

A Critical Analysis of *Spectrum*'s Visual and Functional Design in Malaysian Higher Education

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ABSTRACT

Learning Management Systems (LMSs) are central to higher education, yet their effectiveness depends on design as much as functionality. At the University of Malaya (UM), SPeCTRUM, a Moodle-based LMS, underpins blended and online learning but remains underexplored from a design perspective. This study critically evaluates SPeCTRUM V3 through Nielsen usability heuristics, cognitive load theory, and Universal Design for Learning (UDL). Using a qualitative descriptive approach, data were collected from 20 participants, including 5 lecturers and 15 postgraduate students via interviews and focus group discussion (FGD), institutional documentation, and researcher observations. The absence of undergraduate participants who are typically more mobile dependent is acknowledged as a limitation, affecting representativeness. Thematic analysis revealed that while SPeCTRUM reliably supports grading and content delivery, weaknesses persist in navigation, visual aesthetics, and mobile responsiveness. Over two-thirds of participants reported navigation inefficiencies, and many mobile-dependent learners found multimedia integration unreliable, raising equity concerns. Benchmarking against Canvas, Blackboard Ultra, and Moodle highlighted deficits in accessibility and learner-centred design. Findings indicate that stability alone cannot compensate for poor usability and design misalignments that increase cognitive load and limit pedagogical flexibility. Immediate interventions should focus on streamlined navigation and mobile optimisation, while longer-term strategies should embed UDL principles and strengthen collaborative learning tools. By explicitly connecting these findings to Malaysia's e-Learning Policy 2.0, the study underscores the policy imperative of inclusivity and mobile optimisation.

Keywords: LMS design, usability, cognitive load, Universal Design Learning, Malaysian higher education, functional design

INTRODUCTION

The accelerated pace of digital transformation in higher education has heightened scholarly and institutional focus on the design and usability of learning management systems (LMSs). Beyond serving as repositories of teaching materials, LMSs facilitate interaction, assessment, and pedagogy (Al-Fraihat, Joy, Masa'deh, & Sinclair, 2020). Consequently, their design is not solely technical but a pivotal determinant of educational outcomes (Nguyen, Nguyen, Kieu, Nguyen, Dang, Singer, Schrufer, Tran, & Lambrechts, 2022).

The University of Malaya (UM), Malaysia's premier public institution, has adopted SPeCTRUM, a Moodle-based LMS, as its primary platform for digital and blended learning. Despite its longstanding adoption, SPeCTRUM has received limited critical evaluation in terms of design assessment. Existing scholarship in Malaysia has predominantly focused on adoption models (e.g., TAM, UTAUT) or policy-level implementation (Ahmad, Mohd Noor, Alwan, Gulzar, Khan, & Reegu, 2023), with limited analysis of how its visual and functional characteristics influence learning experiences.

The COVID-19 pandemic underscored the crucial role of LMSs in institutional sustainability, ensuring learning continuity, engagement, and equity (Almaiah, Al-Khasawneh, & Althunibat, 2020; Shahriar, Arafat, Islam, Nur, Rahman, Khan, & Alam, 2023). This article addresses this gap by conducting a critical analysis of SPeCTRUM's

V3 design. It interrogates its strengths and weaknesses through the lenses of usability, cognitive load, and pedagogical alignment. By situating SPeCTRUM within global debates while aligning findings with Malaysia's e-Learning Policy 2.0, the study highlights both institutional and policy implications.

LITERATURE REVIEW

Research on learning management systems (LMSs) spans adoption, usability, pedagogy, and institutional policy, but three strands are most relevant here: usability frameworks, design affordances, and Malaysian higher education challenges.

Usability has long been recognised as central to educational technologies. Nielsen and Molich (1990) heuristics stress consistency, error prevention, and minimalist design, while cognitive load theory (Mayer, 2022) shows how cluttered or inconsistent interfaces impose unnecessary effort. More recent work situates usability within institutional contexts Selwyn (2021), and reframes accessibility as a design priority through Universal Design for Learning (UDL), which promotes multiple pathways for engagement (Rao, Gravel, Rose, & Tucker-Smith, 2023).

Recent studies Al-Fraihat et al. (2020); Yeboah and Nyagorme (2022) reinforces Nielsen and Molich (1990) reinforce these principles, showing how inconsistent LMS interfaces disproportionately burden mobile-first learners.

Together, these frameworks foreground inclusivity and equity. Yet many LMS evaluations still emphasise adoption models over design, leaving a gap in understanding how visual and functional choices shape learning outcomes. Figure 1 outlines this study's conceptual framework, linking SPeCTRUM's design features to usability, learning, and accessibility outcomes.

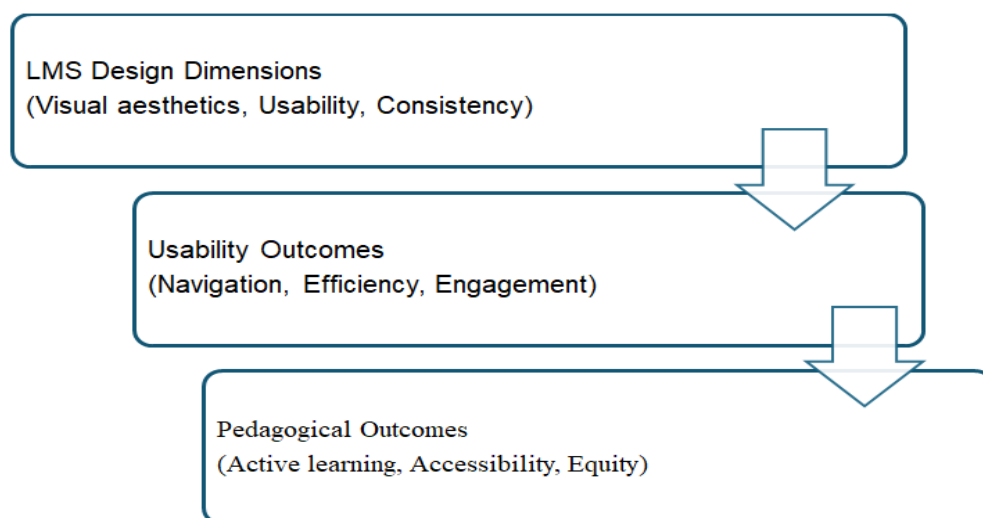


Figure 1. Conceptual framework linking LMS design to usability & pedagogy

Research consistently shows that LMS design affects motivation, navigation, and effectiveness. Visual elements such as layout, colour, and typography influence clarity and engagement (Al-Fraihat et al., 2020), while functionality must balance robust core tools (assessment, grading, forums) with adaptability for multimedia integration. Comparative studies reveal tensions between commercial and open-source platforms: Canvas and Brightspace generally excel in aesthetics, mobile optimisation, and consistency due to vendor governance (Maphosa, 2023), whereas Moodle's flexibility often produces fragmented user experiences when governance is weak (Yeboah & Nyagorme, 2022).

In contrast, Moodle's open-source flexibility allows deep customisation but often leads to fragmented user experiences when institutional design governance is weak (Yeboah & Nyagorme, 2022). This suggests that flexibility without oversight can undermine usability, resulting in inconsistent navigation and uneven learning experiences across courses.

Global design standards provide further benchmarks. The Web Content Accessibility Guidelines (WCAG 2.1) and ISO 9241-210 (human-centred design for interactive systems) stress mobile-first responsiveness, multimodal content representation, and accessibility for diverse learners. Yet, many institutional implementations of Moodle including SPeCTRUM fall short of these standards, particularly in mobile optimisation and inclusive accessibility. This underscores the need to evaluate LMS design not only against peer platforms but also against international usability and accessibility benchmarks.

Malaysia's e-Learning Policy 2.0 positions technology-enhanced learning as central to competitiveness, yet empirical studies reveal persistent challenges in usability, accessibility, and training (IRFAN, 2020; Younis, Ruhaiyem, Ghaban, Gazem, & Nasser, 2023). Students frequently report difficulty navigating dense, text-heavy interfaces, mirroring global concerns but intensified by Malaysia's digital equity gap, where many learners rely primarily on smartphones and limited data plans.

SPeCTRUM occupies a paradoxical position: while it is nationally significant as UM's flagship LMS, research has largely centred on adoption models (e.g., TAM, UTAUT) rather than systematic design evaluation (Ahmad et al., 2023). This neglect leaves unresolved whether SPeCTRUM's design aligns with contemporary pedagogical needs and policy expectations. Moreover, while global platforms increasingly pursue mobile-first and learner-centred design, SPeCTRUM remains anchored in stability and administrative reliability at the expense of user-centred functionality.

The contrast between Malaysia's policy ambitions and SPeCTRUM's practical limitations highlights a critical gap: without deliberate design improvements, the LMS risks reproducing inequities rather than reducing them. This tension situates SPeCTRUM not only within local institutional debates but also within global discussions about equity, usability, and accessibility in digital higher education.

Research Gap and Contribution

While prior Malaysian research has largely adopted TAM/UTAUT frameworks, few studies interrogate whether local LMS designs meet inclusivity, mobile optimisation, and learner-centred goals explicitly mandated in e-Learning Policy 2.0. This paper contributes by filling that gap. Prior studies Ahmad et al. (2023) have predominantly applied technology acceptance models, which explain usage intention but not whether platforms reduce cognitive load, support diverse learners, or meet global accessibility standards.

Moreover, existing scholarship underexplores how local systems like SPeCTRUM compare against global benchmarks such as Canvas, Blackboard, and WCAG 2.1. This is problematic given that Malaysia's e-Learning Policy 2.0 explicitly emphasises inclusivity, mobile optimisation, and learner-centred pedagogy. Without systematic design evaluation, policy ambitions risk remaining aspirational rather than operational.

This study addresses these gaps by: (1) Applying usability heuristics, cognitive load theory, and Universal Design for Learning (UDL) to evaluate SPeCTRUM V3. (2) Benchmarking UM's LMS against international design standards and leading platforms. (3) Highlighting tensions between institutional stability and learner-centred design in a Southeast Asian context. By situating UM's case within global debates, the research contributes both theoretical insights (positioning design as central to digital pedagogy and equity) and practical recommendations (guidelines for redesign, mobile optimisation, and inclusive accessibility).

METHODOLOGY

This study employed a qualitative descriptive design, selected for its suitability in capturing user perceptions and system characteristics without imposing restrictive theoretical preconditions. Unlike experimental or survey-based approaches, which prioritise measurement, qualitative description enables a rich, practice-oriented understanding of how users experience design in everyday contexts (Braun & Clarke, 2022). To ensure breadth and depth, three complementary sources of evidence were used: (1) User Narratives – Semi-structured interviews with 20 participants (five lecturers and fifteen postgraduate students) from diverse faculties provided insight into both instructional and learning perspectives.

Postgraduate students were chosen as primary participants because they use SPeCTRUM more frequently and consistently in blended and online courses. Their advanced engagement with the LMS allows for deeper insights into instructional and learning experiences, particularly regarding navigation, mobile accessibility, and pedagogical functionalities. However, this focus excludes undergraduate perspectives, who may have different usage patterns and dependency on mobile devices.

The sample size is consistent with qualitative inquiry, prioritising depth of understanding over statistical generalisation. (2) System Documentation – Institutional guides and update records (2020–2023) were examined to trace design decisions and contextualise user experiences within UM’s broader e-learning strategy. (3) Researcher Observation – Structured walkthroughs of course pages, plugins, and mobile interfaces enabled the systematic identification of interface-level inconsistencies and usability barriers. Data were analysed using Braun and Clarke’s (2022) six-phase thematic analysis. Coding began inductively with repeated readings of interview transcripts and observation notes, followed by iterative categorisation of design-related features. Codes were then organised into broader themes aligned with the study’s conceptual framework (usability heuristics, cognitive load theory, and UDL). To enhance interpretive rigour, the researcher employed reflexivity and peer debriefing. As an academic and university student, and a user of SPeCTRUM, the researcher engaged in peer debriefing to effectively mitigate bias.

Table 1. Benchmarking of SPeCTRUM V3 against selected global LMSs

Criterion	SPeCTRUM V3 (UM)	Moodle (Global)	Canvas	Blackboard Ultra
Navigation simplicity	Low	Moderate	High	High
Visual aesthetics	Low	Moderate	High	High
Mobile responsiveness	Low	Moderate	High	High
Cognitive load management	Low	Moderate	High	Moderate
Accessibility (UDL)	Low	Moderate	High	Moderate
System stability	High	High	High	High
Integration flexibility	Low	Moderate	High	High

Note. Scores derived from participant feedback, institutional documentation, and comparative vendor specifications.

The benchmarking process (Table 1) was calibrated through triangulation: (i) participant narratives from interviews and FGDs, (ii) institutional documentation and vendor specifications, and (iii) prior LMS evaluations in peer-reviewed studies. This ensured transparency and reduced subjectivity in assigning comparative scores.

Scores in Table 1 were qualitatively derived through triangulation of narratives, documentation, and prior evaluations. This aligns with recent Malaysian studies that adapted established instruments to LMS contexts, such as Thamilarasan, Ikram, Osman, Salahuddin, Bujeri and Kanchymalay (2023), who enhanced the System Usability Scale by mapping it against ISO standards, and Mkpojiogu (2022), who measured user experience among SEGi University students using a combination of efficiency, satisfaction, and error-tolerance indicators. Including such perspectives increases the transparency and validity of the comparative scoring process.

In addition to thematic analysis, a comparative benchmarking Table 3 exercise was conducted to situate SPeCTRUM against other LMS platforms (Moodle, Canvas, Blackboard Ultra). Scores were qualitatively derived using a five-point scale, triangulating three sources: (i) participant narratives from interviews, (ii) documented system features from institutional and vendor reports, and (iii) usability and accessibility

benchmarks from prior LMS evaluations in the literature. This approach ensured that comparative judgments were grounded in both empirical evidence and established design frameworks.

Validity And Ethical Considerations

Triangulation across interviews, documents, and observations enhanced credibility by enabling the convergence of multiple perspectives. Ethical clearance was obtained from the University of Malaya, and informed consent was secured from all participants. Anonymity and confidentiality were maintained throughout. This design balances methodological rigour with practical relevance, producing findings that not only diagnose design weaknesses but also inform evidence-based recommendations for system improvement.

Findings: Critical Design Analysis

Analysis revealed three interrelated themes that capture the strengths and weaknesses of SPeCTRUM's design: (1) reliable functionality but outdated visual design, (2) fragmented navigation and limited mobile responsiveness, and (3) constrained pedagogical affordances. Together, these themes illuminate how institutional priorities appear to reinforce these weaknesses. UM has historically emphasised system stability and cost efficiency, leading to limited investment in user-centred design governance. As a result, persistent problems such as redundant menus and poor mobile responsiveness endure across updates. To summarise the recurring patterns in SPeCTRUM's design,

Table 2 presents three major themes derived from interviews and observations.

Table 2. Overview of emergent themes from SPeCTRUM V3 design analysis.

Theme	Strengths	Weaknesses
Reliable Core, Weak Visual Design	Stable backend; dependable for grading/quizzes	Outdated interface; cluttered layouts; poor aesthetics
Fragmented Navigation and Mobile Use	Broad range of tools available	Confusing menus; poor scaling on mobile devices
Constrained Pedagogical Affordances	Supports content delivery and assessments	Limited collaboration tools; weak multimedia support

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Table 2 highlights that while SPeCTRUM is functionally reliable, weaknesses in visual design, navigation, and pedagogical support are consistently reported.

Participants acknowledged that SPeCTRUM reliably supports core tasks such as uploading content, delivering quizzes, and managing grades. As one lecturer noted, *"It never fails when I need to release exam results; it is dependable in that way."* Yet this reliability is undermined by an outdated, text-heavy interface. Students frequently described the platform as *"Visually monotonous"* and *"Cognitively fatiguing,"* citing monotonous colour schemes and cluttered layouts. Researcher observations confirmed inconsistent typography, redundant icons, and an absence of design templates across courses. This aligns with heuristic principles of consistency and minimalist design, which are routinely violated.

Navigation emerged as a persistent frustration. Users reported confusion caused by overlapping menus and difficulty locating frequently used tools. A postgraduate student explained, *"navigation as maze-like, requiring multiple clicks to access key functions."* Observations supported this claim: duplicate links and inconsistent course structures disrupted efficiency and autonomy. The problem was amplified on mobile devices, where dense pages failed to scale appropriately. Students who relied primarily on smartphones, especially those from rural

areas, found access particularly burdensome. This underscores equity concerns: poor mobile responsiveness disproportionately affects learners with limited device options.

Beyond usability, participants highlighted how SPeCTRUM’s design constrains teaching and learning practices. While basic forums and assignment uploads are functional, lecturers described collaboration tools as “primitive” compared to platforms such as Canvas. Multimedia integration was also reported as unreliable, with videos occasionally failing to load on mobile devices. These limitations discourage innovative pedagogy: *“I stopped trying to use group activities online because it was too messy for the students,”* one lecturer explained. Researcher observation confirmed that many courses relied heavily on static PDFs, reflecting both system design limitations and user adaptation strategies.

SUMMARY OF FINDINGS

Overall, SPeCTRUM exemplifies the trade-off between reliability and user experience. Its dependable backend functionality is overshadowed by weak visual design, inconsistent navigation, and limited pedagogical affordances. These shortcomings not only increase cognitive load but also exacerbate equity gaps by disadvantaging mobile-dependent learners.

To further contextualise the design issues within theoretical frameworks, Table 3 maps emergent themes against cognitive load, usability heuristics, and UDL principles.

Table 3. Thematic findings aligned with frameworks.

Theme	Cognitive Load Theory	Usability Heuristics	UDL (Accessibility & Equity)
Reliable Core, Weak Visual Design	High extraneous load from cluttered UI	Violates consistency and minimalist principles	Limited multiple representations
Fragmented Navigation and Mobile Use	Increased navigation load	Poor error prevention and efficiency	Disadvantages mobile-dependent users
Constrained Pedagogical Affordances	Limits active cognitive engagement	Lack of flexibility in interactions	Reduces learner choice and expression

This alignment Table 3 shows that design weaknesses are not merely aesthetic but have measurable implications for cognitive processing, interface efficiency, and equitable access. To contextualise SPeCTRUM’s design performance globally, Figure 2 benchmarks it against Canvas, Blackboard Ultra, and Moodle across five key dimensions.

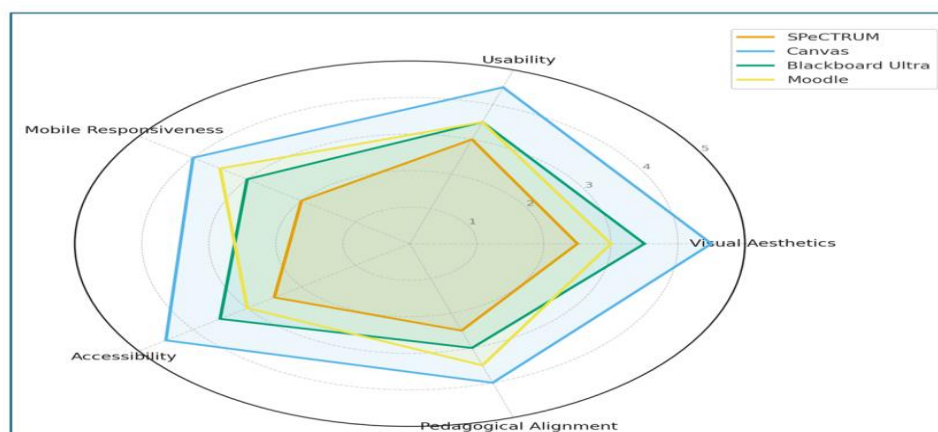


Figure 2. Comparative benchmarking of LMS platforms (SPeCTRUM, Canvas, Blackboard Ultra, Moodle)

The Figure 2 compares SPeCTRUM to Canvas, Blackboard Ultra, and Moodle, three popular LMS platforms. The radar chart shows SPeCTRUM's strengths and weaknesses in visual aesthetics, usability, mobile responsiveness, accessibility, and pedagogical alignment. Canvas excels in design aesthetics and accessibility, while Moodle and Blackboard Ultra offer a balanced approach to usability and pedagogical support.

DISCUSSION

The analysis of SPeCTRUM's visual and functional design reveals challenges that extend beyond surface-level usability issues, pointing to deeper questions of governance and institutional priorities. While the findings section described participant frustrations with navigation, mobile access, and visual overload, the discussion here moves toward interpreting why these issues persist despite being widely recognised.

Navigation inefficiencies and text-heavy layouts not only create cognitive load but also reduce motivation to engage actively. Ahmad et al. (2023) show that persuasive interface design plays a critical role in sustaining student engagement in Malaysian LMS contexts, suggesting that poor aesthetics and weak consistency are not just inconveniences but barriers to motivation and persistence. Similarly, the reliance of Malaysian students on smartphones for access intensifies these issues. Abdullah Thani, Rosely, Alias, Nik Mohd Zainordin and Ismail (2025); Samala, Papadakis and Rawas (2025) found that mobile limitations and inconsistent interface responsiveness were major barriers in distance education settings, reinforcing the present study's findings on SPeCTRUM's equity challenges.

First, the persistence of redundant menus and text-heavy layouts suggests an institutional reliance on legacy design choices rather than proactive adoption of user-centred practices. This reflects a broader tension in Malaysian higher education, where LMS upgrades are often treated as technical maintenance rather than strategic redesign. Unlike Canvas or Blackboard, which prioritise mobile-first and intuitive design as part of their commercial competitiveness, SPeCTRUM appears constrained by its role as a university-administered platform with slower innovation cycles.

Second, the weak mobile optimisation reported by participants is particularly concerning when viewed against Malaysia's e-Learning Policy 2.0, which explicitly calls for mobile-first inclusivity. The gap between policy intent and platform performance underscores a misalignment between national priorities and institutional implementation. By failing to provide seamless mobile access, SPeCTRUM inadvertently disadvantages undergraduate students who are most reliant on mobile devices, thereby amplifying inequities.

Third, the benchmarking exercise (Table 1) indicates that SPeCTRUM's strongest attribute is stability, while its weakest lie in design, accessibility, and integration. This raises an interpretive insight: stability has been prioritised over innovation, ensuring reliability at the cost of student engagement and inclusivity. Such prioritisation reflects institutional risk-aversion, where minimising system downtime outweighs efforts to reimagine the learning experience.

Finally, the reported design inefficiencies (Figure 1 and Figure 2) are not merely usability flaws but symptoms of a broader governance gap. Without a clear accountability framework linking LMS design to teaching and learning outcomes, improvements remain incremental and reactive. Here, SPeCTRUM's evolution diverges from global platforms like Canvas, which embed Universal Design for Learning (UDL) principles into iterative upgrades.

Taken collectively, these findings highlight the need for a dual strategy: short-term fixes that streamline navigation and improve mobile layouts, alongside long-term reforms that embed UDL and accessibility standards (e.g., WCAG 2.1, ISO 9241) into institutional policy. This duality would align SPeCTRUM more closely with both global best practices and Malaysia's e-Learning Policy 2.0, ensuring that design equity is not treated as an optional feature but as a core principle of digital higher education.

CONCLUSION AND IMPLICATIONS

This study critically examined the visual and functional design of SPeCTRUM V3 within the University of Malaya, situating its strengths and limitations in comparison to global LMS platforms such as Moodle, Canvas, and Blackboard Ultra. While the platform provides stability and institutional control, its weaknesses in navigation, mobile responsiveness, and accessibility undermine inclusivity and learner engagement.

In the short term, improvements should prioritise streamlining redundant navigation pathways, reducing text-heavy layouts, and adopting mobile-first optimisation. These immediate adjustments would directly address the frustrations most frequently voiced by students and lecturers.

In the longer term, however, sustainable reform requires embedding Universal Design for Learning (UDL) principles and internationally recognised standards such as WCAG 2.1 and ISO 9241 into platform governance. This would not only enhance usability but also align SPeCTRUM with Malaysia's e-Learning Policy 2.0, which emphasises inclusivity and equitable access for mobile-first learners.

The study's contribution lies in reframing LMS design not simply as a technical matter but as a question of educational equity and institutional accountability. By linking user experiences to policy goals, it offers both practical recommendations for platform developers and strategic insights for higher education decision-makers in Southeast Asia.

Future research should include more undergraduate students and cross-institutional comparisons to expand the representativeness of perspectives. This study lacks undergraduate students who often rely on mobile devices for learning. Future research should include them to compare their experiences with postgraduate users, providing a more comprehensive understanding of SPeCTRUM's usability and equity for all students. This would help determine if the challenges identified in SPeCTRUM are unique to the University of Malaya or reflect broader regional trends in digital learning environments.

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