

The Implementation of Artificial intelligence in Packaging Design Education toward Personalization & Sustainability

Dr. Ahmed Mohamed Attia Ismail

Lecturer at October University for Modern Sciences and Arts - Faculty of Arts and
Design

aatteya@msa.edu.eg

Abstract:

The study emphasizes the importance of integrating AI in packaging design education to enhance learning experiences, prepare students for future packaging industry challenges, and promote personalization and sustainability. Students can adapt to technological advancements and market demands by incorporating AI into teaching methods. The study also provides some emerging techniques and global trends and suggests recommendations for implementing AI tools to strengthen the connection between packaging design, sustainability, and innovation. The study aims to explore AI's role in packaging design education, its potential benefits, and its connection to sustainability, personalization, and creativity. It also discusses emerging techniques, global trends, and market needs. Therefore, the analytical descriptive approach of descriptive analysis has been used to study market requirements and needs, global packaging trends, future technologies and some artificial intelligence application processes in packaging design education. Some of the available trends, methods, and tools have been found that could enhance the link between packaging design and sustainability education using artificial intelligence techniques, packaging functions, interaction, personality, and creativity. The study has been concluded with a series of results, the most important of which is that artificial intelligence applications in packaging design education provide students with the ability to read the future directions of the market based on the use of modern techniques to analyze different market data and variables. This leads to the recommendation that the use of different artificial intelligence applications should be expanded in design education in its general form and packaging design in its own form.

Keywords:

Artificial Intelligence (AI), Education, Packaging Design, Sustainability, Personalization.

مستخلص البحث:

تؤكد الدراسة على أهمية إدماج الذكاء الاصطناعي (AI) في تعليم تصميم التغليف من أجل تعزيز الخبرات التعليمية، وإعداد الطلاب لمواجهة تحديات صناعة التغليف في المستقبل، وتشجيع الشخصية والاستدامة. ودمج الذكاء الاصطناعي في التعليم يمكن للطلاب أن يتكيفوا مع أوجه التطور التكنولوجي واحتياجات السوق. كما توفر الدراسة أيضًا بعض التقنيات الناشئة والاتجاهات العالمية وتقدم توصيات لاستخدام وتنفيذ أدوات الذكاء الاصطناعي لتعزيز العلاقة بين تصميم التغليف والاستدامة والابتكار.

وتهدف الدراسة إلى استكشاف الذكاء الاصطناعي في تعليم تصميم التغليف، والفوائد المتوقع الحصول عليها، وصلته بالاستدامة، والشخصنة، والإبداع. كما تناقش التقنيات الناشئة والاتجاهات العالمية واحتياجات السوق. ولذلك فقد تم استخدام المنهج الوصفي التحليلي المتمثل في وصف لاتجاهات التغليف العالمية، والتكنولوجيات المستقبلية وبعض عمليات تطبيق الذكاء الاصطناعي في تعليم تصميم التغليف وتحليل متطلبات واحتياجات السوق. وتم التوصل لبعض

الاتجاهات والأساليب والأدوات المتاحة التي يمكن أن تعزز الصلة بين تصميم التغليف وتعليم الاستدامة باستخدام تقنيات الذكاء الاصطناعي، ووظائف التغليف، والتفاعل بينهما، والشخصنة، والإبداع. وقد انتهت الدراسة إلى مجموعة من النتائج، أهمها أن تطبيقات الذكاء الاصطناعي في تعليم تصميم التغليف تتيح للطلاب القدرة على قراءة الاتجاهات المستقبلية للسوق استناداً إلى استخدام التقنيات الحديثة لتحليل مختلف بيانات ومتغيرات السوق. ويفضي ذلك إلى التوصية بتوسيع نطاق استخدام مختلف تطبيقات الذكاء الاصطناعي في تعليم التصميم بشكل عام وفي تصميم التغليف بشكل خاص.

الكلمات المفتاحية:

الذكاء الاصطناعي، التعليم، تصميم التغليف، الاستدامة، الشخصنة.

The research importance:

The research highlights the potential effect of integrating of integrating AI in packaging design education to develop fixable, customized learning experiences promoting personalization, in order to prepare students for future industry challenges regarding sustainability. By incorporating AI in teaching methods, students can adapt to technological advancements and market demands. The study also provides valuable insights into emerging techniques and global trends and suggests recommendations for implementing AI tools to strengthen the connection between packaging design, sustainability, and innovation.

The research aims:

The research explores the possible implementations of AI in packaging design education, its potential benefits, in relation to sustainability, personalization, and creativity.

Research Methodology:

Using the descriptive analytical approach of describing global packaging trends, and upcoming technologies to examine market demands. Recommending some approaches, techniques, and resources that can improve the relationship between interactive and personalized packaging design education, and sustainability and usability on the other side.

Introduction:

Packaging design is a discipline that deals with the creation and development of packaging for various products, such as food, beverages, furniture, cosmetics, clothes, electronics, or pharmaceuticals. Packaging design has multiple functions and objectives, such as protecting, preserving, transporting, communicating, or attracting the product (Chiu, 2021). Packaging design also has multiple impacts and influences on the product itself, the user experience, the supply chain, and the environment (Phoebe, 2021). Therefore, packaging design requires a combination of technical skills, aesthetic sensibilities, and ethical awareness. Wherefore, packaging design education is a field that aims to prepare students for the challenges and opportunities of designing packaging for various products and markets. Packaging design education involves not only teaching the technical and aesthetic aspects of packaging, such as materials, structures, graphics, or ergonomics, but also the social and environmental implications of packaging waste and consumption, such as recycling, reuse, refilling, or reduction (Jane Southworth, 2023). It also involves developing creative and critical thinking

skills, research and problem-solving abilities, and the communication and collaboration competencies that are essential for successful packaging design practice.

On the other hand, "Artificial Intelligence (AI) serves as a revolutionary technology that equips machines or systems with the capability to execute tasks that generally necessitate human intelligence, encompassing learning, reasoning, or decision-making. Within the realm of packaging design, AI provides the potential to incorporate more sophisticated and intelligent characteristics, such as personalization, optimization, and automation, (Russell & Norvig, 2016).

From the perspective of the end-user, AI has the capacity to tailor packaging in accordance with individual preferences, needs, or behavior by employing machine learning, natural language processing, and computer vision methodologies (Felfernig et al., 2014). In addition, AI can enhance packaging design, production, and distribution through the application of data analytics, optimization algorithms, and simulation models. Furthermore, AI can automate a variety of packaging functions, operations, and interactions by utilizing robotics, speech recognition, and chatbots (Kusiak, 2018). Moreover, AI models can be trained to refine search requests for more accurate and personalized outcomes (Gandomi & Haider, 2015). By leveraging the capabilities of AI in packaging design, businesses can augment customer experiences, boost operational efficiency, and maintain a leading edge in innovation."

Preparing the Packaging Design Course Based on AI

As packaging design is constantly evolving due to new technologies, trends, and demands, packaging design education needs to adapt and innovate to keep up with the changes and prepare students for the future. Therefore, this research will discuss some of the future implementations of AI in packaging design education, based on the analysis of emerging technologies, global packaging trends, and market projections. Proposing some possible topics, methods, and tools that can enhance packaging design education in terms of sustainability, functionality, personalization, and creativity.

A Practical Approach for AI Implementation in Packaging Design Education

Considering several specific topics, methods, and tools to the educational curriculum, could be addressed following these steps (shown in Fig.1).

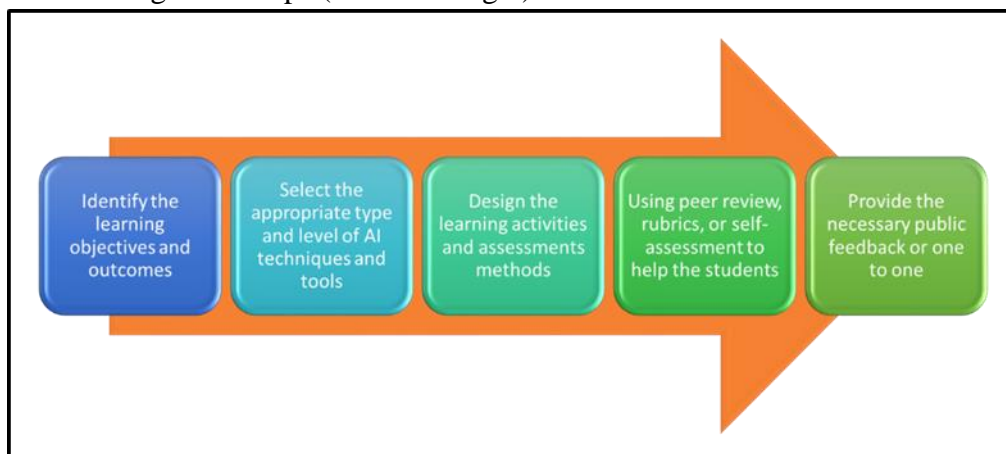


figure 1 - the main suggested steps to produce the new topics, methods, and tools

1- Identify the learning objectives and outcomes of the packaging design course, and align them with the relevant AI concepts and skills that students need to learn and apply. Several AI applications can help suggest learning objectives and outcomes for each module in a curriculum, as well as provide clear grading rubrics or criteria for evaluation. Some of these applications include:

a. ChatGPT :It is an artificial intelligence (AI) tool that can be used in education. It demonstrates how ChatGPT can help with content creation, grammar and spelling checks, and grading. The tool can generate lesson plan ideas and create educational materials tailored to the needs of students. However, concerns have been raised about academic integrity and potential plagiarism.

It is critical for students to develop the ability to use AI language tools, and that education should focus more on improving students' creativity and critical thinking rather than general skills, (Zhai, Xiaoming, 2022).

b.Smodin AI Grader: Smodin AI Grader is a tool that enhances the writing process by providing objective feedback and enhancing writing skills. It offers unbiased feedback, eliminating bias and subjectivity that may influence traditional grading methods. Smodin AI Grader uses data-driven algorithms to provide fair and unbiased evaluations, allowing for quick and accurate analysis of essays. Users can establish custom assessment criteria and choose from various assignment types to grade. The tool is easy to use, allowing users to upload documents in bulk and use the "Write with AI" tool to transform ideas into words. It also offers educational benefits, freeing up time for teachers to focus on teaching and helping students improve their writing skills and achieve academic excellence, (Smodin: Multi-lingual Writing Assistance - 2023).

c.Taskade AI Grading Rubric Generator: Taskade's AI Grading Rubric Generator is a tool that streamlines the grading process to improve the educational experience. It enables educators to quickly and consistently create grading rubrics with the flexibility to meet unique requirements. The generator generates clear and detailed rubrics, promoting grading transparency and encouraging student engagement. It improves grading efficiency and enriches the learning experience for students by leveraging AI, (Taskade. 'Grading Rubric Generator, 2023.).

2- Select the appropriate type and level of AI techniques and tools that match students' prior knowledge, interests, abilities, and needs. For example, choosing between low-code or no-code AI platforms, such as Scratch Nodes Machine Learning or Teachable Machine, or more advanced AI programming languages, such as Python or R, or mixing between some tools and using it as a personal AI kit.

3- Design the learning activities and assessment methods that can engage students in exploring, creating, and evaluating AI-enabled packaging solutions. For example, using project-based learning (PBL), design thinking methodology, user-centered design (UCD), or value-sensitive design (VSD) approaches to guide the students through the process of defining the problem, ideating the solution, prototyping the packaging, testing the functionality, usability, and reflecting on the impact and ethics of their AI-enabled packaging.

4- Using peer review, rubrics, design critique sessions, or self-assessment to help the students monitor and improve their AI-enabled packaging projects (L. Chen, 20202).

5- Provide the necessary public feedback or one-to-one to support the student's learning and development until they reach the final solutions (Ramsden, 2003). For example, using online tutorials, case studies, discussions, videos, or examples to demonstrate how to use AI tools and techniques.

Choosing the Right AI Tools for Students

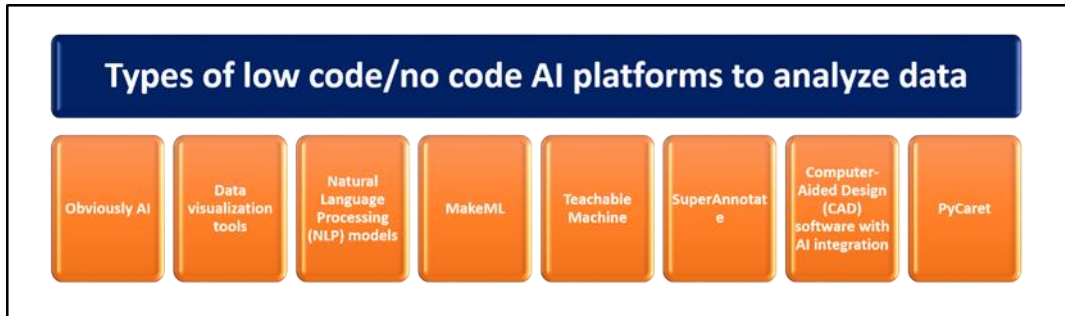


figure 2 - types of low code/no code ai platforms to analyze data

The second point particularly that could be considered a new step in designing an educational course is packaging, in a different way than the regular course. There are several no-code or low-code AI platforms available for beginners that might be utilized without writing code and will help the student to use different AI technologies in each process of packaging design starting with collecting data to know and select the customer needs until producing the new packaging product (shown in Fig.2).

Some of them are:

- Obviously, AI: This platform allows users to predict data and generate insights by using natural language queries and drag-and-drop interfaces. He/she can connect his data sources, such as spreadsheets, databases, or cloud services, and ask questions about his data, such as "What factors affect customer needs?" or "How can I increase sales?" The platform will automatically analyze his/her data and provide him/her with visualizations, explanations, and recommendations (CMI, 2023).
- Data visualization tools: Such as Tableau or Power BI, to visually represent and interpret complex data (Smith, J., & Johnson, A., 2020).
- Natural Language Processing (NLP) models: For sentiment analysis of customer feedback and reviews, in real-life market research. (Smith, J., & Johnson, A., 2020).
- MakeML (makeml-app): This platform allows users to create AI and machine learning models for object detection and segmentation without coding. The user can upload his images, annotate them using a web-based tool, and train his models using a cloud-based service. He can also export his models to iOS or Android devices and test them in real time, (Bernard Marr, 2022).
- Teachable Machine: This platform allows users to create AI models for image, sound, or pose recognition without coding. He can use his webcam, and microphone, or upload files to teach his models how to recognize different categories of inputs. He can also export your models to websites, apps, or devices using various formats, (Google AI. "Teachable Machine" - 2023).

- SuperAnnotate: This platform allows users to annotate images and videos for computer vision tasks without coding. He can use a web-based tool to label objects, faces, scenes, or actions using various annotation types, such as bounding boxes, polygons, key points, or masks. He can also use AI-powered features to speed up the annotation process, such as smart segmentation, auto-labeling, or active learning (CMI, 2023).
- Computer-Aided Design (CAD) software with AI integration: AI algorithms can generate design variations, optimize structural integrity, and provide real-time feedback during the design process, (Wang, C., et al., 2023).
- PyCaret: This platform allows users to create and compare machine-learning models for various tasks without coding. He can use a Python-based library to import his data, preprocess it, select and train different models, tune their hyperactive parameters, and evaluate their performance. He can also deploy his models to cloud services or web apps using a few lines of code (PyCaret, April 2020).

Using AI Platform will help positively, in monitoring and analyzing emerging technologies, global packaging trends, and market projections, which play a significant role in defining design directions and ideas for the packaging industry. By analyzing these factors, students can get a glimpse into what the packaging industry will potentially look like in the future.

In addition, some of the major trends that are expected to shape the packaging industry include e-commerce, changing consumer preferences, margin compression, sustainability, and digitization. These trends are expected to raise the bar for performance in the packaging industry over the next few years, (pakfactory.com).

It is important to consider the specific needs and goals of the student when suggesting an AI platform for packaging design. Some factors to consider might include the student's level of experience with AI and design tools, the type of design work they will be doing, and their preferred learning style (David Feber, 2022).

Numerous AI tools are accessible to beginners to help them enhance their design workflow and produce better designs. Some of these tools include ChatGPT, which can help automate repetitive tasks; Fotor (for the free tool), Midjourney; and Adobe Firefly, which can generate images from text. It might be helpful to research and compare different AI platforms to find one that best meets the student's needs.

Personalizing Packaging Design Education with AI

As mentioned before, one of the papers aims to be a personalized educational course, based on the student's needs and capabilities. The implementation of AI in personalizing design education can provide a unique educational approach that is fully tailored to individual learners' abilities and needs (Lasse, 2019). AI-based learning systems can give professors useful information about their students' learning styles, abilities, and progress, and provide suggestions for how to customize their teaching methods to students' individual needs.

For example, according to Lasse, some students might be experiencing learning difficulties or challenges that require extra attention or tutoring to keep up. Others might be advancing so rapidly that they are not being intellectually challenged and would benefit from additional study materials or assignments. In both of these scenarios, AI learning systems would be helping students to reach their full potential, possibly preventing them from dropping out by identifying problems early enough to allow the appropriate corrective measures to be taken. In other words,

the implementation of AI in personalizing design education can provide a more effective and engaging learning experience for students by adapting instruction to their individual needs and abilities.

Sustainability is another crucial aspect that the implementation of AI helps cover throughout packaging design education. However, AI technology has been applied to the field of design education to improve teaching methods and actual design productivity (Jing, 2022). AI has the potential to enhance sustainability in packaging design education by facilitating the acquisition of knowledge and skills related to sustainable design practices and materials. Moreover, AI can provide tools for evaluating the environmental impact of various design alternatives and for optimizing the design process according to sustainability criteria. Minimizing the negative environmental impact of packaging by using eco-friendly materials and processes. Providing tips and examples of sustainable packaging design approaches and directions (shown in Fig. 3), such as:

1. **Reusable Packaging:** Packaging that can be used multiple times, reducing waste.
2. **Plantable Packaging:** Packaging made from biodegradable materials embedded with seeds, allowing them to be planted and grow into plants after using them.
3. **Cardboard Boxes:** A traditional option made from renewable materials that can be easily recycled.
4. **Compostable Packaging:** Packaging is made from materials that can break down into natural components in a composting environment.
5. **Environmentally Friendly Labels:** Labels made from eco-friendly materials such as recycled paper or bioplastics.
6. **Returnable Packaging:** Packaging that can be returned to the manufacturer for reuse.
7. **Upcycling:** Transforming waste materials into new products, reducing the need for new resources.
8. **Edible Packaging:** Packaging made from edible materials, reduces waste.

In addition, it can help compare and improve the selection of the proper packaging material and printing technique too. By analyzing the environmental impact of different materials and techniques, and by providing tools for optimizing the use of resources in the production process.

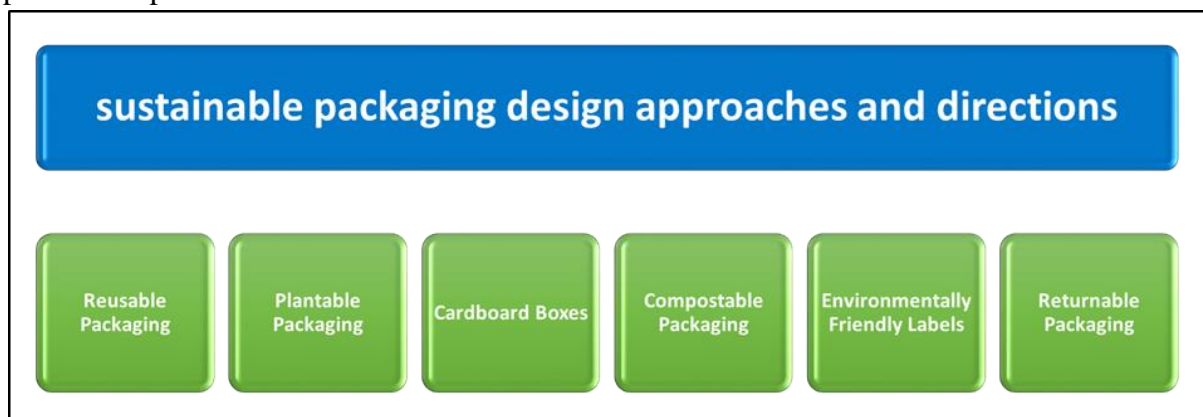


figure 1 - examples of sustainable packaging design approaches and directions

Some of them are:**1. AI-Powered Vision Systems for Packaging Inspection**

AI-Powered Vision Systems have become an important tool for evaluating packaging and finding any flaws. These systems can efficiently assess packaging materials to assure the highest protection and safety of the contained product by utilizing cutting-edge algorithms and machine learning approaches. AI-powered vision systems provide a quick and accurate way to spot any flaws or anomalies that might jeopardize the integrity of the packaging through automated visual examination. As a result, producers may maintain strict quality control standards and offer goods that adhere to the strictest safety regulations.

2. Date labeling for packaging:

The application of AI technology has the potential to improve data significantly, labeling procedures on packages. Date labeling may be made better with the use of AI algorithms to guarantee accurate and trustworthy information about the safety and freshness of the packaged goods. AI systems are able to give instantaneous evaluations of a product's suitability for eating by examining numerous criteria including manufacture dates, expiration dates, and storage conditions. Through the promotion of food safety and the reduction of the danger of ingesting rotten or expired goods, this skill enables customers to make knowledgeable decisions.

3. AI-based recycling systems for packaging:

A viable approach for streamlining the recycling of packaging materials is the use of AI-based recycling systems. These systems can improve the efficacy and efficiency of recycling processes using AI algorithms, hence lowering waste and promoting sustainability. AI-based recycling systems can properly sort and identify various types of packaging materials by using machine-learning algorithms, which streamlines the recycling process. This reduces the need for human work while also raising recycling rates generally, making package disposal more environmentally benign.

4. Artificially intelligent engineering (AIE) of products and packaging:

Artificially Intelligent Engineering (AIE) according to many researchers such as *Kim. et al.* in their book titled "Recent Advances of Artificial Intelligence in Manufacturing Industrial Sectors: A Review." has become a revolutionary method for enhancing product and package design and production. AIE helps manufacturers cut costs and enhance operational efficiency by utilizing AI technology. AIE systems can evaluate enormous volumes of data pertaining to product and package design, discovering opportunities for improvement and optimization, by using machine-learning algorithms. AIE makes it easier to create high-quality goods and packaging that satisfy consumer standards while reducing manufacturing costs and time by automating and optimizing numerous engineering processes.

5. AI for generating packaging prototypes in 3D space:

A new and effective method for the design process is the incorporation of AI technology in the creation of packaging prototypes in 3D space (Ansari, 2021). It is now feasible to create package prototypes without requiring a lot of human input by programming AI algorithms. This quickens the design phase and enables frequent revisions and improvements. Prototype packaging may be correctly depicted in three dimensions by utilizing AI's capacity to decipher and understand complicated design criteria. This makes it possible for a more simplified and effective design process, which boosts productivity and shortens the time it takes innovative packaging solutions to hit the market.

Conclusion:

Artificial Intelligence (AI) is a powerful tool that can perform tasks that require human intelligence, including learning, reasoning, and decision-making. It can be used in packaging design to enhance personalization, optimization, and automation. AI can tailor packaging to individual preferences, use machine learning, natural language processing, and computer vision methodologies, and automate various functions. It can also train AI models to refine search requests for more accurate and personalized outcomes. This technology can improve customer experiences, operational efficiency, and innovation. In packaging design education, AI can enhance learning experiences by enabling advanced features like optimization and automation. By identifying learning objectives, selecting appropriate AI techniques, and designing engaging activities, educators can create a rich and rewarding learning experience for their students. AI-based learning systems can provide educators with valuable information about students' learning styles, abilities, and progress, allowing them to customize teaching methods to meet individual needs. This helps students reach their full potential by identifying and addressing learning difficulties early on.

In addition to personalizing the learning experience, AI can support sustainability in packaging design education by helping students learn about sustainable design practices and materials. By providing tools for analyzing the environmental impact of different design choices, AI can help students make informed decisions about materials and printing techniques that minimize negative environmental impacts.

Results:

The study has ended with the following results:

1. Integration of AI in packaging design education, by incorporating AI concepts, tools, and techniques into the curriculum, students can develop a deeper understanding of sustainable practices, functionality, personalization, and creativity in packaging design. Moreover, enables students and prepares them with the necessary skills to adapt to the evolving industry.
2. Enhanced learning experiences: The incorporation of AI in packaging design education offers various benefits in terms of learning experiences. Students can engage in project-based learning, design-thinking methodologies, and user-centered design approaches to solve real-world packaging challenges.

3. Preparing students with a forward-thinking mindset, enabling them to design packaging solutions that meet future demands and align with industry advancements. Throughout anticipating industry trends by analyzing emerging technologies, global packaging trends, and market projections in shaping the future of the packaging industry.

Recommendations:

Implementing AI in packaging design education might include several benefits for design students and a positive impact on the environment, which requires more in-depth studies, on the following points:

1. Incorporating AI concepts and skills into the packaging design curriculum to help students develop the competencies needed to succeed in the rapidly evolving field of packaging design.
2. Encouraging the Usage of low-code or no-code AI platforms and tools such as ChatGPT, Midjourney, and Adobe Firefly to help students improve their design workflow and create better designs.
3. Utilizing AI-based learning systems to provide professors with valuable information about their students' learning styles, abilities, and progress, allows them to customize their teaching methods to meet individual needs.
4. Providing tools for analyzing the environmental impact of different design choices to help students make informed decisions about materials and printing techniques that minimize negative environmental impacts.
5. Promoting sustainability in packaging design education by helping students learn about sustainable design practices and materials.

By following these recommendations, educators can create a rich and rewarding learning experience for their students while also promoting sustainability in the field of packaging design.

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