city that has expressed interest in cooperation (<https://www.enviroportal.sk/clanok/trashout-mapuje-negalne-skladky>). Since 2010, the Reference for Mayor platform has been increasingly used, through which citizens can report to the municipality categories of incentives and environmental problems, including “black dumps” (<https://www.odkazprestarostu.sk/>).

Within this level, it is possible to use various interdisciplinary relations by which pupils apply the previously learned knowledge and skills in acquiring and processing spatial data. For example mathematics – calculation of landfill area, expression of percentage of individual types of waste; informatics – creation of charts and graphs; geography – creation of analogue or digital map by GIS, surveying (positioning) of landfill by GPS; biology – description of habitat/ecosystem situated landfill; chemistry – landfill potential for chemical pollution of individual environmental compartments, etc.

*Level 2* – is a continuation of work on pupil projects. Attention is focused on the prevention of illegal dumps. Pupils learn how to handle municipal waste, respectively how to separate out what we know to use as a secondary raw material in the recycling process from mixed municipal waste disposal by landfills. At the same time, pupils will learn to save natural resources, energy, and water by correct separation.

At this level, pupils use the Green Daily application, which is a suitable guide for the correct separation of municipal waste, respectively the possibility of using the collection yard (Fig. 4).

*Level 3* – the longest lasting part of our model is the use of the mobile application Czech Zero Waste. Through the 40-day challenge included in this application, pupils learn to prevent waste production. As they say about zero waste, we apply voluntary modesty in pupils' lives and teach pupils to think before each purchase. This is changing their consumer mindset and behaviour for the future. Pupils will understand that what they buy today will become waste tomorrow (Fig. 4).

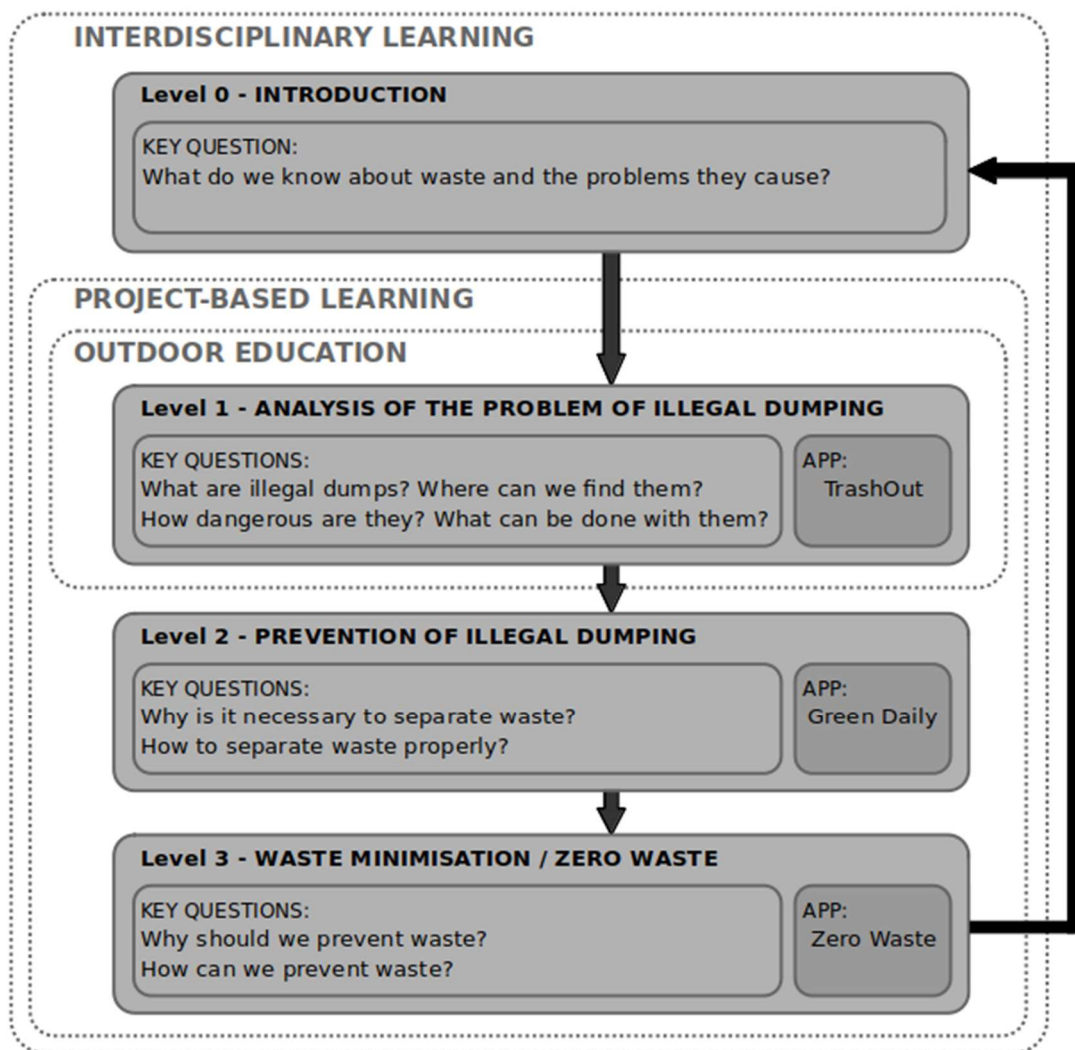


Figure 4: Scheme of the educational model with available mobile applications to teachers and pupils of lower secondary education with the possibility of their application within the environmental education

After the third level, the question raised in “level 0” can be reopened: What do we know about waste and the problems it causes? It is interesting to trace the shift in pupils' knowledge of skills and habits. The model can be continued by mapping other waste problems (for example, the mapping of the aforementioned littering). If interested, the project can be continued through peer education, which Shiner (1999) describes as the education of young people by young people. Pupils can share the experience gained by project teaching to classmates or younger pupils in the form of not only contact teaching, but also the use of ICT - for example by creating a short video about the progress and results of the mapping.

## DISCUSSION

The topic of waste is currently discussed quite often. The economic development, production and changing market of human consumption have led to a surge in waste

worldwide over the last decades. Waste disposal harms the environment and poses a threat to human health. Therefore, there is a great deal of effort to reduce the total waste of each of us.

Education is very important to reduce waste production because education can change people's knowledge, attitudes, and behaviour towards waste management. Since 2009, the topic of waste has become a part of the state educational program for the first and second grades of primary schools and for eight-year grammar schools in the SR within the cross-sectional theme of Environmental Education. Within the 2 thematic areas Human Activities and Environmental Problems and Human Relation to the environment, pupils are acquainted with waste and ways of managing it, even with the example of a city or municipality, and as well as within the lifestyle of each of us (areas: waste and nature, principles and ways of waste management, ways of utilization and solution of waste management, types of waste, disposal, separation, recycling of waste, consumption of things, saving of natural resources and energy, impact on environment).

On one hand, we are trying to educate the younger generation, and on the other, the waste situation is not improving because we are increasing the amount of municipal waste per capita in Slovakia every year (Fig. 5). Compared to the average amount of municipal waste per capita in the EU (489 kg) and in individual EU countries, Slovakia is one of the countries with lower quantities, but landfilling predominates in waste management (61%) and thus the Slovak Republic ranks among the countries with a high share of landfilled waste. The EU has set itself the target of landfilling only 10% of municipal waste by 2035 (currently around 23.5%) (<https://www.europarl.europa.eu/>).

In these years the problem with waste disposal seems to be the biggest problem in waste management in Slovakia. Too much waste goes to landfills and their capacity is, of course, reduced. Pursuant to the legislation in force, the obligatory separate collection of paper, plastics, glass, and metals, later biodegradable waste and multi-layer composite materials based on cardboard was gradually introduced from 1 January 2010 in the Slovak Republic. All these commodities are prohibited from landfills in accordance with applicable waste legislation, it is forbidden to throw these into mixed waste, which is directly transported to the landfill. Although the share of separation is increasing every year, we are still relatively at a low level compared to EU countries.

One possibility is to change people's minds by avoiding or at least reducing waste.

The model proposed by us connects the worldwide topic of waste with modern pedagogical approaches, i.e. using mobile phones within ICT in teaching and with pupils' lives and their environment. In addition to the educational objectives that aim to raise pupils' environmental awareness, the model has the potential to develop a wide range of other skills and we agree with Belisle, Rosado (2007) active use of ICT develops skills associated with ICT.

Using interdisciplinary education, pupils develop interdisciplinary thinking, improve critical thinking skills, cognitive skills, and understand the relationships between different disciplines (Ivanitskaya et al., 2002). Project-based learning develops reasoning, problem-solving and communication skills (Barrows, Tamblyn, 1980).



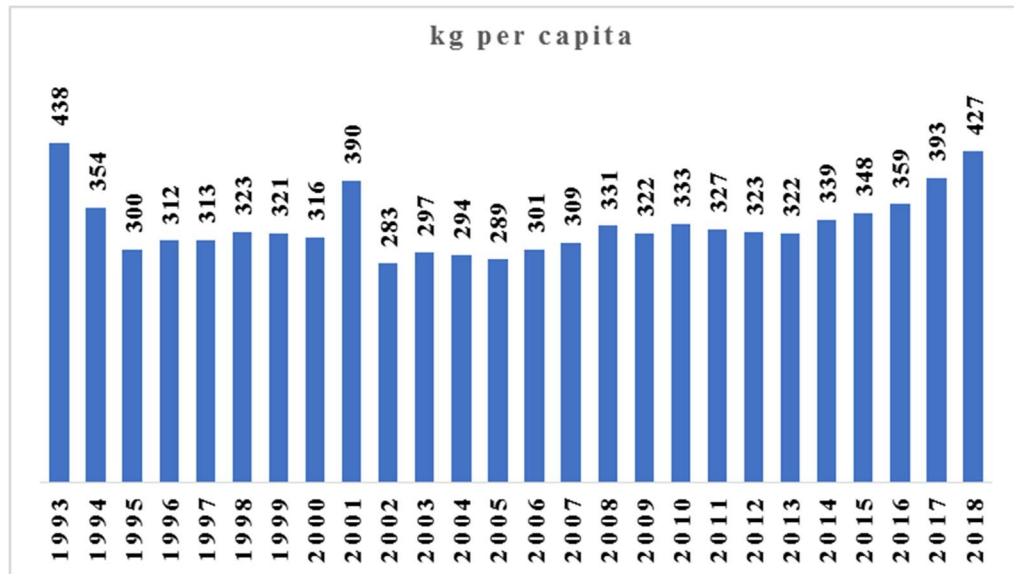


Figure 5: The amount of municipal waste per capita of the SR in the years 1993 – 2018 (<https://www.enviroportal.sk/spravy/kat21>)

According to Mergendoller et al. (2006) in project teaching, pupils acquire 21st-century skills such as collaboration, communication, critical thinking, creativity, language skills, innovation, global relationships, technology use and much more. Studies (Dresner, Gill, 1994; Palmberg, 1989) comparing pupils with experience in outdoor teaching with pupils without experience show that the difference between them is in the acquisition, improvement of action skills.

As a result, experienced learners were more confident in their activities, feeling safe without adult dependency (teachers), more committed to engaging, knowing their limits, and, positively, being spontaneous, open and willing to cooperate.

## CONCLUSION

Waste production has its own history in human society. The current age has the attribute of a "consumer society" with typical redundant consumption. People often buy what they do not need and after a certain time, unnecessary things go to trashbins, containers, landfills or incinerators.

Every year, as the population grows, the economic activity of the population increases. Waste is generated in every part, so it is related not only to production but also to consumption. In this way, the so-called "human standard", which is also linked to increased waste production, is growing.

Many of these wastes can be recycled, many of them are destined for disposal, eg. to incinerators or to legal landfills, but a significant part of these wastes end up in places that are arbitrarily and in violation of several laws established by so-called "cultural person".

According to Hazra, Goel (2009) environmentally friendly management of municipal waste has become a global challenge due to limited natural resources, exponentially increasing population, rapid urbanization, and global industrialization.

We will certainly not be able to solve the waste problems within a day, but the way the environment is going to look in the future depends on our current behaviour and decision-making.

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## REFERENCES

- Alabaster G., Asante K.A., Bergman A., Birnbaum L., Brune-Drisse M.N., Buka I. et al. 2013. The Geneva Declaration on E-waste and Children's Health, 2013. WHO Working Meeting on E-waste and Child Health, 11–12 June 2013, Geneva, Switzerland
- Balogh, Z., Koprda, Š. 2014. Application of Petri Net for Evaluation Modeling of Student in the LMS. In: Turčáni, M. et al. (Eds.) *DIVAI 2014: 10th International Scientific Conference on Distance Learning in Applied Informatics. Conference proceedings* (p. 229-239), Wolters Kluwer, ISBN 978-80-7478-497-2.
- Balogh, Z., Kucharik, M. 2019. Predicting Student Grades Based on Their Usage of LMS Moodle Using Petri Nets. *Applied Sciences-Basel*, 9 (20). 4211. 10.3390/app9204211.
- Barrows, H.S., Tamblyn, R.M. 1980. *Problem-based learning: An approach to medical education*. New York: Springer Publishing Company
- Belisle, C., Rosado E. 2007. *Analysing Digital Literacy Frameworks*. Research Report for "A European Framework for Digital Literacy" (eLearning Programme 2005-2006). <https://halshs.archives-ouvertes.fr/halshs-00137779/document>, 69 p.
- Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., Palincsar, A. 1991. Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning. *Educational Psychologist*, 26 (3-4), p. 369-398. <https://doi.org/10.1080/00461520.1991.9653139>
- Boltižiar, M., Michaeli, E., Solár, V., Ivanová, M. 2016. Selected localities of environmental loads of Western Slovakia as limiting factors of regional development. In Klímová, V., Žitek, V. (Eds.), *XIX. mezinárodní kolokvium o regionálních vědách. Zborník príspevkov z medzinárodnej konferencie*. (p. 648-656) Brno: Masarykova univerzita. ISBN 978-80-210-8272-4 doi: 10.5817/CZ.MUNI.P210-8273-2016-83 (WOS)
- Dresner, M., Gill, M. 1994. Environmental Education at Summer Nature Camp. *Journal of Environmental Education*, volume: 25 nr. 3 p. 35-41
- Earll, R.C. Williams, A.T., Simmons, S.L., Tudor, D.T. 2000. Aquatic litter, management and prevention – the role of measurement. *Journal of Coastal Conservation* 6:2000, p. 67-78
- FAO, 2013. *The State of Food Insecurity in the World 2013. The Multiple Dimensions of Food Security*. Food and Agriculture Organisation of the United Nations (FAO), International Fund for Agricultural Development (IFAD), United Nations World Food Programme (WFP), FAO, Rome (Italy) (2013) <http://www.fao.org/3/a-i3434e.pdf>
- Ford, P. 1986. *Outdoor education: Definition and philosophy*. ERIC Digest. Las Cruces, NM: ERIC Clearinghouse on Rural Education and Small Schools. ERIC Document Reproduction Service No. ED 267 941.

- Grant K., Goldizen F., Sly P., Brune M., Neira M., Van den Berg M. et al. 2013. Health consequences of exposure to e-waste: a systematic review. *Lancet Glob Health* 1(6): e350-e361, DOI:10.1016/S2214-109X(13)70101-325104600. Crossref, Medline
- Gross, M. 2015. Oceans of plastic waste. *Current Biology*, Volume 25, Issue 3, 2 February 2015, Pages R93-R96
- Hazra, T., Goel, S. 2009. Solid waste management in Kolkata, India: Practices and challenges. *Waste management*, 29 (2009), p. 470-478
- Heacock M., Kelly C.B., Asante K.A., Birnbaum L.S., Bergman A.L., Bruné M.N., Buka, I., Carpenter D.O., Chen, A., Huo, X., Kamel, M., Landrigan, P.J., Magalini, F., Diaz-Barriga, F., Neira, M., Omar, M., Pascale, A., Ruchirawat, M., Sly, L., Sly, P.D., Van den Berg, M., Suk, W.A. 2016. E-waste and harm to vulnerable populations: a growing global problem. *Environ Health Perspect* 124:550–555; <http://dx.doi.org/10.1289/ehp.1509699>
- Ivanitskaya, L., Clark, D., Montgomery, G., Primeau, R. 2002. *Interdisciplinary Learning: Process and Outcomes*. Innovative Higher Education. Volume 27, (2002), p. 95–111
- Kukulska-Hulme, A., Traxler, J. 2005. *Mobile Learning: A Handbook for Educators and Trainers*. Oxon: Routledge, 1-6
- Lechner, A., Keckeis, H., Lumesberger-Loisl, F., Zens, B., Krusch, R., Tritthart, M., Glas, M., Schludermann, E. 2014. The Danube so colourful: A potpourri of plastic litter outnumbers fish larvae in Europe's second largest river. *Environmental Pollution* 188 (2014), p. 177-181
- Magnus, V. J., Martinez, P., Pedauye, R. 1997. Analysis of environmental concepts and attitudes among biology degree students. *Journal of Environmental Education*, 29(1), 28-33.
- Melikoglu, M., Sze Ki Lin, C.†, Webb, C. 2013. Analysing global food waste problem: pinpointing the facts and estimating the energy content. *Central European Journal of Engineering*, 3(2), 2013, p. 157-164
- Mergendoller, J. R., Markham, T., Ravitz, J., Larmer, J. 2006. Pervasive Management of Project Based Learning: Teachers as Guides and Facilitators. In C. M. Evertson & C. S. Weinstein (Eds.), *Handbook of classroom management: Research, practice, and contemporary issues* (p. 583–615). Lawrence Erlbaum Associates Publishers.
- Palmberg, I.E., Kuru, J. 2000. Outdoor Activities as a Basis for Environmental Responsibility, *The Journal of Environmental Education*, 31:4, 32-36, DOI: 10.1080/00958960009598649.
- Pucherová, Z., Jakab, I., Zígová, M. 2019. Modernization of Environmental Education with the Use of Project-Based Learning, Outdoor Education and Mobile Learning Supported by Information and Communication Technology. In: *Universities in the Networked Society: Cultural Diversity and Digital Competences in Learning Communities*. Cham: Springer Nature, 2019, p. 246-271.
- Rowntree, D. 1982. *A Dictionary of Education*. Totowa, N.J.: Barnes & Noble Books
- Shiner, M. 1999. Defining peer education. *Journal of Adolescence*, 22(4), p. 555–566. DOI: 10.1006/jado.1999.0248
- Smitek, Š. 1998. Informační technologie v logistickém řetězci. In: *Logistika*, č. 3, p. 11-16
- Stoffová, V. 1998. Počítačové siete – nové zdroje informácií – nové didaktické prostriedky. In: *Nitra: Zborník z medzinárodnej konferencie UNIFOS 1998*
- Tasaki, T., Kawahata, T., Osako, M., Matsui, Y., Takagishi, S., Morita, A., Akishima, S. 2007. A GIS-based zoning of illegal dumping potential for efficient surveillance. *Waste Management*, 27 (2007), p. 256-267

- Tibbetts, J.H. 2015. Managing Marine Plastic Pollution: Policy Initiatives to Address Wayward Waste. News - Spheres of Influence, Vol. 123, No. 4, A90-A93, <https://doi.org/10.1289/ehp.123-A90>
- Valiente, R., Escobar, F., Pearce, J., Bilal, U., Franco, M., Sureda, X. 2020. Estimating and mapping cigarette butt littering in urban environments: A GIS approach, Environmental Research (2020), DOI: <https://doi.org/10.1016/j.envres.2020.109142>
- WWF, 2019. Solving Plastic pollution 2019 through accountability, <https://www.worldwildlife.org/publications/solving-plastic-pollution-through-accountability>
- Zigová, M., Pucherová, Z., Jakab, I. 2018. Innovative Model of Environmental Education in Lower Secondary Education. In: DIVAI 2018 – Proceedings from 12th International Scientific Conference on Distance Learning in Applied Informatics. Praha: Wolters Kluwer, 2018, p. 205-216
- <http://datatopics.worldbank.org/what-a-waste/>
- Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives
- <https://www.eea.europa.eu/>
- <https://www.enviroportal.sk/clanok/trashout-mapuje-nelegalne-skladky>
- <https://www.enviroportal.sk/spravy/kat21/>
- <https://europarl.europa.eu/>
- <http://www.minzp.sk/>
- <https://www.odkazprestarostu.sk/>
- <http://www.statpedu.sk/>
- <https://www.trashout.ngo/>
- <http://www.zerowasteslovakia.sk/>