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Expert User Validation of Perceived Quality and Purchase Intention: Perspectives from Product Designers and Industry Practitioners

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ABSTRACT

Perceived product quality and purchase intention influence the acceptance of sustainable products, yet a user derived design model requires professional validation before wider application. This study evaluates the content validity of a Sustainable Product Design Model developed from a preceding survey of 300 end users. The model contains 37 indicators across seven criteria, namely FORM, FUNCTION, SAFETY, SUSTAINABILITY, QUALITY, COMMERCIALITY, and INNOVATION. Thirty product designers and industry practitioners with at least five years of relevant experience were purposively selected. Each indicator was rated using a four point relevance scale. Item Level Content Validity Index and Scale Level Content Validity Index Average were calculated. All 37 indicators exceeded the predetermined retention threshold, with Item Level Content Validity Index values ranging from 0.80 to 1.00 and an overall average of 0.94. FUNCTION recorded the highest criterion value at 0.98, followed by QUALITY at 0.97 and FORM at 0.95. The findings support retention of the seven criteria and show that expert relevance ratings complement rather than replace the priority structure established by users. The study provides a two stage validation approach for strengthening a user centred sustainable product design model.

Keywords: *Content Validity, Expert Validation, Perceived Product Quality, Purchase Intention, Sustainable Product Design.*

1 INTRODUCTION

Product success depends not only on technical conformance but also on whether intended users recognise, trust, value, and ultimately choose the product. Perceived product quality therefore provides an important connection between design decisions and market response. Golder et al. (2012) describe quality as a set of interconnected production, experience, and evaluation processes. From a product development perspective, this distinction matters because a technically adequate product may still fail when users do not perceive sufficient value, usability, reliability, or desirability.

Purchase intention extends this evaluative process into a behavioural orientation. Tsiotsou (2006) demonstrated that perceived product quality influences purchase intention, while Beneke et al. (2013) linked perceived quality with perceived value and willingness to buy. These relationships are particularly relevant to sustainable products. Environmental or lifecycle improvements create limited practical benefit when users reject a product, replace it prematurely, misunderstand its use, or judge it as poor value. Sustainable product design must therefore reconcile environmental, social, and economic requirements with the product cues and decision criteria that users recognise.

Research on sustainable product development has produced a substantial range of tools, criteria, and lifecycle methods. Ahmad et al. (2018) found that many approaches remain oriented toward sustainability dimensions or stages of the lifecycle. More recently, Hunger et al. (2025) concluded that important gaps remain in the practical integration of multiple sustainability facets during the early stages of new product development. This is the stage in which designers often must make consequential decisions while information is still incomplete. Structured product development methods likewise emphasise identifying customer needs and translating them into product requirements during early concept development (Ulrich & Eppinger, 2012).

At the same time, research on perceived quality demonstrates the value of identifying and ranking attributes that matter to users. Stylidis et al. (2020) show that perceived quality can be decomposed into attributes that support systematic prioritisation during product development. Content validity research addresses a different question. It asks whether proposed items are relevant, sufficiently representative, and understandable within an intended conceptual domain (Mokkink et al., 2025; Polit et al., 2007). The two forms of evidence should therefore not be treated as interchangeable.

The Sustainable Product Design Model examined in this study was developed to bring these perspectives together. Its conceptual foundation integrates Perceived Product Quality, Purchase Intention, and design evaluation within social, environmental, and economic sustainability. The operational layer consists of seven criteria, namely FORM, FUNCTION, SAFETY, SUSTAINABILITY, QUALITY, COMMERCIALITY, and INNOVATION. Each criterion contains indicators arranged according to priorities established in a preceding empirical study involving 300 end users.

The research gap addressed in this paper concerns the methodological relationship between user priority and professional validation. Existing literature explains how users can rank perceived product attributes and how experts can judge content relevance, yet there is limited guidance on how these two evidence streams should be combined in a user derived design model without allowing later expert scores to overwrite the original user priority structure. A further issue concerns the interpretation of variation in expert relevance ratings. Quantitative questionnaire scores show the level of agreement but do not reveal why individual experts selected ratings. Any discussion of these variations therefore needs to remain grounded in the numerical findings and be contextualised through established theory rather than through assumptions about expert reasoning.

The novelty of the present study lies in this validation architecture rather than in claiming that every individual design indicator is new. The earlier user study establishes relative priority. The expert stage tests content relevance through quantitative ratings. Differences in I-CVI values are then considered against relevant literature to understand how each indicator is positioned theoretically, without treating that literature as evidence of the experts' personal reasons. Expert scores are therefore used to validate the model rather than to create a second ranking. This approach preserves the empirical voice of users while adding professional content validation. The objectives of this paper are to evaluate the content relevance of the 37 indicators, to interpret the pattern of relevance ratings in relation to existing theory, and to explain how expert validation strengthens the Sustainable Product Design Model without changing its user derived priority order.

2 LITERATURE REVIEW AND CONCEPTUAL BACKGROUND

2.1 Perceived Product Quality and Purchase Intention

Perceived product quality concerns the user judgement of the overall excellence or superiority of a product relative to expectations and available alternatives. It differs from objective quality because it is formed through the interpretation of product cues rather than through technical measurement alone.

Agarwal and Teas (2004) show that evaluations of value are influenced by extrinsic cues such as brand and price as well as by perceived quality, sacrifice, and risk. Quality perception can therefore arise from intrinsic product characteristics and market facing information.

From a design engineering perspective, perceived quality can be translated into attributes that support deliberate prioritisation during product development. Stylidis et al. (2020) argue that perceived quality is a critical aspect of successful product development and propose a method for ranking perceived quality attributes. Such prioritisation is useful because design teams operate under constraints involving time, cost, manufacturing capability, and sustainability. A framework that identifies which attributes users consider more important can guide early design attention more effectively than assuming that all quality cues carry equal weight.

Purchase intention represents a user willingness or predisposition to select a product. Although intention is not identical to actual purchasing behaviour, it is an important intermediate outcome because it reflects how consumers translate perceptions into a potential behavioural response. Tsiotsou (2006) found a direct relationship between perceived quality and purchase intentions. Beneke et al. (2013) similarly linked perceived product quality with willingness to buy through perceived value. These findings support the inclusion of purchase intention within a design model that seeks to connect user centred quality evaluation with market acceptance.

The relationship becomes especially important when sustainable attributes are introduced. Sustainable features can increase product value, but they can also create tradeoffs involving price, appearance, material choice, repairability, complexity, or performance. A design model therefore needs to recognise how sustainability decisions interact with the cues through which users judge quality and value.

2.2 Sustainable Product Design and User Centred Evaluation

Sustainable product design requires environmental, social, and economic considerations to be addressed throughout product development rather than added as a final compliance activity. The World Commission on Environment and Development (1987) established the principle of meeting present needs without compromising the ability of future generations to meet their own needs. In product development, this principle is translated into decisions involving materials, energy, durability, maintenance, repairability, disassembly, recycling, manufacturing, user wellbeing, and economic viability.

Ahmad et al. (2018) reviewed sustainable product design tools and found that integrated approaches remain less mature than partial or lifecycle specific tools. Gupta et al. (2015) likewise emphasised environmental, economic, and social determinants in sustainable product design and manufacturing. Hunger et al. (2025) further showed that holistic integration during early product development remains difficult even as multi criteria tools continue to expand. These findings reinforce the need for a structured design reference that can be used when product requirements are still being defined.

User centred evaluation complements lifecycle thinking by asking whether sustainable design decisions remain meaningful in actual use. A durable product produces limited sustainability benefit if users find it difficult to use and replace it prematurely. An energy efficient product may be technically superior but commercially unsuccessful if its benefits are unclear. Conversely, a commercially attractive product may achieve initial sales while producing weak long term sustainability outcomes if it is unreliable or difficult to repair. The SPDM therefore treats user acceptance and sustainability as interdependent considerations.

Du and Ayob (2024) show that sustainability can be considered through aesthetic and material decisions in contemporary product design. Abdul Jamil and Abu Bakar (2025) further demonstrate that design development can influence public acceptance and purchase intention. Mohd Hasbullah et al.

(2025) illustrate how human centred design can be combined with environmental, social, and economic considerations. Together, these studies reinforce the relevance of considering sustainability, user acceptance, and human centred evaluation as connected concerns within product design.

2.3 Expert Validation and Content Validity

Expert validation is appropriate when a model or instrument requires evidence that its proposed content adequately represents the intended conceptual domains. Recent methodological literature continues to support quantitative content validation through independent expert relevance ratings. Mikkonen et al. (2022) describe instrument development procedures in which experts evaluate item relevance individually using a four point scale and content validity indices. Madadizadeh and Bahariniya (2023) provide a practical account of quantitative content validity assessment using the Content Validity Index, while Hurtado-Arenas et al. (2025) compare several content validity indices and identify the Polit et al. approach as a comparatively rigorous option. These more recent publications demonstrate the continued use and refinement of procedures that originated in earlier content validity work, including Lynn (1986) and Polit et al. (2007).

The Content Validity Index provides item level and scale level evidence. Polit and Beck (2006) distinguish the Item Level Content Validity Index from scale level procedures and recommend transparent reporting of the calculation method. Polit et al. (2007) further discuss the interpretation of item agreement. Recent methodological work frames content validity through relevance, comprehensiveness, and comprehensibility, reinforcing that content validation is concerned with whether content appropriately represents a construct rather than with ranking the importance of that content (Mokkink et al., 2025).

In the present study, Scores 3 and 4 represent relevant judgements, while Scores 1 and 2 represent lower relevance. The I-CVI is calculated as the proportion of experts rating an indicator as 3 or 4. The S-CVI/Ave is calculated by averaging I-CVI values across indicators within each primary criterion. The purpose of this analysis is to determine whether indicators are sufficiently relevant to remain within their conceptual domains. It is not intended to determine which indicator users should prioritise.

This distinction is essential because the indicator order in the SPDM was established in the preceding user study. User data establish priority and expert questionnaire data establish content relevance. If expert scores were used to reorder the model, the validation stage would replace rather than validate the user derived structure. The analytical logic adopted in this paper is therefore to retain indicators that meet the relevance criterion and to contextualise variations in their ratings through existing theory without attributing unmeasured reasons to the experts.

2.4 Research Gap and Study Contribution

Three connected gaps inform the present study. First, sustainable product design research continues to report difficulty translating broad sustainability goals into integrated early-stage decisions (Ahmad et al., 2018; Hunger et al., 2025). Second, perceived quality research provides ways to identify and prioritise attributes from the user perspective, while content validity research provides ways to establish professional relevance, but these forms of evidence serve different inferential purposes. Third, there is limited methodological discussion of how a user derived priority structure should be handled when later expert validation produces uneven agreement across indicators. The study contributes a two-stage evidence structure for design model development. The first stage uses user data to establish relative priority among indicators. The second stage uses qualified expert ratings to determine whether the proposed indicators are relevant representations of their intended criteria. The expert stage does not re-rank the model. Where I-CVI values differ, the variation is reported quantitatively and then discussed against established literature relevant to the indicator. This keeps the interpretation within the limits of the questionnaire data while still allowing the results to be situated theoretically.

3 METHODOLOGY

3.1 Study Design and Origin of the Framework

This study employed a quantitative expert content validation design. The object of validation was the Sustainable Product Design Model developed from the preceding phases of the research. The model integrates social, environmental, and economic sustainability with Perceived Product Quality, Purchase Intention, and a Design Evaluation Element. Its operational component comprises 37 indicators distributed across seven primary criteria.

FORM comprises Shape, Appearance, Colour, Product Finishing, and Texture. FUNCTION comprises Easy to Understand, Ergonomic, Comfortable, Convenient or User Friendly or Easy to Use, and Performance. SAFETY comprises Spare Part Availability, Test Results, Warranty Provisions, Maintenance, and Compliance with Standards and Regulations. SUSTAINABILITY comprises Stability, Material Use or Type, Energy Efficient, Assemble and Disassemble, and Recyclability. QUALITY comprises Reliability, Durability, Product Specifications, Material Selection, and Conformance. COMMERCIALITY comprises Brand, Recommendation, Price, Product Information, Customer Review, Service after Purchase, and Online Reviews. INNOVATION comprises Product Benefit, Uniqueness, Prestige Value, Exclusiveness or Limited, and Novelty or Originality.

The priority order within each criterion had already been established through the preceding 300 user study. The expert stage was conducted after model development to determine whether those indicators were sufficiently relevant to their assigned criteria. This sequential logic preserves the user centred origin of the model while adding professional content validation.

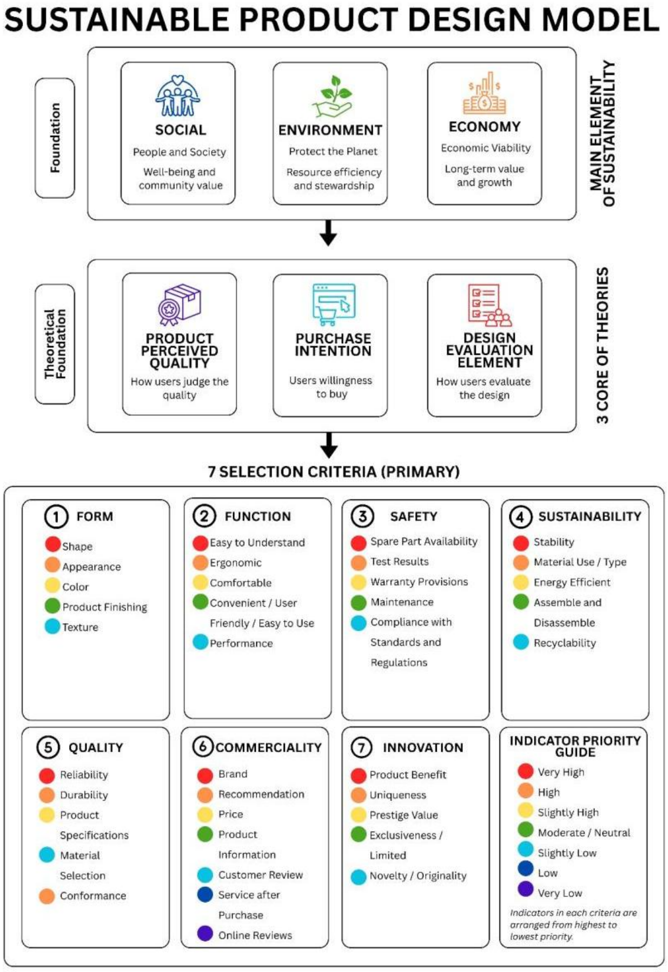

Figure 1 Sustainable Product Design Model subjected to expert validation

3.2 Expert Selection and Panel Characteristics

Purposive expert sampling was used because content validation requires informed judgement from individuals who possess knowledge and experience relevant to the content being assessed rather than statistical representation of a general population. Expert selection was therefore based on professional relevance to the Sustainable Product Design Model. Contemporary guidance on instrument development emphasises that reviewers should have previous or current experience with the phenomenon being assessed and should receive clear information about the conceptual basis and purpose of the evaluation (Mikkonen et al., 2022). This position is consistent with earlier expert selection guidance that stresses deliberate selection according to expertise, experience, and familiarity with the domain (Davis, 1992; Grant & Davis, 1997).

Eligibility required a minimum of five years of relevant professional, academic, or industry experience in product design, industrial design, product development, sustainable design, engineering, manufacturing, design education, design management, sustainability, consumer behaviour, marketing, commercialisation, or another field directly related to the model. The five year threshold was adopted as a study specific criterion for substantive field experience rather than as a universal definition of expertise. Its use is consistent with previous questionnaire validation research in which content experts were required to have more than five years of relevant work experience (Bukenya et al., 2017).

Thirty eligible experts were deliberately targeted for the validation stage. The panel size was not calculated as a proportion of the preceding 300 user respondents because the two samples served different methodological purposes. The 300 users established relative priority among the indicators, whereas the expert panel assessed content relevance. More recent methodological guidance illustrates that expert panels larger than the classical minimum are used in instrument development. Mikkonen et al. (2022), for example, describe individual content evaluation involving 20 experts and retain an I CVI threshold of 0.78. Madadizadeh and Bahariniya (2023) likewise present CVI as an established quantitative approach for assessing item relevance, while Hurtado-Arenas et al. (2025) demonstrate that CVI based methods remain actively evaluated in contemporary validation research. Against this methodological background, the decision to involve 30 experts in the present study was a pragmatic study specific choice intended to obtain broader professional representation across the multidisciplinary domains incorporated in the SPDM rather than a numerical requirement derived from the user sample.

The panel comprised product designers and industry practitioners. The expert profile section recorded area of expertise, highest academic or professional qualification, current position, organisation, total years of professional or academic experience, years of experience specifically related to product design or sustainability, and relevant research, publication, or project experience. The quantitative content validity dataset is analysed as one expert panel and is not used for subgroup comparisons by qualification, sector, or years of experience.

3.3 Expert Recruitment and Data Collection Procedure

Following completion of the user study and development of the Sustainable Product Design Model, a separate expert validation stage was undertaken. Thirty experts who met the eligibility criteria were identified and invited to participate. All 30 completed the questionnaire, resulting in a response rate of 100 percent.

Expert validation was conducted between May and July 2025 using an online questionnaire administered through Google Forms. Electronic non face to face content validation is compatible with established procedures when experts are given clear instructions and complete their ratings independently (Yusoff, 2019). Mikkonen et al. (2022) similarly describe individual expert evaluation conducted remotely, supporting the use of an independently completed electronic validation process.

The questionnaire was self-administered and each expert completed the instrument independently. The validation procedure did not involve an interview, focus group, or group consensus session. The resulting dataset therefore represents independent quantitative questionnaire ratings rather than qualitative expert feedback.

Thirty complete submissions formed the analytic dataset. All 37 relevance items contained responses from the same 30 experts, which provided a constant denominator for the Item Level Content Validity Index calculation. No item level missing value imputation was required. The analysis therefore used the 30 completed questionnaires in their entirety.

3.4 Validation Instrument

The expert questionnaire was designed for independent quantitative review of the proposed model. Experts were asked to rate the relevance of each indicator to its assigned criterion using the specified four-point relevance scale. The questionnaire ratings provide numerical evidence of content relevance and agreement. They do not provide interview-based explanations, qualitative reasons, or group consensus statements about why individual experts selected particular scores.

For the quantitative relevance assessment reported in this article, every indicator was rated on a four-point scale. Score 1 represented not relevant. Score 2 represented somewhat relevant. Score 3 represented quite relevant. Score 4 represented highly relevant. For I CVI calculation, Scores 3 and 4 were classified as relevant judgements. The four point relevance format and dichotomisation of the upper two ratings for I CVI calculation remain consistent with contemporary guidance on quantitative content validation (Yusoff, 2019; Mikkonen et al., 2022; Madadizadeh & Bahariniya, 2023).

The instrument retained the seven-criterion structure and the indicator labels generated from the earlier phase. Experts therefore evaluated the relevance of the proposed indicators rather than producing a new priority ranking. The numerical results reported in this article are based on the relevance ratings used for I-CVI and S-CVI/Ave analysis.

3.5 Research Ethics and Informed Participation

The online expert questionnaire opened with information describing the purpose of the validation and the role of the expert. Participation was voluntary. Experts were informed that the information they provided would be treated confidentially and used only for academic and research purposes. They were also informed that responses would be reported in aggregate and would not be used to identify individual experts unless explicit permission was obtained.

Experts reviewed this information before completing the questionnaire and were instructed to provide independent professional judgement. No individual expert is identified in the present article. The paper reports aggregated validation results and professional profile categories only. These procedures reflect the informed participation and confidentiality arrangements documented in the research instrument.

3.6 Content Validity Analysis

For each indicator, the Item Level Content Validity Index was calculated by dividing the number of experts assigning a Score 3 or Score 4 by the total number of experts. With N equal to 30, an indicator endorsed as relevant by all 30 experts received an I-CVI of 1.00. Twenty-nine relevant ratings produced 0.97. Twenty-eight produced 0.93. Twenty-seven produced 0.90. Twenty-six produced 0.87. Twenty-five produced 0.83. Twenty-four produced 0.80.

The Scale Level Content Validity Index Average was calculated separately for each primary criterion by averaging the I CVI values of its indicators. An I CVI threshold of 0.78 was adopted as the predetermined retention criterion. This threshold remains consistent with contemporary instrument development guidance using I CVI procedures (Mikkonen et al., 2022) and with the established recommendations of Polit et al. (2007). Recent comparative work also confirms that CVI based procedures continue to be used and evaluated in current validation research (Hurtado-Arenas et al., 2025). Because the observed minimum I CVI in the study was 0.80, all proposed indicators met the retention criterion.

The analysis was interpreted at two levels. Threshold compliance was used to determine whether an indicator possessed sufficient content relevance for retention. The distribution of I-CVI and S-CVI/Ave values was then compared descriptively across indicators and criteria. These numerical differences were not treated as evidence of why experts selected particular ratings and were not used as a second ranking system. In the Discussion, selected variations are contextualised using existing literature relevant to the theoretical role of each indicator.

4 RESULTS

4.1 Overall Content Validity

The validation results provide strong overall support for the content of the SPDM. Across all 37 indicators, I-CVI values ranged from 0.80 to 1.00 and the average I-CVI across the complete indicator set was 0.94. At the criterion level, S-CVI/Ave values ranged from 0.88 to 0.98. No indicator fell below the predetermined retention threshold of 0.78.

FUNCTION recorded the strongest criterion level agreement with an S-CVI/Ave of 0.98. This was followed by QUALITY at 0.97, FORM at 0.95, SAFETY at 0.93, SUSTAINABILITY at 0.93, COMMERCIALITY at 0.91, and INNOVATION at 0.88. The values show quantitative variation across the seven criteria, while every criterion remained within the acceptable range for content validity.

Table 1 Content validity summary for the seven primary criteria

Criterion	No. of Indicators	S-CVI/Ave	Lowest I-CVI	Highest I-CVI	Indicators ≥ 0.78
FORM	5	0.95	0.90	1.00	5
FUNCTION	5	0.98	0.97	1.00	5
SAFETY	5	0.93	0.87	1.00	5
SUSTAINABILITY	5	0.93	0.83	1.00	5
QUALITY	5	0.97	0.93	1.00	5
COMMERCIALITY	7	0.91	0.83	0.97	7
INNOVATION	5	0.88	0.80	0.97	5

Table 2 Indicator level content validity results

Criterion	Indicator	Relevant Ratings (3+4), n	I-CVI
FORM	D1 Shape	30	1.00
FORM	D2 Appearance	29	0.97
FORM	D3 Color	29	0.97
FORM	D4 Product Finishing	28	0.93
FORM	D5 Texture	27	0.90
FUNCTION	E1 Easy to Understand	29	0.97
FUNCTION	E2 Ergonomic	30	1.00
FUNCTION	E3 Comfortable	29	0.97

Criterion	Indicator	Relevant Ratings (3+4), n	I-CVI
FUNCTION	E4 Convenient / User Friendly / Easy to Use	30	1.00
FUNCTION	E5 Performance	29	0.97
SAFETY	F1 Spare Part Availability	26	0.87
SAFETY	F2 Test Results	29	0.97
SAFETY	F3 Warranty Provisions	27	0.90
SAFETY	F4 Maintenance	28	0.93
SAFETY	F5 Compliance with Standards and Regulations	30	1.00
SUSTAINABILITY	G1 Stability	25	0.83
SUSTAINABILITY	G2 Material Use / Type	29	0.97
SUSTAINABILITY	G3 Energy Efficient	30	1.00
SUSTAINABILITY	G4 Assemble and Disassemble	28	0.93
SUSTAINABILITY	G5 Recyclability	27	0.90
QUALITY	H1 Reliability	30	1.00
QUALITY	H2 Durability	29	0.97
QUALITY	H3 Product Specifications	30	1.00
QUALITY	H4 Material Selection	28	0.93
QUALITY	H5 Conformance	29	0.97
COMMERCIALITY	I1 Brand	26	0.87
COMMERCIALITY	I2 Recommendation	28	0.93
COMMERCIALITY	I3 Price	25	0.83
COMMERCIALITY	I4 Product Information	29	0.97
COMMERCIALITY	I5 Customer Review	27	0.90
COMMERCIALITY	I6 Service after Purchase	28	0.93
COMMERCIALITY	I7 Online Reviews	29	0.97
INNOVATION	J1 Product Benefit	29	0.97
INNOVATION	J2 Uniqueness	27	0.90
INNOVATION	J3 Prestige Value	24	0.80
INNOVATION	J4 Exclusiveness / Limited	24	0.80
INNOVATION	J5 Novelty / Originality	28	0.93

4.2 Form

FORM achieved an S-CVI/Ave of 0.95. Shape achieved complete agreement with an I-CVI of 1.00. Appearance and Color each achieved 0.97, Product Finishing achieved 0.93, and Texture achieved 0.90. These values indicate strong professional agreement that the five indicators represent formal product characteristics.

Texture recorded the lowest I-CVI within FORM at 0.90, although the value remained well above the retention threshold. The questionnaire establishes this difference in relevance rating but does not establish its cause. Within product design, texture can refer to visible surface treatment as well as tactile properties such as roughness, softness, friction, and material grain. This broader design meaning provides context for defining how Texture should be applied in future use of the model, without attributing a particular interpretation to the experts.

4.3 Function

FUNCTION achieved the highest S-CVI/Ave in the framework at 0.98. Ergonomic and Convenient or User Friendly or Easy to Use each achieved complete agreement. Easy to Understand, Comfortable, and Performance each achieved 0.97. The narrow range indicates unusually strong professional consensus.

The five indicators represent distinct aspects of product function within design practice. Ergonomics and comfort concern physical compatibility with the user. Easy to Understand concerns comprehension of controls, instructions, and product logic. Easy to Use concerns the effort required for successful operation. Performance concerns whether the product delivers its intended function. These distinctions provide the theoretical basis for retaining separate functional indicators and do not depend on assumptions about how individual experts interpreted them.

4.4 Safety

SAFETY achieved an S-CVI/Ave of 0.93. Compliance with Standards and Regulations achieved complete agreement, followed by Test Results at 0.97, Maintenance at 0.93, Warranty Provisions at 0.90, and Spare Part Availability at 0.87. The distribution shows stronger consensus for direct evidence of safety than for post purchase support indicators.

Standards compliance and test results provide direct evidence that a product meets specified safety requirements. Maintenance, warranty, and spare part availability contribute to continued safe operation across the product lifecycle. A product that cannot be maintained or repaired may become less safe as components wear. This lifecycle perspective provides a theoretical context for the inclusion of post purchase support indicators within SAFETY, while the I-CVI values themselves are reported only as quantitative relevance ratings.

4.5 Sustainability

SUSTAINABILITY achieved an S-CVI/Ave of 0.93. Energy Efficient received complete agreement. Material Use or Type achieved 0.97, Assemble and Disassemble achieved 0.93, Recyclability achieved 0.90, and Stability achieved 0.83. The results confirm strong recognition of energy, materials, disassembly, and end of life concerns.

Stability recorded the lowest I-CVI within SUSTAINABILITY at 0.83 and remained above the predetermined retention threshold. The questionnaire does not establish why individual experts assigned lower relevance ratings. The result can, however, be considered in relation to existing sustainable product design literature. Energy use, material efficiency, disassembly, recyclability, durability, and product lifetime are frequently treated as direct sustainability concerns (Ahmad et al., 2018; Bocken et al., 2016; Hunger et al., 2025; Mesa et al., 2022). Within this theoretical context, Stability has a stronger sustainability meaning when it refers to the capacity of a product to maintain intended performance and physical integrity over its expected service life. This interpretation supports retention of the indicator in its user derived position while defining its role in relation to product longevity and reduced premature replacement.

4.6 Quality

QUALITY recorded the second highest S-CVI/Ave at 0.97. Reliability and Product Specifications each achieved complete agreement. Durability and Conformance achieved 0.97, while Material Selection achieved 0.93. The pattern indicates strong conceptual coherence.

Material Use or Type under SUSTAINABILITY recorded an I-CVI of 0.97, while Material Selection under QUALITY recorded 0.93. Both values demonstrate strong content relevance. Existing literature provides a basis for distinguishing the theoretical role of the two indicators. Engineering material selection focuses on identifying materials that satisfy functional requirements, performance constraints, durability, manufacturing conditions, and product specifications (Ashby, 2024). By contrast, sustainability-oriented material assessment considers lifecycle impact, resource demand, environmental burden, recyclability, and end of life implications during design decisions (Pollini & Rognoli, 2021). This distinction supports the placement of Material Selection within QUALITY and Material Use or Type within SUSTAINABILITY. The difference in I-CVI values is therefore discussed in relation to these theoretical roles and is not presented as evidence that experts consciously applied this distinction when completing the questionnaire.

4.7 Commerciality

COMMERCIALITY achieved an S-CVI/Ave of 0.91. Product Information and Online Reviews achieved the highest I-CVI values at 0.97. Recommendation and Service after Purchase achieved 0.93. Customer Review achieved 0.90. Brand achieved 0.87 and Price achieved 0.83. These values show a wider numerical range than several other criteria, although all indicators remained above the retention threshold.

Commerciality concerns market facing conditions that can shape perceived value and purchase decisions. Brand, price, reviews, product information, recommendations, and aftersales service influence how consumers evaluate credibility, sacrifice, risk, and willingness to buy (Agarwal & Teas, 2004; Beneke et al., 2013). This literature provides the theoretical context for retaining these indicators within a commercial dimension of the model. It does not establish why individual experts assigned different relevance scores.

4.8 Innovation

INNOVATION recorded the lowest S-CVI/Ave among the seven criteria at 0.88, although the value remained acceptable. Product Benefit achieved 0.97, Novelty or Originality achieved 0.93, Uniqueness achieved 0.90, while Prestige Value and Exclusiveness or Limited each achieved 0.80.

Within INNOVATION, Product Benefit recorded an I-CVI of 0.97, Novelty or Originality recorded 0.93, Uniqueness recorded 0.90, while Prestige Value and Exclusiveness or Limited each recorded 0.80. All five indicators remained above the predetermined retention threshold. The questionnaire data do not indicate why this variation occurred. Existing literature nevertheless provides a useful theoretical context. Research on perceived product innovativeness places emphasis on perceived newness, relative advantage, and differentiation (Lowe & Alpert, 2015), which correspond closely with Product Benefit, Novelty or Originality, and Uniqueness. Prestige Value and Exclusiveness or Limited also relate to symbolic value, rarity, scarcity, restricted access, and market positioning (Wang et al., 2024). Their position therefore extends beyond technical newness into perceived and symbolic differentiation. This theoretical overlap offers a context for interpreting the pattern of I-CVI values without presenting it as the reason for the experts' ratings.

4.9 Theoretical Positioning and Operational Definitions

All indicators remained above the predetermined retention threshold. Table 3 therefore presents selected operational definitions to specify how several indicators are intended to function within the SPDM. These definitions are grounded in existing literature and in the structure of the model. They are not presented as corrections arising from interview feedback, because the expert validation data analysed in this study consist of quantitative questionnaire ratings.

Table 3 Selected operational definitions and theoretical basis within the Sustainable Product Design Model

Indicator	Criterion	Operational definition	Theoretical basis within the model
Stability	SUSTAINABILITY	The capacity of a product to maintain safe, consistent, and intended functional performance and physical integrity across expected use conditions and service life.	Product durability and lifetime extension literature connects sustained performance and physical integrity with reduced replacement and resource demand (Bocken et al., 2016; Mesa et al., 2022).
Material Use / Type	SUSTAINABILITY	The resource and environmental implications of the material composition and amount used in a product, including lifecycle burden, recycled or renewable content, toxicity, resource demand, and recyclability.	Lifecycle oriented material assessment emphasises resource demand, environmental burden, recycled or renewable content, recyclability, and end of life implications (Pollini & Rognoli, 2021).
Material Selection	QUALITY	The suitability of a chosen material for the intended function, required performance, reliability, durability, finish, manufacturability, and conformance.	Engineering material selection focuses on satisfying intended function, performance, durability, manufacturing, and specification requirements (Ashby, 2024).
Prestige Value	INNOVATION	The symbolic esteem or status that users may associate with a differentiated or innovative product offering. It is treated as a perceived outcome of differentiation rather than as technical newness itself.	Prestige can operate as symbolic esteem or status associated with differentiated offerings. Its theoretical role extends beyond technical newness into perceived and market value (Wang et al., 2024).
Exclusiveness / Limited	INNOVATION	The perception that product availability or access is deliberately restricted, scarce, or limited in a way that strengthens perceived distinctiveness.	Exclusivity and rarity are associated with scarcity, restricted access, and perceived value, while perceived innovativeness literature focuses more directly on newness and relative advantage (Lowe & Alpert, 2015; Wang et al., 2024).

The definitions in Table 3 are supported by literature that links durability and product longevity with sustainable design (Bocken et al., 2016; Mesa et al., 2022), distinguishes engineering material selection from lifecycle-oriented material assessment (Ashby, 2024; Pollini & Rognoli, 2021), and separates perceived innovativeness from symbolic and exclusivity related market value (Lowe & Alpert, 2015; Wang et al., 2024). These sources are used to position the indicators theoretically rather than to infer the reasons behind individual expert ratings.

5 DISCUSSIONS

5.1 Strength of the Validated Seven Criteria Architecture

The central result is that all 37 indicators met the predetermined relevance criterion while the seven primary criteria achieved S-CVI/Ave values between 0.88 and 0.98. This provides a defensible basis for retaining the overall SPDM architecture. The differences across criteria are reported as quantitative variation in relevance agreement. Their theoretical meaning is considered through the literature without treating the scores as direct evidence of how or why experts interpreted individual indicators.

The strong validation of FUNCTION is theoretically meaningful. Sustainable products must remain usable, understandable, comfortable, and effective if their intended environmental or social benefits are to be realised in practice. A technically sustainable product that is difficult to use may be rejected, misused, or replaced prematurely. FUNCTION therefore acts as a practical condition through which sustainability can be realised during use.

The strong QUALITY result is similarly important. Reliability, durability, specifications, material suitability, and conformance can contribute to longer product life, lower replacement frequency, reduced perceived risk, and stronger user confidence. Perceived quality research emphasises that customers evaluate quality through a combination of product performance, expectations, and experience (Golder et al., 2012; Stylidis et al., 2020). The SPDM extends this logic by placing quality alongside sustainability and market oriented considerations during design evaluation.

FORM also received strong support. Shape, appearance, colour, finishing, and texture are among the first attributes encountered by users. These cues can communicate quality before functional performance is experienced directly. In sustainable product design, formal qualities can therefore support adoption by making a responsible product desirable as well as technically acceptable. This interpretation is consistent with design research showing that sustainability can also be articulated through aesthetic and material decisions rather than treated only as a technical requirement (Du & Ayob, 2024).

5.2 User Derived Priority and Expert Derived Relevance

A major methodological contribution of this study is the explicit separation of user derived priority from expert derived relevance. The preceding 300 user study established how users prioritised indicators within each criterion. The expert study involved 30 independently completed questionnaires and established whether those indicators were relevant representations of the intended conceptual domains. The number of experts was not mathematically linked to the number of users because the two datasets answer different research questions. These measurements are complementary, but they are not equivalent.

An I-CVI of 1.00 does not mean that an indicator should automatically occupy the first position in the SPDM. It means that all experts judged the indicator to be relevant. Likewise, an I-CVI of 0.80 does not mean that an indicator is unimportant to users. It means that 24 of the 30 experts rated it as relevant. User priority concerns relative importance in user evaluation. Content validity concerns professional agreement about conceptual representation.

This distinction is clearly visible in SUSTAINABILITY. Stability was placed prominently by users, while Energy Efficient recorded an I-CVI of 1.00 and Stability recorded 0.83 in the expert questionnaire. These results should not be read as disagreement between the two groups because the two datasets answer different questions. Reordering the criterion on the basis of I-CVI would substitute expert relevance for user priority and change the evidential meaning of the model. The user derived order is therefore preserved, while the expert scores are used only as evidence of content relevance.

The resulting approach separates priority from validation. User data show the relative importance assigned to indicators by intended users. Expert questionnaire data show the proportion of professionals who rated each indicator as relevant to its criterion. Variation in the expert scores can then be discussed in relation to established theory, but the questionnaire does not reveal the reasons behind individual ratings. This separation maintains a clear boundary between observed data and theoretical interpretation.

5.3 Theoretical and Methodological Contribution

The theoretical contribution of the SPDM is the integration of perceived quality, purchase intention, and sustainability within one operational design evaluation structure. Existing sustainable product design research provides many lifecycle tools and sustainability criteria, while perceived quality research explains how users judge product excellence and value. The SPDM connects these streams by treating product acceptance, perceived quality, and sustainability as related design concerns rather than separate downstream assessments.

The methodological contribution is more specific. The model development process separates two questions that are often collapsed. The first asks which indicators users consider more important. The second asks whether those indicators are conceptually appropriate representations of the proposed criteria. The first question is answered by the user study. The second is answered by the expert validation. This separation prevents expert judgement from becoming a hidden reranking mechanism.

This matters because content validity concerns whether the proposed content adequately represents the intended construct rather than whether an item is important to users. Mokkink et al. (2025) frame content validity in terms of relevance, comprehensiveness, and comprehensibility, while recent methodological work continues to distinguish item relevance assessment from broader psychometric testing (Madadizadeh & Bahariniya, 2023; Hurtado-Arenas et al., 2025). By preserving the original user priority while using expert ratings to test content relevance, the study provides a transparent way to integrate consumer evidence and professional judgement. Existing theory is used to contextualise differences in the rating pattern rather than to infer unmeasured expert reasoning. The novelty is therefore located in the evidence architecture and decision logic of the model, not in a claim that individual attributes such as form, quality, or innovation have never appeared in earlier design literature.

5.4 Theoretical Interpretation of Variations in Expert Relevance Ratings

Stability recorded an I-CVI of 0.83, while Energy Efficient and Material Use or Type recorded higher values of 1.00 and 0.97 respectively. This difference can be considered in relation to how sustainability is commonly operationalised in product design literature. Sustainable product design studies frequently emphasise energy consumption, material efficiency, product longevity, disassembly, and end of life recovery as direct design considerations (Ahmad et al., 2018; Hunger et al., 2025). Product durability literature also connects extended service life with reduced replacement and resource consumption (Bocken et al., 2016; Mesa et al., 2022). Within this theoretical context, Stability has a clearer sustainability role when it refers to maintaining intended performance and physical integrity throughout the expected service life. The literature provides a theoretical explanation for the position of the indicator in the model, but it does not establish why individual experts selected particular relevance scores.

Material Use or Type under SUSTAINABILITY recorded an I-CVI of 0.97, while Material Selection under QUALITY recorded 0.93. Both values demonstrate strong content relevance. The small difference can be considered in relation to the different theoretical roles of material decisions in product development. Material selection literature commonly focuses on whether a material can satisfy functional requirements, performance constraints, durability, manufacturing conditions, finish, and product specifications (Ashby, 2024). Sustainability oriented material evaluation addresses lifecycle impacts, resource consumption, recyclability, and environmental burden (Pollini & Rognoli, 2021). The literature therefore supports retaining Material Selection under QUALITY and Material Use or Type under SUSTAINABILITY. The I-CVI difference is interpreted as consistent with these different theoretical roles rather than as evidence that experts consciously distinguished the two concepts in this manner.

Within INNOVATION, Product Benefit recorded an I-CVI of 0.97, Novelty or Originality recorded 0.93, Uniqueness recorded 0.90, while Prestige Value and Exclusiveness or Limited each recorded 0.80. Research on perceived product innovativeness places substantial emphasis on newness, relative advantage, differentiation, and the benefits recognised by users (Lowe & Alpert, 2015). These ideas correspond closely with Product Benefit, Novelty or Originality, and Uniqueness. Prestige Value and Exclusiveness or Limited occupy a broader theoretical position because studies of exclusivity and rarity also associate them with symbolic value, status, scarcity, restricted access, and market positioning (Wang et al., 2024). This theoretical overlap provides one possible context for understanding why these indicators sit differently within the innovation domain. It is not presented as the measured reason for the expert scores, since the questionnaire did not collect explanations for individual ratings.

Taken together, the variation in I-CVI values can be interpreted alongside the theoretical proximity of each indicator to its assigned criterion. Indicators such as Energy Efficient, Reliability, Product Specifications, Product Benefit, and Novelty or Originality have relatively direct relationships with established sustainability, quality, and innovation concepts. Other indicators, including Stability, Prestige Value, and Exclusiveness or Limited, operate across broader product lifecycle, symbolic, or market considerations. The literature therefore provides theoretical context for the pattern observed in the questionnaire. The quantitative findings remain the primary evidence, while theory is used to interpret the position of the indicators without attributing unmeasured explanations to the experts.

5.5 Implications for Product Designers and Industry Practitioners

The validated SPDM offers a structured way for product development teams to translate user expectations into design discussions. During early concept development, teams can use the seven criteria as a review structure while retaining the user derived order within each criterion as a prioritisation reference. This helps prevent sustainability from becoming an isolated environmental checklist disconnected from usability, quality, safety, market viability, and innovation.

For product designers, the model can support requirement definition. FORM can guide visual and sensory decisions. FUNCTION can guide comprehension, ergonomics, comfort, usability, and performance. SAFETY can guide compliance, testing, maintenance, warranty, and parts strategy. SUSTAINABILITY can guide energy, material, disassembly, longevity, and end of life decisions. QUALITY can guide reliability, durability, specifications, material fitness, and conformance. COMMERCIALITY can guide market facing information and support. INNOVATION can guide user benefit, novelty, uniqueness, and differentiated value.

For industry practitioners, the model can also support cross functional discussion. Engineering, industrial design, marketing, sustainability, quality assurance, and aftersales teams often define product success differently. A shared model makes tradeoffs visible. A material decision may improve environmental performance but weaken perceived finish quality. An innovative feature may increase novelty but reduce ease of use. A lower cost design may improve price competitiveness but weaken durability or repairability. The SPDM does not mechanically resolve these tradeoffs, but it gives teams a common structure for discussing them. Comparable design studies have linked product development with public acceptance (Abdul Jamil & Abu Bakar, 2025) and have shown how human centred design can incorporate environmental, social, and economic considerations (Mohd Hasbullah et al., 2025).

5.6 Limitations and Future Research

The findings should be interpreted within the boundaries of content validation. The study demonstrates content relevance and expert agreement. It does not establish construct validity, predictive validity, causal relationships, or the effectiveness of the SPDM when used in live industrial projects. The expert panel is analysed as one group. All 30 participants met the minimum five-year experience criterion, and the questionnaire recorded professional background, qualification, position, organisation, and experience. However, the quantitative dataset used for the present article is not stratified by these profile variables. The purposively selected panel should therefore be understood as a multidisciplinary content validation panel rather than as a statistically representative sample of all product design and industry practitioners. Future work could examine whether professional background is associated with differences in relevance ratings for particular indicators.

The model also originates from a Malaysian empirical context involving user evaluation of sustainable product considerations. The seven criteria are broad enough to support wider design discussion, but generalisation to different product categories, cultural settings, and industrial sectors requires additional testing. Medical products, mobility systems, furniture, consumer electronics, and digital physical systems may assign different meanings or priorities to the same indicators.

Future research should test the model across multiple product categories and with independent expert panels. A second validation round would be appropriate if indicator wording is substantially revised. Qualitative expert interviews could be added in future studies to investigate the reasons behind differing relevance ratings, which the present questionnaire was not designed to capture. Later studies may also examine construct structure, convergent and discriminant validity, and the relationship between model-based evaluation and actual product acceptance. Longitudinal design studies could test whether teams using the SPDM make different decisions or achieve stronger user acceptance than teams using conventional design development procedures.

CONCLUSION

This study validated the content of a Sustainable Product Design Model through the judgements of 30 product designers and industry practitioners. The model comprises 37 indicators distributed across FORM, FUNCTION, SAFETY, SUSTAINABILITY, QUALITY, COMMERCIALITY, and INNOVATION. Every indicator exceeded the predetermined I-CVI retention threshold. Values ranged from 0.80 to 1.00, criterion level S-CVI/Ave values ranged from 0.88 to 0.98, and the overall average I-CVI was 0.94.

The findings support retention of the seven criteria architecture. FUNCTION, QUALITY, and FORM demonstrated particularly strong relevance agreement, while the I-CVI values across the complete indicator set ranged from 0.80 to 1.00. Differences in these values are interpreted in this paper through relevant product design, sustainability, material selection, and innovation literature. The discussion does not treat the numerical ratings as evidence of why individual experts selected scores.

The study also establishes a clear methodological distinction between user priority and expert relevance. The 300-user study determines the priority structure of the indicators. The 30 expert questionnaire determines whether the indicators are sufficiently relevant to represent the proposed criteria. Expert scores are not used to rerank user priorities and are not treated as interview evidence. Instead, they provide quantitative content validity evidence, while existing theory is used to contextualise the observed rating pattern. This preserves both the empirical origin of the model and its professional defensibility.

The contribution of the SPDM therefore lies in its integration of perceived product quality, purchase intention, sustainability, and design evaluation, and in the two-stage evidence logic used to develop and validate that structure. The model provides a practical basis for early product design discussion while remaining open to further validation across sectors, products, and cultural contexts.

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All authors contributed to the conceptual development, review, and preparation of this paper.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest with respect to the research, authorship, and publication of this article.

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