https://doi.org/10.36315/2024v2end042
Education and New Developments 2024

ECODESIGN AS A NEW POSSIBILITY IN TEACHING TECHNICAL SUBJECTS IN SECONDARY SCHOOLS

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Abstract

The article's main goal is to provide a new tool for teaching technical subjects in secondary schools. Specifically, it is ecodesign as a systematic process of designing and developing a product, which, in addition to features such as functionality, safety, technical feasibility, etc., places great emphasis on achieving a minimal negative impact of the product on the environment, mainly from the point of view of the life cycle. Life cycle assessment (LCA) evaluates the environmental impacts of production, services and technologies. The LCA method is internationally recognised and can be applied in all spheres of human activity. LCA is used when comparing products and services, when planning processes in the field of the company's environmental policy, and when creating strategic plans in various industries. One of the fundamental and recognised factors that negatively affect our planet is global climate change, affecting not only stable global ecosystems but also human communities. The article uses studies prepared according to the international standard ISO 14040 Environmental management requirements. In the article's introduction, the product's production process is described as a system that is managed with respect to the environment. A manufacturing company must manage aspects not only of its own production and non-production processes but also aspects related to the impacts of its products throughout the entire life cycle of a specific product. In addition to the production phase, the life cycle also includes aspects of extraction of raw materials, purchase or production of materials, transport, distribution, logistics and the phase of product use, including preventive maintenance and subsequent disposal or recycling. The next part of the article summarises the theory on the integration of environmental aspects into the product design process using the ecodesign methodology. In conclusion, the article compares metal and plastic 3D printed products and considers the usual requirements for product properties such as functionality, quality, safety, price and appearance. The connection of ecodesign and environmental management systems is an effective implementation of a preventive approach to the identification of risks of products, activities and services and the subsequent setting of preventive measures, which will clearly show the students the importance of Ecodesign as a tool.

Keywords: *Ecodesign, sustainable development, life cycle assessment, recycling, 3D print.*

1. Introduction

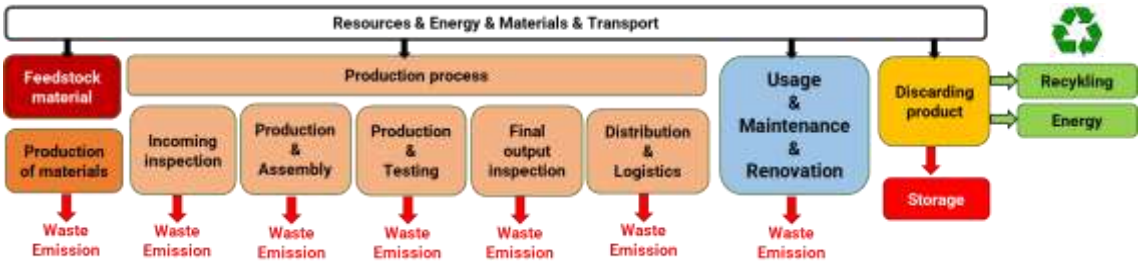
Environmental education aims to lead to responsible behaviour towards the environment, living organisms, other people, and oneself. The key question is how to approach the teaching of sustainable development in schools and how to familiarise pupils with the topic. Here, we can encounter several problematic points. The first problem point may be the student's initial knowledge. It can be assumed that students have already heard about the theory of sustainable development and environmental management, but the constant question remains how extensive and deep the knowledge is. Another problem is the implementation of the theory of sustainable development and environmental management into study programs because sustainable development has an interdisciplinary character, and therefore, we must work simultaneously in areas such as economic, environmental, social, and cultural. Therefore, the main goal of the article is to provide a new way of teaching technical subjects in secondary schools. Specifically, it is Ecodesign as a systematic process of product design and development. Ecodesign is one of the very important preventive voluntary tools of environmental policy. Ecodesign, in addition to features such as functionality, safety, quality, technical feasibility, etc., places great emphasis on achieving a minimum negative impact of the product on the environment, mainly from the life cycle perspective. LCA is a method of assessing the environmental impacts of production, services and technologies.

p-ISSN: 2184-044X e-ISSN: 2184-1489 ISBN: 978-989-35728-0-1 © 2024

2. Life cycle assessment of a product

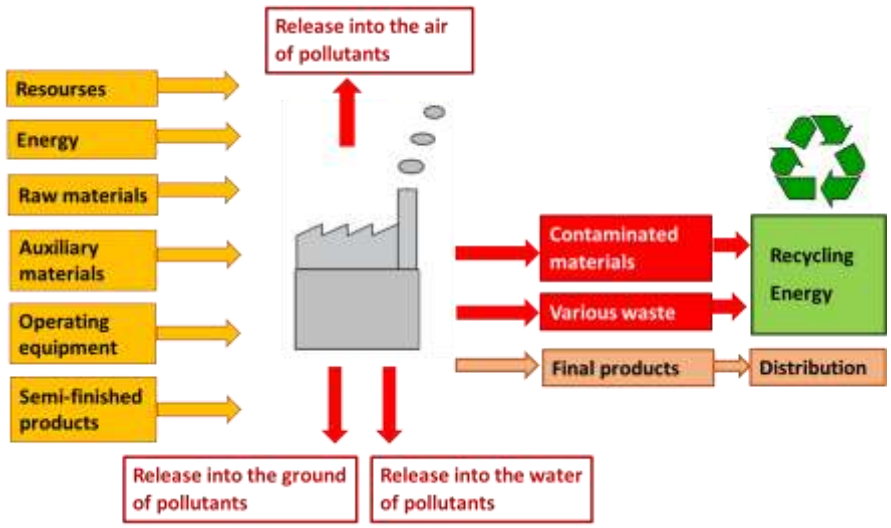
In the following part of the article, the teaching of the issue of sustainable development is demonstrated in the example of a comprehensive view of the general scheme of the production process, which is based on the concept of the product life cycle (Figure 1). This cycle does not start with production, but already at the stage of obtaining raw materials and materials. It continues with their transport, input control, processing in production, output control and subsequent packaging, selected transport and distribution of the final or semi-finished product. The life cycle continues with the preventive maintenance phase. In most cases, the life cycle ends with the disposal of the product at the end of its useful life.

Figure 1. General scheme of the production process, which is based on the concept of the life cycle of the product.



For most products, environmental aspects and impacts occur at all life cycle stages. Inputs and outputs at each stage of the product's life cycle are key to assessing these environmental impacts (Figure 2).

Figure 2. General scheme of inputs and outputs of an industrial company.



An educator using the goals of global education and a comprehensive view of the general scheme of the production process, which is based on the concept of the product life cycle (Figure 1 and Figure 2) and the use of active learning methods (for example, project and situational learning, experiential pedagogy, engaged learning) can draw up a sustainable development teaching plan. Considering the entire life cycle of a product allows students to obtain the following interesting information: an overview of all materials entering the life cycle; a description of all significant product features; familiarisation with the individual steps of production and processes; description of the environmental impact of intermediate products or auxiliary materials that are not part of the final product; understanding the function of the system within which the final product is used; identification of possible undesirable environmental impacts of the final product between individual phases of the life cycle.

3. Ecodesign – concept, goal, implementation

Ecodesign can be defined as a comprehensive concept of designing and developing products with the aim of reducing the number of negative impacts on the environment during the entire life cycle. By considering the environmental aspects of the products in addition to their standard properties such as functionality, durability, aesthetics, quality, safety, economy and ergonomics from the initial design phase, this approach aims to minimise the negative effects of products on the environment in the future. (Pigosso et al., 2010; Bertini et al., 2022).

The goal of the ecodesign concept is to reduce the product's negative impact on the environment in terms of its entire life cycle. It is important for students to realise that the main purpose of ecodesign is to find successful innovative solutions while simultaneously reducing the negative environmental effects of products. In this context, however, it is important to draw students' attention to the fact that ecodesign is not only an approach emphasising environmental issues in product designs, but also strives to introduce a global concept of the environment, which should ensure a systematic and comprehensive assessment of environmental impacts.

Ecodesign is a concept based on the principle of prevention, as it defines, based on analysis, the possibility of reducing potential adverse effects of the product even before its production. This principle is very important in the field of environmental standards and law, as environmental damage is often irreparable (Damohorský et al., 2010; Bundgaard & Huulgaard, 2023). Using a concrete example, it is necessary to explain to the students that due to the inclusion of dangerous and harmful substances in the composition of the product, subsequent recycling processes may be impossible, as such components prevent the reuse of the material. At the same time, it is necessary to show students a positive example of ecodesign, for example, if dangerous substances are not used during production, there will be positive effects immediately in two life stages of the product, which include using the product without health risks and another possibility is to use the material for recycling. As part of eco-design, it is important to analyse the product as well as logistics and infrastructure systems.

For a better presentation of the product life cycle to students, it is appropriate to divide the product life cycle into stages (Tab. 1). The first stage of conception and determination of requirements (e.g. customer, state) and includes, for example, the definition of requirements for quality, reliability, service life, safety. The next stage of design and development includes, for example, product design, material selection, creation of production documentation, prototype production, and sampling. Marketing and research can also be included in this stage, the results of which can be incorporated into the main phase. The main one is the production phase, and it includes, for example, serial production according to the documentation, delivery of materials from suppliers and performance of input inspection, performance of tests, establishment of rules for final inspection and issuance of a certificate of conformity, delivery of the product to the customer. In the operation stage, maintenance is important, which will extend the life of the products. The last stage is the disposal of the products and includes, for example, decommissioning, disassembly, and recycling.

The knowledge and skills of educators were defined for the individual stages of the product life cycle. For the students to be involved in the discussion, basic requirements for the student's knowledge were assigned for each stage of the product life cycle. At the end of the implementation of the project, newly acquired knowledge in the field of ecodesign and the product life cycle is expected.

Table 1. Educator's competency matrix for the presentation of the product life cycle to students

Stage Nr.:	**Ecodesign process**	**Knowledge and skills of a teacher**	**Requirements for student knowledge**	**Newly acquired knowledge and experience**
1.	conception and determination of requirements: the definition of requirements for quality; reliability; service life; safety; price	orientation in the standards and requirements of customers from various industrial sectors; knowledge of quality management; experience with financial analysis;	knowledge of the division of industry and its history; awareness of the role of work in our lives;	connecting the necessary knowledge from the field of quality to specific industrial sectors; basic knowledge of reliability theory - connecting technical issues related to construction and materials;
2.	design and development: product design; material selection; creation of production	knowledge of 3D modelling; knowledge of the basis of marketing and its role in product	knowledge of the structure and physical properties of substances; basics of technical drawing;	connecting the knowledge of the material engineering with technical documentation; knowledge of the role of

	documentation; marketing;	development; prototype production;		evaluating results of prototype production;
3	production phase: serial production; delivery of materials from suppliers; inspection and delivery of the final product to the customer;	knowledge of the importance of quality control of incoming material and final product in relation to the environment; overview of audit types;	knowledge of the classification of industries;	overview of the activities of production and non-production processes in a production company; knowledge of the setting production process;
4	operation and maintenance;	knowledge of the type of maintenance; basic maintenance rules; knowledge in the field of rationalization;	types of machines and equipment in households and industrial production companies;	knowledge of role of diagnostics and preventive maintenance using mathematical statistics;
5	disposal of the products: decommissioning; disassembly; recycling;	differences in the recycling of plastics, metal and other materials; carbon footprint of the product;	knowledge of basic waste sorting rules;	knowledge of sustainable development goals; knowledge of the principle and application of ecodesigning;

4. 3D printing technologies and developing creativity

The 3D printing process begins with design and modelling, followed by material preparation, printing, post-processing and quality control of the final manufactured product. If we compare the process of manufacturing a product on a 3D printer and a classic manufacturing process (for example, casting, forging, machining, pressing, extrusion, etc.), the technologies are different and related to this are also different requirements for the quality of the final product (Krotký et al., 2016; Böhm et al., 2023).

Table 2. Differences in the processes of 3D printing and standard production

Topic	**Standard production**	**3D printing**
Production method	Subtractive; Formative;	Additive
Production process	a) Transformation; b) Control quality; c) Transport & Storage;	a) Transformation; b) Control quality;
Production cycle time	Longer	Shorter
Materials according to production technology	Metals: Plate, Block, etc.; Plastics: Granulate;	Metals: Powder; Plastics: Filament, Tapes, Liquid Photopolymer;
Efficiency	Lower	Higher
Waste	Larger	Smaller
Human Recourses	Higher the number of various specialists	Deep knowledge of specific specialists
Life cycle	Longer	Shorter
Finance & Cost	Lower	Higher

This also gives rise to various rights and obligations in relation to the environment and waste management (Tomášková & Bícová, 2021; Bícová & Tomášková, 2022; Zhichao et al., 2016; Al Rashid & Koç, 2023). Some differences in the processes of 3D printing and standard production are shown in Table 2. When designing metal and plastic 3D printed products, safety, functionality and quality requirements are always taken into account. These requirements must always be in accordance with legislation and certain standards. An equally important requirement is the requirement for the appearance of the product, which is related to the intended use.

5. Conclusions

In environmental education, it is important to pay attention to the interconnectedness of seemingly different topics and to explain these connections even in areas that are very far away. Currently, an increasing number of secondary schools are observing the trend of implementing 3D modelling in teaching. More and more attention is being paid to this area, among other things, because

secondary schools are acquiring 3D printers for educational purposes. As the teaching of 3D modelling and 3D printing appears to be a very current topic, attention should be paid to this area at the level of the didactic theory of technical subjects. Future research will be devoted to preparing detailed mind maps for assessing environmental impacts according to inputs and outputs in each phase of the life cycle of a specific product. Mind maps will be linked to specific projects with defined goals, a described procedure, and clearly defined competencies and responsibilities of individual participants. Within these new projects, space will be created for creativity and originality, and this space will be accompanied by economic, environmental and social awareness.

Acknowledgements

The article was created as part of the project solution: SGS-2022-032 Testing a set of experiments about technology with interactive worksheets for primary schools.

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