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THE CONTRIBUTION OF INDUSTRIAL DESIGNERS FROM THE REPUBLIC OF MOLDOVA TO PACKAGING DESIGN IN THE CONTEXT OF CURRENT SUSTAINABLE DESIGN TRENDS

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In the context of national and global challenges related to plastic waste management and carbon emission reduction, this paper explores the integration of circular economy and ecodesign principles into educational practice. The aim of the research is to develop sustainable containers for the selective collection of plastic caps (HDPE and PP), created through a partnership between the Faculty of Design at the Technical University of Moldova and Recycline SRL. The methodology was based on the project-based learning (PBL) approach, which involved the following stages: researching the context and user requirements, conceptual design, digital prototyping, and technical-aesthetic validation. The research results materialized in functional prototypes made from recycled plastic and assembled using a “puzzle”-type milling technique, incorporating modular elements and attractive forms. In conclusion, the study demonstrates that applying ecodesign principles and project-based learning generates viable solutions for the community, directly supporting national regulations and European directives on reducing packaging waste. The study was conducted within the national project 020408: Research on Ensuring Sustainable Development and Increasing Competitiveness of the Republic of Moldova in a European Context.

Key words: sustainability, ecodesign, packaging, prototype, waste.

INTRODUCTION

In the context of global climate change and the increasing volume of plastic waste, sustainable design projects are becoming increasingly important. Recent data indicate that approximately 141 million tons of single-use plastic packaging are produced annually, and their production and disposal generate around 1.8 billion tons of CO₂ emissions [4]. Within this framework, pollution reduction through recycling and the circular economy has become a global priority. The packaging industry is directly affected: integrating ecodesign into education promotes the rational use of resources and sustainable solutions [1]. Plastics coded as 2 (High-Density Polyethylene – HDPE) and 5 (Polypropylene – PP) are recognized as recyclable [5], offering the potential for repeated resource reuse and pollution reduction. At the local level, Recycline – a manufacturer and educational partner of the Faculty of Design at the Technical University of Moldova – initiated a sustainable packaging project dedicated to the collection of plastic caps (types 2



and 5) through the use of the project-based learning (PBL) method. The objective is twofold: to valorize recyclable materials and to encourage community participation in selective collection, thereby supporting and promoting the national regulatory framework on packaging and packaging waste (Government Decision 561/2020), the National Development Strategy "European Moldova 2023," and EU Directive 2019/904 on the reduction of the environmental impact of certain plastic products. By combining functional design with sustainability principles, the project demonstrates how practical initiatives can reduce environmental impact. For example, students at NC State developed compostable food containers, conducting user interviews and collaborating with industry to create packaging that is "easy to assemble, use, and dispose of" [2,3]. Such studies illustrate how well-founded, user-oriented design can effectively address the problem of plastic packaging waste.

PURPOSE

For the development of the collection packaging, clear technical and aesthetic constraints were defined to ensure that the final product is efficient, functional, and coherent both technically and visually. The main criteria included:

- **Material** – Recyclable plastics, such as HDPE and PP (plastic types 2 and 5), were chosen due to their mechanical properties and compatibility with recycling processes. Selecting these materials contributes to maintaining a clear material valorization chain and ensures a high content of recyclable material. Additionally, the components are joined using a "puzzle"-type milling system, allowing precise and efficient assembly of the parts without requiring additional fasteners.

- **Shape and dimensions** – These were established considering both functional requirements and the technological limitations of the company, particularly the types of available machinery and the maximum sizes of producible components. The dimensions were limited so that the packaging remains portable and easy to integrate into educational or community spaces for selective collection. The resulting design ensures structural stability and provides sufficient internal volume for collecting a large number of caps without compromising maneuverability.

- **Color palette and aesthetics** – The palette was restricted to maintain visual clarity and emphasize the ecological purpose of the product. The colors are determined directly by the available plastic and the company's existing stock, inspired by hues associated with recycling. This approach enhances the legibility of symbols and ecological messages, facilitates the identification of the container as a cap-collection unit, and reduces additional environmental impact by minimizing the use of synthetic pigments.

These criteria reflect the principles of sustainable design and global objectives regarding emissions and waste reduction. Recycline, as an educational partner, contributed to defining these requirements, ensuring alignment with real manufacturing and recycling processes.

RESULTS AND DISCUSSION

The project followed an iterative design process, which involved the following stages:



1. Research and Requirements Definition: Initially, students reviewed the specialized literature, interviewed potential users, and visited Recycline SRL, a company recycling plastics types 2 and 5. This stage was similar to practices used in existing case studies: for example, at NC State, students interviewed packaging manufacturers, restaurant operators, and consumers to understand all levels of the user chain [2]. User behavior and the spaces where the container would be placed were evaluated to establish requirements regarding the packaging's size, capacity, and ergonomics.

2. Design: Based on the collected requirements, students sketched multiple concepts both in traditional format (on paper) and digitally. Different solutions were tested for openings, shape, and compartmentalization (for example, separating type 2 from type 5 caps or separating by color). Some sketches included internal divisions for each type of plastic and large openings for easy emptying. Handling elements (such as a transport handle) and safety features (simple closures) were also considered. At this stage, lightweight wood and recycled plastic were used for initial mock-ups.

3. Prototyping: To validate the proposed dimensions and functionality, full-scale digital prototypes were developed. This stage was complemented by a documentation visit to the company to directly analyze existing models and prototypes, and to gain a better understanding of the material properties used in production.

4. Finalization and Evaluation: The outcomes derived from the implementation of the PBL project were assessed.

The iterative design process described above provided the methodological foundation for developing the final collection packaging solution. The stages of research, design, and prototyping allowed for the gradual definition and testing of the product's functional, technical, and aesthetic requirements. Information obtained from the literature review, discussions with potential users, and evaluation of the usage context guided the creation of initial concepts and design variants. Subsequently, full-scale digital prototypes and direct documentation within the company validated both the proposed dimensions and functionality, as well as compatibility with material properties and production capabilities.

Within this context, the final result of the design process was the development of functional prototypes: a robust box made from recycled plastics (HDPE/PP), equipped with a hinged lid and visual elements associated with recycling. The prototypes demonstrated that a coherent integration of ergonomic, aesthetic, and structural aspects can enhance the efficiency of selective collection processes by facilitating use and clearly communicating the ecological purpose of the container. Moreover, the proposed solution proved easy to implement in educational or community settings, confirming the relevance of a prototyping- and testing-based approach in the design process of sustainable packaging.

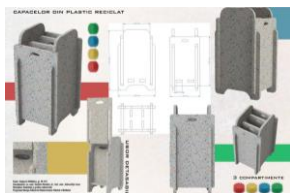


Fig. 1. Packaging with detachable elements, student Mădălina Ciupercă, group DI-221; supervisors: Nicoleta Vasilev, Lucia Adascalita**



Fig. 2. "Cupbuddy" packaging, student Rodica Ceban, group DI-221; supervisors: Nicoleta Vasilev, Lucia Adascalita



Fig. 3. Plastic cap collection system, student Valeria Ursu, group DI-222; supervisors: Nicoleta Vasilev, Lucia Adascalita



Fig. 4. Plastic cap collection box, Xenia Andrițchi, group DI-222; supervisors: Nicoleta Vasilev, Lucia Adascalita



Fig. 5. Packaging inspired by the shape of a gift box, Tatiana Țigănaș, group DI-222; supervisors: Nicoleta Vasilev, Lucia Adascalita



Fig. 6. Modular packaging, Evghenia Bronistov, group DI-222; supervisors: Nicoleta Vasilev, Lucia Adascalita

CONCLUSIONS

The research results highlight that integrating sustainable design principles and the project-based learning (PBL) method into the educational process, alongside collaboration with industry, can generate viable solutions to reduce the environmental impact of plastic waste. The project carried out in partnership with Recycle demonstrates that applying an iterative design methodology—based on research, design, and prototyping—enables the development of functional products that are adapted both to user requirements and to the technological constraints of production. The selection of recyclable materials (HDPE and PP), the definition of appropriate dimensions for use in educational or community settings, and the use of a color palette inspired by recycling symbolism contributed to the creation of a prototype that is coherent functionally, aesthetically, and ecologically.

In this regard, the research emphasizes the importance of collaboration between universities and industry in developing innovative and implementable solutions that can support the transition to a circular economy and help mitigate the negative environmental impact of plastic packaging.

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ВАСІЛІЄВ Н., АДАСКАЛІЦА Л.

ВНЕСОК ПРОМИСЛОВИХ ДИЗАЙНЕРІВ РЕСПУБЛІКИ МОЛДОВА У ПРОЕКТУВАННЯ УПАКОВКИ В КОНТЕКСТІ СУЧАСНИХ ТЕНДЕНЦІЙ СТАЛОГО ДИЗАЙНУ

У контексті національних та глобальних викликів щодо управління пластиковими відходами та скорочення викидів вуглецю, дана робота досліджує інтеграцію принципів циркулярної економіки та екодизайну в освітню практику. Метою дослідження є розробка стійких контейнерів для селективного збору пластикових кришок (HDPE та PP), що здійснюється в рамках партнерства між Факультетом дизайну Технічного університету Молдови та компанією Recycleline SRL. Методологія базувалася на методі проектного навчання (PBL), що передбачало проходження таких етапів: дослідження контексту та вимог користувачів, концептуальне проектування, цифрове прототипування та технічно-естетична валідація. Результати дослідження втілювалися у функціональних прототипах, виготовлених з переробленого пластику та зібраних за допомогою фрезерування типу «пазл», модульних елементів та привабливих форм. У висновку робота демонструє, що застосування принципів екодизайну та навчання на основі проектів генерує життєздатні рішення для громади, безпосередньо підтримуючи національну нормативну базу та європейські директиви щодо зменшення відходів упаковки. Дослідження було проведено в рамках національного проекту 020408 «Дослідження щодо забезпечення сталого розвитку та підвищення конкурентоспроможності Республіки Молдова в європейському контексті».

Ключові слова: сталий розвиток, екодизайн, упаковка, прототип, відходи.