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EXPLORING STUDENT EXPERIENCES WITH PRODUCT LINE-UP ANALYSIS IN INDUSTRIAL DESIGN CURRICULUM

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ABSTRACT

Product Line-Up Analysis (PLA), a traditional marketing tool used to evaluate and optimise product portfolios, offers a systematic approach to identifying consumer preferences and market trends. This study examines the integration of an enhanced, quantitative PLA method into the International Islamic University Malaysia (IIUM) industrial design curriculum, framed within the context of the New Product Development (NPD) process. The research involved 14 final-year Industrial Design students from the AAD Department, KAED, enrolled in the BAAD 4201 Final Year Project (Industrial Design), Semester 2, 2024/2025. The study employed two methods: a studio-based PLA conducted during Weeks 1–3, where students analysed 50–80 product samples to extract key design features and quantify their prevalence using percentages, and a survey to gather students' experiences and feedback. A three-part questionnaire addressed students' backgrounds, PLA experiences, and reflections, with responses analysed using data analysis software to generate descriptive statistics. The findings indicate that students found PLA valuable for enhancing analytical thinking, understanding product variations, and aligning design decisions with market insights. However, challenges such as unfamiliarity with the method and the need for additional instructional support were also noted. This study highlights the potential of PLA as a quantitative pedagogical tool that bridges academic learning and real-world design practice.

Keywords: Product Line-Up Analysis, Industrial Design Education, Curriculum Development, Quantitative Design Method, Design Pedagogy

1.0 INTRODUCTION

In the evolving landscape of industrial design education, there is increasing emphasis on aligning academic curricula with industry practices to better prepare students for real-world challenges. One such practice is the adaptation of Product Line-Up Analysis (PLA), a strategic tool traditionally used in marketing to evaluate and optimize product portfolios. By analysing variations within a product line, businesses can discern consumer preferences, identify market trends, and make informed decisions regarding product offerings.

The integration of PLA into industrial design education offers a systematic approach for students to analyse product variations, identify key features, and comprehend market trends early in the design process. This methodology deepens students' understanding of how design decisions correlate with market demands and consumer preferences, bridging the gap between theoretical knowledge and practical application.

Product development in industrial design is often guided by structured frameworks such as the New Product Development (NPD) model, which outline stages from idea generation and research to concept development, prototyping, and product launch. PLA can be positioned within the research and analysis phase of NPD, providing empirical insights into product features, market trends, and consumer preferences. By integrating PLA into this

stage, students can make informed design decisions grounded in both quantitative data and qualitative understanding, thereby linking systematic analysis with creative intuition.

Despite its potential benefits, the application of PLA in design education remains underexplored. Current pedagogical approaches often rely on qualitative analyses, which may not provide students the quantitative insights to fully understand market dynamics. This gap underscores the need for research into effective methods of incorporating PLA into design curricula to enhance students' analytical capabilities and market awareness.

This study aims to address this gap by examining the implementation of PLA within industrial design education. The research assesses how PLA can improve students' understanding of market trends and inform their design proposals. By exploring the methodological integration of PLA into the curriculum, the study seeks to highlight the potential outcomes of this educational strategy and its implications for theoretical knowledge and practical skills development.

The paper is structured as follows: the subsequent section reviews relevant literature on PLA and its applications in marketing and design education. Following this, the research methodology is outlined, detailing the approach taken to investigate the integration of PLA into the curriculum. The findings are then presented and discussed, highlighting the impact of PLA on students' design processes. Finally, the paper concludes with reflections on the study's implications for design education and suggestions for future research.

2.0 LITERATURE REVIEW

2.1 Product Line-Up Analysis in Marketing

Product Line-Up Analysis (PLA) has long been used in marketing to evaluate and optimise product portfolios. By analysing variations within a product line, businesses can understand consumer preferences, identify market trends, and make informed product decisions. Thomadsen (2011) highlights how product-line expansion affects market dynamics and profitability, while the U.S. Small Business Administration emphasises the importance of competitive analysis for understanding market segments. Recent studies reinforce PLA's relevance: Product Portfolio Optimisation Using MCDA (2024) demonstrates structured prioritization of product variants, Product Portfolio Optimisation for LTV Maximisation (2023) shows how selecting the right products enhances customer lifetime value, and McKinsey (2024) illustrates how cost, complexity, and performance data help refine portfolios. Additionally, Simon-Kucher (2023) outlines current drivers, such as sustainability and AI, for adjusting product lines. Beyond marketing, systematic feature analysis in design contexts (Rahman et al., 2018) parallels PLA's structured approach, guiding informed decision-making in product assessment.

2.2 Application of PLA in Industrial Design Education

The integration of PLA into industrial design education offers a systematic approach for students to analyze product variations, identify key features, and comprehend market trends early in the design process. This methodology facilitates a deeper understanding of how design decisions correlate with market demands and consumer preferences. A study by Asia University and National Cheng Kung University provides insights into how industrial design students evaluate products, emphasising the importance of comprehensive product analysis in educational settings. Research by Liu et al. (2021) discusses the implementation of innovative enterprise product design models for industrial design students, highlighting the benefits of integrating real-world analysis tools, such as PLA, into the curriculum. More recent studies further support this trend: Product Portfolio Strategies in Product Design Education (Tsai Lu Liu et al., 2023–2024) proposes curriculum frameworks that require students to consider product portfolios, not just individual products, fostering a broader strategic perspective. Design Project Classroom (Razali, Zulkifli & Mohamad, 2024) shows how industry-academic collaboration in project-based learning helps students confront real market constraints and feature trade-offs. The empirical work on Inclusive Design Capabilities (Razali et al., 2024) adds that students can better manage product variation when inclusive design principles are integrated early. Finally, Research on Teaching Mode in Local Universities (2023) indicates that teaching modes combining classroom involvement, interdisciplinary awareness, and industry engagement significantly enhance students' professional abilities—skills aligned with what PLA seeks to build.

2.3 Quantitative Analysis in Design Education

Quantitative analysis methods are increasingly incorporated into design education to enhance students' analytical capabilities and decision-making skills. These methods enable students to objectively assess design elements and their alignment with market trends using measurable tools. For example, Yao, Zhang, and Li (2023) introduced a decision-making approach based on product family architecture and systematic evaluation to enhance industrial design competitiveness. Studies such as Abd. Jalil, Yunus, Said, and Iqbal (2016) demonstrate how perceptual responses, like physiological reactions to color in stimulating environments, can be systematically quantified, highlighting the value of objective, data-driven evaluation of design elements. Furthermore, the development of quantitative design ability assessment tools, as discussed in MDPI's Sustainability journal, underscores the growing emphasis on measurable outcomes in design education. Recent studies continue this trend: Fuertes-Camacho, García-Rodríguez, and López-López (2025) developed and validated a multidimensional assessment tool for evaluating eco-social competences; Akpınarlı, Yılmaz, and Demir (2025) created the Plant Perception Scale to quantify students' awareness of ecological and cultural significance; and Bataleblu (2024) highlighted the integration of sustainability-driven regulations into higher education, emphasising systematic evaluation and quantitative assessment in educational practices. Together, these studies demonstrate the expanding role of quantitative methods in equipping design students with robust analytical and decision-making skills, including the ability to measure perceptual and sensory responses.

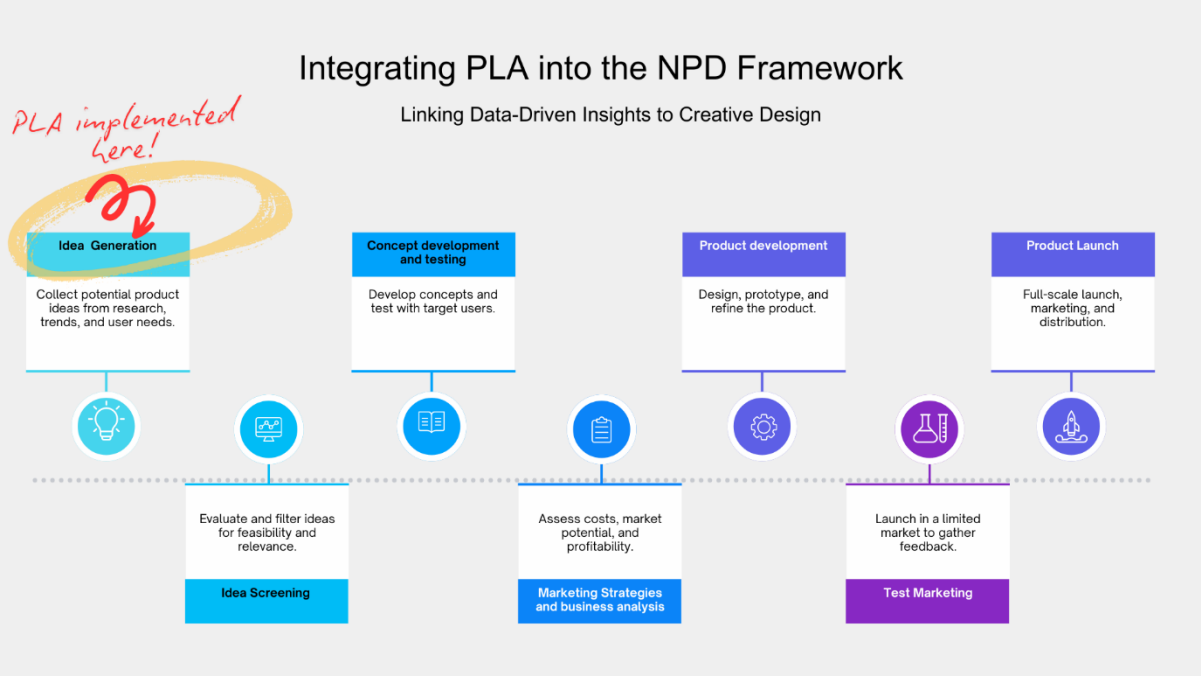

Fig. 1: PLA in the NPD Framework

2.4 Integrating PLA into the Studio-Based Design Process and NPD Framework

Studio-based design education mirrors real-world product development through a structured, iterative process that aligns with the New Product Development (NPD) framework. The NPD process is commonly structured into seven stages: (1) idea generation, (2) idea screening, (3) concept development and testing, (4) business analysis, (5) product development, (6) market testing, and (7) commercialisation. Within this sequence, Product Line-Up Analysis (PLA) can be effectively integrated into the idea generation stage, enabling students to examine existing product portfolios, identify market gaps, and anticipate consumer preferences before concept development. Studies by Liu et al. (2021) and Yao et al. (2023) demonstrate that data-driven tools such as PLA enhance students' ability to generate informed, market-relevant ideas. Grounding ideation in PLA insights supports the creation of concepts that are both innovative and user oriented. As students' progress through subsequent stages—such as mock-ups, modelling, presentations, and portfolio assessments—the early integration of PLA fosters market-oriented thinking and strengthens the connection between academic learning and industry practice.

3.0 METHODOLOGY

This study investigates the experiences of 14 final-year Industrial Design students from the AAD Department, KAED, IIUM, enrolled in the BAAD 4201 Final Year Project (Semester 2, 2024/2025), with a focus on their engagement with Product Line-Up Analysis (PLA). Over 14 weeks, students conducted background studies, including PLA activities during Weeks 1–3, integrating quantitative data into their design process. Following this, a three-part questionnaire was administered to gather information on students' backgrounds, experience their experiences with PLA, and their reflections. The collected data were analysed using Microsoft Excel to generate descriptive statistics (percentages), providing insights into student perceptions of PLA's role in their learning and design development.

4.0 RESULTS

Product Line-Up Analysis (PLA), conducted during the idea generation stage of the New Product Development (NPD) process, was performed out on 50–80 product samples selected by students in the studio (Figures 2–4). Although compiling and analysing all 80 products initially seemed challenging, this process provided substantial long-term benefits. Traditional PLA involved comparison tables to evaluate products across elements such as features, form, shape, materials, function, target audience, and price (Figure 2). Product mapping highlighted market clustering using X–Y axes to compare positioning and identify potential directions for future research (Figure 3). An enhanced quantitative approach incorporated percentage-based analysis of product elements—including shape, features, plant integration, plant size, and materials—showing, for example, that 55.7% of products had rectangular or square shapes, 36.6% were round, and 9.8% were irregular shaped (Figure 4).

These insights helped students better understand design trends, informed their decision-making, and guided the development of innovative concepts for their final-year projects. In addition, the PLA process improved students' analytical and critical thinking skills, enhanced their ability to identify market gaps, and provided a structured reference for ideation when they encountered design challenges. It also fostered awareness of user preferences, product positioning, and strategic design opportunities, enabling students to approach concept development more confidently and strategically. By completing this detailed analysis early, students gained a valuable resource they could refer to throughout the ideation and development process.

Figure 2. Sample of Product Line Up – Table

Figure 3. Sample of Products Mapping

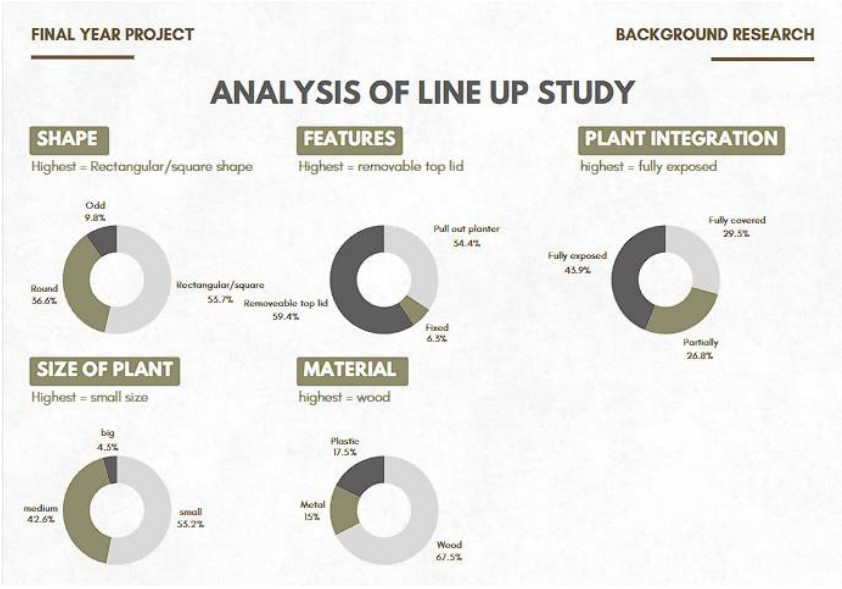

Figure 4: Sample of Enhanced Product Line-Up Analysis (PLA) Incorporating Quantitative Percentage-Based Feature

The survey, consisting of 14 questions, was organised into four key themes to better understand students' experiences with the manual Product Line-Up Analysis. Table 1 focuses on the perceived effectiveness of the method and how it compares with newer approaches. Table 2 explores how students understood product features, particularly in identifying functional and aesthetic differences. Table 3 summarises their suggestions for improving the activity, such as clearer instructions, standardised templates, and incorporating real-world observations. Lastly, Table 4 captures additional insights and reflections that reveal deeper learning outcomes and challenges encountered during the process. These categories provide a structured view of the feedback and point toward meaningful enhancements for future studio-based learning.

Table 1: Method Effectiveness

Question	Related Survey Items	Key Findings
Effectiveness of manual approach	B1: "How effective did you find this approach?"	60% found it "Very effective" or "Somewhat effective"
Usefulness of manual feature extraction	B2: "How useful was it to manually extract and list product features?"	47% found it "Moderately useful" or "Very useful"
Comparison of methods	B4: "Compared to the new method... how do you feel about the previous manual method...?"	40% felt "Both methods were equally helpful"
Value of percentage-based analysis	B7: "Do you think incorporating percentage-based feature occurrence would have made your analysis more insightful?"	67% answered "Probably yes" or "Definitely yes"

The survey results indicate that the manual approach was generally well received, with 60% of the participants finding it very or somewhat effective. Nearly half of the participants (47%) also found manual feature extraction moderately to very useful. When comparing methods, 40% felt both the manual and newer approaches were equally helpful, suggesting the manual method still holds value. Additionally, 67% of the participants believed incorporating percentage-based feature occurrence would have made their analysis more insightful, highlighting interest in combining manual methods with quantitative insights. (see Table 1). This highlights the potential of integrating traditional manual evaluation with data-driven PLA methods to strengthen ideation in the NPD process.

Table 2: Most Valuable Benefits (3 Questions)

Question	Related Survey Items	Key Findings
Understanding product variations	B3: "How did the manual extraction of features help you understand product variations and differences?"	47% said it "Helped identify key differences, but without deeper trend analysis"
Identifying functional and aesthetic differences	B6: "How did the previous method affect your ability to identify functional and aesthetic differences...?"	53% said it "Helped identify functional differences but not aesthetic ones"
Most valuable aspect	C1: "What was the most valuable part of using Product Line-Up Analysis for your design process?"	Common themes: understanding features, dimensions, mechanisms, market trends

The survey also explored the participants' views on the insights provided by the manual feature extraction process. Regarding the understanding of product variations, 47% stated that it *"helped identify key differences, but without deeper trend analysis"*. When it came to identifying functional and aesthetic differences, 53% felt the manual method *"helped identify functional differences but not aesthetic ones"*. Lastly, when asked about the most valuable aspect of using Product Line-Up Analysis for the design process, common themes emerged, such as understanding features, dimensions, mechanisms, and market trends (see Table 2).

Table 3: Impact on Design Process (11 Questions)

Question	Related Survey Items	Key Findings
Understanding product features	B8: "The line-up activity helped me understand differences in product features and aesthetics."	100% "Agree" or "Strongly agree"
Insight into consumer trends	B9: "I gained insight into consumer trends by analysing product variations."	93% "Agree" or "Strongly agree"
Identifying market preferences	B10: "I was able to identify market preferences using percentage or feature mapping."	100% "Agree" or "Strongly agree"
Deepening product understanding	B11: "The quantitative analysis deepened my product understanding."	93% "Agree" or "Strongly agree"
Strategic design direction	B12: "This method helped me develop a more strategic and informed design direction."	100% "Agree" or "Strongly agree"
Confidence in comparison	B13: "I feel more confident comparing existing products using structured visual methods."	100% "Agree" or "Strongly agree"
Improved decision-making	B14: "The approach improved my decision-making during concept development."	100% "Agree" or "Strongly agree"
Real-world relevance	B15: "The studio activity reflects how designers work in real-world industry settings."	100% "Agree" or "Strongly agree"
Awareness of global trends	B16: "I became more aware of global trends and market diversity through this activity."	87% "Agree" or "Strongly agree"
Recommendation for future use	B17: "I would recommend using Product Line-Up Analysis in future studio projects."	100% "Agree" or "Strongly agree"
Influence on concept development	C2: "How did this method influence your concept development or final mock-up?"	Common themes: informing measurements, identifying gaps in market, justifying design decisions

The survey also examined participants' perspectives on the impact of Product Line-Up Analysis on their design process. When asked how the manual extraction of features helped understand product variations, 47% of respondents indicated it *"helped identify key differences, but without deeper trend analysis"*. Regarding identifying functional and aesthetic differences, 53% mentioned it *"helped identify functional differences but not aesthetic ones"*. The most valuable aspect of using Product Line-Up Analysis was understanding key features, dimensions, mechanisms, and market trends, which were common themes across responses (see Table 3).

Table 4: Suggestions for Improvement (1 Question)

Question	Related Survey Items	Key Findings
Improvement suggestions	C3: "Do you have any suggestions for improving this studio activity in the future?"	Key recommendations: - Collaborative ground analysis - Clearer instructions from lecturers - Standardized content in tables - More hands-on activities - Site visits for real-life observation

The survey also collected feedback on potential improvements for the studio activity. Participants provided several key recommendations for future sessions, including the need for collaborative ground analysis, clearer lecturer instructions, and standardised table content. Many suggested incorporating more hands-on activities and emphasised the importance of site visits for real-life observation of product line-ups in actual situations, rather than relying solely on digital content from platforms such as Google.

5.0 DISCUSSIONS

The findings indicate that while the manual Product Line-Up Analysis method is generally effective, it has notable limitations. Most students found it helpful for identifying product features and functional differences, but less for analysing trends or aesthetic qualities. This reflects the method's strength in foundational observation and its lack of analytical depth.

Many respondents suggested that incorporating percentage-based analysis would provide clearer insights. This supports the idea that blending manual and data-driven methods could enrich students' understanding. Additionally, students highlighted the need for real-life observation, clearer guidance, and more hands-on activities, pointing to the value of experiential learning in design education.

The study suggests that although manual analysis remains a useful learning tool, its impact can be significantly enhanced through real-world engagement and structured analytical approaches.

6.0 CONCLUSION

This study has shown that manual Product Line-Up Analysis provides foundational value in helping design students observe and compare product features. However, its effectiveness is limited when deeper analysis or aesthetic evaluation is required. Students appreciated the method's clarity and structure but expressed a strong need for complementary tools, particularly those that incorporate data-driven analysis and real-world experiences.

The feedback highlights the importance of evolving design education by blending traditional observational techniques with analytical and experiential methods. Incorporating percentage-based feature analysis, clearer instructions, hands-on activities, and site visits can make learning more engaging and insightful.

Future research could explore how digital tools and visual analytics further enhance Product Line-Up Analysis, particularly in identifying user preferences and market trends. Expanding this study across different design disciplines could also reveal broader applications and improve curriculum design. Enriching the learning environment with structured and experiential methods can better prepare students for real-world product development challenges.

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