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Teaching web design in secondary schools through HTML and CSS: A systematic synthesis of research evidence and pedagogical implications

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Abstract. Web design education using HTML and CSS represents a critical component of digital literacy in secondary schools, yet empirical research on effective pedagogical approaches remains remarkably limited. This systematic review synthesizes evidence from eight rigorous studies conducted between 2007 and 2023, examining instructional methods, learning outcomes, and implementation challenges. Through comprehensive quality assessment using the Mixed Methods Appraisal Tool and calculation of effect sizes where data permitted, we identify moderate to large positive effects for innovative pedagogical approaches, particularly gamification ($d = 0.58$) and mobile-supported learning ($d = 0.70$). Our thematic synthesis reveals that successful web design instruction requires careful orchestration of technological tools, pedagogical strategies, and motivational elements while managing cognitive load and infrastructure constraints. The geographic concentration of research in Indonesia and the United States, combined with the scarcity of rigorous studies, highlights significant gaps in the global research landscape. We present an evidence-based framework that translates these findings into practical guidelines for educators, addressing persistent challenges including syntax comprehension difficulties, student engagement, and teacher preparation needs. The limited research corpus paradoxically strengthens our analysis by enabling comprehensive examination of all existing rigorous evidence, establishing a critical baseline for future investigation as web technologies become increasingly central to educational and vocational preparation.

Keywords: web design education, HTML, CSS, secondary education, systematic review, gamification, cognitive load, pedagogical framework

1. Introduction

The accelerating digital transformation of society has fundamentally reshaped educational priorities and workforce requirements across the globe. Web design competencies, particularly proficiency in HTML and CSS, have evolved from specialized technical skills to essential components of digital literacy that bridge creative expression and technical implementation [9]. This evolution reflects broader changes in how we conceptualize technological fluency, moving beyond passive consumption of digital content toward active creation and manipulation of web-based resources [1].

The significance of web design education extends well beyond technical skill acquisition. As economies worldwide undergo rapid digitalization, educational systems face mounting pressure to equip students with relevant capabilities that align with contemporary workforce demands. Recent industry analyses indicate that investment

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in digital transformation continues to grow at a compound annual growth rate of 15.5%, with three-quarters of organizations expected to have comprehensive digital transformation roadmaps [4]. This economic reality underscores the urgency of developing effective pedagogical approaches for web design education at the secondary level, where foundational technical competencies and problem-solving skills are cultivated.

Despite this growing importance, empirical research specifically examining pedagogical approaches for secondary school web design education remains surprisingly fragmented and limited. While substantial research has explored web development education in higher education contexts, the unique developmental, motivational, and infrastructural considerations relevant to secondary education have received comparatively little systematic attention. This gap becomes particularly problematic as educators seek evidence-based guidance for curriculum design and instructional practice in an rapidly evolving technological landscape.

1.1. The paradox of limited research as a finding

The scarcity of rigorous empirical studies on secondary-level web design education represents not merely a limitation but a significant finding in itself. Our preliminary investigation revealed substantial inconsistencies across the limited existing research. For instance, Jenq and Bredlau [8] identified server-side programming as the most challenging aspect for students, while Nashiroh, Kamdi and Elmunsyah [10] found HTML syntax to be the primary barrier to learning. Such contradictions underscore the critical need for systematic synthesis to identify patterns, reconcile conflicting findings, and establish a coherent knowledge base for the field.

This limited research landscape paradoxically enhances the value of systematic review methodology. Rather than sampling from a vast literature, we can comprehensively analyze the complete corpus of rigorous research, providing what amounts to a census rather than a sample of high-quality evidence in this domain. This comprehensive coverage enables deep analysis of each study's contributions, methodological approaches, and contextual factors that might be overlooked in reviews of more extensive literatures [6].

1.2. Theoretical foundations for web design pedagogy

Understanding effective web design education requires integration of multiple theoretical perspectives that illuminate different aspects of the learning process. Cognitive load theory provides crucial insights into the mental demands of simultaneously processing HTML structure, CSS styling rules, file organization, and visual design principles [16]. Recent meta-analyses confirm that successful programming education implementations employ specific strategies to manage cognitive load through careful sequencing, worked examples, and progressive scaffolding [14, 15].

The documented effectiveness of gamification strategies in our review aligns with self-determination theory, which posits that intrinsic motivation emerges when learning environments satisfy basic psychological needs for competence, autonomy, and relatedness. Meta-analytic evidence from STEM education contexts demonstrates that gamification yields substantial positive effects on learning outcomes ($g = 0.5492$, 95% CI [0.3943, 0.7041]), with particularly strong impacts on cognitive and skill-based outcomes [2, 18]. These findings suggest that carefully designed gamification elements can address the engagement challenges inherent in teaching technical content to adolescent learners.

The Technological Pedagogical Content Knowledge (TPACK) framework offers another essential lens for conceptualizing effective web design instruction. This framework emphasizes the critical integration of content knowledge regarding HTML and CSS principles, pedagogical knowledge about effective instructional strategies, and techno-

logical knowledge concerning relevant development tools and platforms [5]. The rapid evolution of web technologies makes this integrated knowledge particularly crucial, as educators must continuously adapt both content and pedagogical approaches to maintain relevance.

1.3. Research purpose and questions

This systematic review aims to synthesize the limited but valuable body of empirical research on teaching web design to secondary school students, with the goal of identifying effective instructional approaches, understanding influential factors, and developing evidence-based recommendations for practice. Our analysis addresses three primary research questions that emerged from preliminary examination of the literature and consultation with educational practitioners. First, we examine how digital tools and platforms support HTML and CSS instruction in secondary schools, seeking to understand the technological affordances and constraints that shape instructional practice. Second, we investigate the factors that influence the effectiveness of web design instruction at the secondary level, including student characteristics, pedagogical approaches, and contextual variables. Third, we identify the challenges that arise in teaching web design to secondary students and evaluate the evidence for strategies that effectively address these challenges.

2. Methods

2.1. Systematic review approach

This review employed systematic review methodology following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, adapted for the educational context [11]. Given the limited number of studies identified, we adopted a comprehensive approach that combined systematic search strategies with deep qualitative synthesis and quantitative analysis where data permitted. The review protocol was developed prior to conducting searches, establishing clear criteria for study selection, quality assessment, and data extraction procedures.

2.2. Search strategy and study selection

Our search strategy aimed to capture all relevant empirical research on web design education in secondary contexts while maintaining methodological rigor. The primary search was conducted in the Scopus database in January 2025, selected for its comprehensive coverage of peer-reviewed literature in education and technology fields. The search query was designed to identify studies explicitly mentioning web design concepts in titles while focusing on school-based contexts: `(TITLE("web design" OR "web programming" OR "web development" OR "HTML") AND TITLE(student*) AND TITLE-ABS-KEY(school OR teacher))`.

Studies were included if they met all of the following criteria: focus on teaching web design using HTML and CSS in secondary or vocational technical schools; empirical research design including experiments, surveys, or case studies with reported results; publication in peer-reviewed journals or conference proceedings; full-text availability in English; and publication between 2007 and 2023 to capture contemporary pedagogical approaches while acknowledging technological evolution. Studies were excluded if they consisted of editorial letters or conference abstracts without detailed methodology, focused on content unrelated to HTML, CSS, or general web design education, or targeted exclusively primary education or university-level students.

The selection process involved two stages of review. Initial screening of titles and abstracts identified potentially eligible studies, followed by full-text evaluation against inclusion criteria. Two reviewers independently conducted screening, with disagreements resolved through discussion and consultation with the full research

team. This process identified twelve potentially relevant studies, of which eight met all inclusion criteria for the review.

2.3. Quality assessment

Study quality was rigorously assessed using the Mixed Methods Appraisal Tool (MMAT) version 2018, which provides criteria appropriate for diverse research designs commonly found in educational research. Each study was evaluated on five dimensions: clarity of research objectives, appropriateness of methodology, completeness of data reporting, risk of bias, and overall quality rating. Two reviewers independently assessed each study, with discrepancies resolved through discussion. Studies were categorized as high quality if they met all criteria fully, moderate quality if they met most criteria with minor limitations, and low quality if significant methodological concerns were identified.

2.4. Data extraction and synthesis

Data extraction employed a standardized form capturing study characteristics, participant demographics, instructional approaches, technologies taught, outcome measures, and key findings. Where studies reported sufficient statistical information, we calculated effect sizes (Cohen's d) to enable quantitative comparison of intervention impacts. For studies lacking complete statistical data, we extracted descriptive findings and qualitative outcomes.

Synthesis proceeded through multiple complementary approaches. Quantitative findings were synthesized through calculation and comparison of effect sizes where possible. Qualitative findings underwent thematic analysis to identify recurring patterns, challenges, and solutions across studies. An evidence mapping approach linked pedagogical strategies to specific learning outcomes, creating a visual representation of the evidence landscape. Throughout synthesis, we attended to contextual factors that might moderate intervention effectiveness, including geographic location, school type, student characteristics, and available resources.

3. Results

3.1. Characteristics of the research landscape

The eight studies meeting our inclusion criteria reveal a research landscape that is both geographically concentrated and temporally clustered. Publication dates span from 2007 to 2023, but three-quarters of the studies appeared after 2017, suggesting growing recognition of web design education's importance in recent years. This temporal pattern aligns with broader trends in computing education research and the increasing integration of digital creation skills into secondary curricula worldwide.

Geographic distribution shows notable concentration in specific regions, with three studies conducted in Indonesia, two in the United States, and single studies from Taiwan, Turkey, and Slovakia. This geographic clustering raises important questions about the generalizability of findings across different educational systems, cultural contexts, and resource environments. The predominance of research from Indonesia may reflect national education priorities or specific curriculum reforms, while the relative absence of studies from many technologically advanced nations suggests missed opportunities for comparative analysis.

Student populations across studies were remarkably consistent in age and educational level, with most focusing on students aged 15-17 years in vocational or technical secondary schools. Sample sizes ranged from 28 to 70 participants, with a median of 42 students per study. This consistency in population characteristics facilitates comparison across studies but limits our understanding of how findings might apply to younger students or those in general academic tracks. The vocational school focus

suggests that web design has been primarily conceptualized as career preparation rather than general digital literacy, though this framing may be evolving.

3.2. Quality assessment reveals methodological strengths and limitations

Our quality assessment using the MMAT criteria revealed a generally robust body of research with some notable limitations. Four studies achieved high quality ratings, meeting all assessment criteria with clear objectives, appropriate methodologies, complete data reporting, and low risk of bias. These high-quality studies, including work by Jenq and Bredlau [8], Nashiroh, Kamdi and Elmunsyah [10], Tezer and Çimşir [17], and Alsuhaymi and Alotaibi [1], provide the strongest evidence base for our conclusions.

Three studies received moderate quality ratings, typically due to incomplete data reporting or moderate risk of bias from small sample sizes or lack of control groups. The study by Rosson et al. [13] provided valuable insights into authentic project-based learning but lacked complete outcome data. Similarly, Fitriasari, Ashiddiqi and Nurdin [3] and Huraj, Hrmo and Sejutová Hudáková [7] offered important contributions regarding gamification but had methodological limitations that temper confidence in their findings. One study received a low quality rating due to multiple methodological concerns, though it still contributed to our understanding of implementation challenges.

The overall quality profile suggests that while the research base is limited in quantity, much of it meets reasonable standards for rigor. The predominance of quasi-experimental designs reflects practical constraints in educational research, where random assignment to conditions is often infeasible. Most studies attempted to address this limitation through pre-test comparisons or matched control groups, though selection bias remains a potential concern across the literature.

3.3. Quantitative synthesis reveals promising effect sizes

Where sufficient statistical data were available, we calculated effect sizes to quantify the impact of different instructional approaches. These calculations reveal consistently positive effects for innovative pedagogical strategies compared to traditional instruction, though the magnitude varies across interventions and outcome measures.

The study by Alsuhaymi and Alotaibi [1] examining gamification in HTML teaching reported a t-value of 1.719 with 18 students in the experimental group and 17 in the control group. Our calculation yields a Cohen's d of 0.58, indicating a medium effect size favoring the gamified approach. This effect emerged after just three weeks of instruction, suggesting that even brief gamification interventions can produce meaningful improvements in both programming skills and motivation. Students in the gamified condition demonstrated superior performance on practical programming tasks and reported significantly higher levels of engagement and willingness to practice outside class hours.

Tezer and Çimşir [17] investigated mobile-supported learning management systems, finding even stronger effects. With 35 students in each condition and a t-value of 2.947, the calculated Cohen's d of 0.70 represents a medium-to-large effect. The experimental group achieved a final mean score of 68.3 compared to 60.1 for the control group, a difference that proved statistically significant and practically meaningful. Beyond quantitative improvements, students using the mobile LMS reported increased interest in web design and greater satisfaction with the learning experience.

Nashiroh, Kamdi and Elmunsyah [10] provided detailed outcome data showing that students using a scientific approach module achieved an average post-test score of 79.91, exceeding the minimum criterion value of 75. Additionally, 82.98% of students demonstrated proficient logical thinking skills, and 81.86% expressed satisfaction

with the learning module. While effect sizes could not be calculated due to the single-group design, these outcomes suggest substantial learning gains from the structured scientific approach.

These quantitative findings align remarkably well with recent meta-analyses in related domains. Arlinwibowo et al. [2] found an overall effect size of $g = 0.5492$ for gamification in STEM education, while Xu, Xu and Xing [18] reported even stronger effects for cognitive ($g = 0.716$) and skill-based ($g = 0.605$) outcomes in higher education contexts. The consistency between our calculated effect sizes and these broader meta-analytic findings strengthens confidence in the positive impact of innovative pedagogical approaches for web design education.

3.4. Thematic analysis reveals persistent challenges and effective solutions

Our thematic synthesis identified recurring patterns across studies that illuminate both the challenges of teaching web design to secondary students and strategies that effectively address these difficulties. These themes emerged through careful analysis of reported difficulties, intervention strategies, and outcomes across all eight studies.

The most prevalent challenge, appearing in five of eight studies, concerned student difficulties with HTML syntax and code structure. Students consistently struggled with the precision required in HTML markup, frequently making errors with tag closure, nesting, and attribute syntax. Nashiroh, Kamdi and Elmunsyah [10] documented that syntax errors accounted for the majority of student difficulties in early lessons, while Jenq and Bredlau [8] noted that debugging skills developed slowly even with explicit instruction. Successful interventions addressed this challenge through multiple strategies including real-time visual feedback that immediately showed the effects of code changes, structured progression from simple tags to complex nested structures, extensive worked examples with detailed annotations, and peer debugging exercises that developed error recognition skills.

Engagement and motivation emerged as another critical theme, with four studies explicitly addressing motivational challenges. Traditional instructional approaches often failed to maintain student interest, particularly when lessons focused on syntax memorization or abstract concepts without clear application. The studies documenting gamification approaches showed remarkable consistency in their positive effects on engagement. Fitriasari, Ashiddiqi and Nurdin [3] found that adventure game elements transformed student attitudes toward HTML learning, while Alsuhaymi and Alotaibi [1] demonstrated that points, badges, and leaderboards created a competitive environment that motivated practice and experimentation. These gamification elements appeared to work by providing immediate feedback on progress, creating achievable short-term goals, fostering healthy competition among peers, and connecting abstract concepts to concrete rewards.

Cognitive overload represented a third major theme, with six studies noting that students struggled to simultaneously manage multiple aspects of web design. The concurrent demands of understanding HTML structure, applying CSS styling, managing file organization, and considering visual design principles overwhelmed many novice learners. Jenq and Bredlau [8] observed that introducing server-side programming concepts too early exacerbated this problem, while Rosson et al. [13] found that authentic projects sometimes introduced too much complexity at once. Effective approaches to managing cognitive load included careful sequencing of concepts with HTML structure taught before CSS styling, scaffolding that gradually removed supports as competence developed, visual tools that externalized some cognitive processes, and collaborative learning that distributed cognitive demands across team members.

Infrastructure limitations appeared in three studies, primarily those conducted in developing educational contexts. Limited computer access, unreliable internet

connectivity, and outdated software created significant barriers to effective instruction. Tezer and Çimşir [17] addressed these challenges through mobile-supported learning that leveraged students' personal devices, while other studies adapted by using offline development environments or adjusting project scope to match available resources. These adaptations suggest that effective web design education is possible even with infrastructure constraints, though they may limit the complexity of projects and technologies that can be explored.

3.5. Pedagogical approaches show differential effectiveness

Analysis of pedagogical strategies across studies reveals clear patterns in their effectiveness for different learning outcomes. Table 1 synthesizes this evidence, mapping teaching methods to their observed impacts on skills development, motivation, and engagement.

Table 1
Evidence synthesis linking pedagogical approaches to learning outcomes across studies.

Teaching method	Skills	Motivation	Engagement	Evidence base
Gamification	++	+++	+++	4 studies, $d = 0.58 - 0.70$
Project-based learning	+++	++	++	2 studies, qualitative
Mobile-supported LMS	++	++	++	1 study, $d = 0.70$
Scientific approach	++	+	++	1 study, 79.91% achievement
Traditional lecture	+	–	–	2 control groups
Collaborative learning	++	++	++	1 study, qualitative

Note: +++ = Strong positive effect; ++ = Moderate positive effect;
+ = Small positive effect; – = Negative effect

Project-based learning emerged as particularly effective for skills development, with students creating authentic websites demonstrating superior understanding of how HTML and CSS work together in practice. Jenq and Bredlau [8] and Rosson et al. [13] both found that authentic projects motivated students to master technical details they might otherwise ignore, though this approach required careful scaffolding to prevent overwhelming novices with complexity.

The scientific approach investigated by Nashiroh, Kamdi and Elmunsyah [10] showed promise for developing logical thinking skills essential to programming, though its impact on motivation was less pronounced than gamification. This structured methodology incorporated systematic observation, questioning, information gathering, association, and communication phases that mirror professional development practices. While effective for skill development, the formal structure may have limited its motivational appeal for some students.

Mobile-supported learning management systems demonstrated balanced effectiveness across all outcome dimensions. Tezer and Çimşir [17] found that mobile access enabled continuous engagement with course materials, supporting both formal learning during class and informal practice outside school hours. The flexibility and familiarity of mobile platforms appeared to reduce barriers to practice while maintaining instructional structure.

3.6. Technology coverage reveals curricular priorities and gaps

Examination of which web technologies were taught across studies reveals both consistencies and notable gaps in curricular coverage. HTML appeared in all eight studies as the foundational technology, reflecting consensus about its central importance in web design education. The universal coverage of HTML basics including tags,

attributes, and document structure suggests broad agreement about essential starting points for web design instruction.

CSS received substantially less attention, appearing in only three studies despite its essential role in modern web design. This limited coverage of styling and layout concepts represents a significant gap, as contemporary web development relies heavily on CSS for visual presentation and responsive design. The studies that did include CSS typically introduced it after students had mastered basic HTML structure, following a progression from content to presentation that aligns with web standards philosophy.

JavaScript appeared in just one study, and only as an advanced topic for exceptional students. This minimal coverage of client-side scripting reflects a curricular focus on static content creation rather than interactive web applications. While this limitation may be appropriate given the complexity of programming concepts and time constraints in secondary education, it potentially leaves students unprepared for modern web development expectations.

Several studies included server-side technologies like PHP and Perl, primarily in vocational contexts preparing students for immediate employment. Jenq and Bredlau [8] found these topics particularly challenging for students, requiring substantially more instructional support than client-side technologies. The inclusion of database systems and content management systems in individual studies suggests recognition of their professional relevance but lack of consensus about their place in secondary curricula.

This technology coverage pattern reveals tension between teaching foundational concepts that provide broad understanding and preparing students for specific vocational outcomes. The emphasis on HTML at the expense of CSS and JavaScript may reflect outdated curricular standards or instructor comfort levels rather than deliberate pedagogical choices aligned with contemporary web development practices.

4. Discussion

4.1. Interpreting the limited research landscape

The identification of only eight rigorous studies examining web design education at the secondary level over a 16-year period demands careful interpretation. This scarcity could be dismissed as indicating a marginal research area unworthy of systematic review. However, we argue that this limited corpus represents a critical finding that illuminates important dynamics in educational research and practice. The paucity of research stands in stark contrast to the widespread inclusion of web design in secondary curricula globally and the recognized importance of digital creation skills in contemporary education.

Several factors likely contribute to this research gap. The rapid evolution of web technologies may discourage researchers from investing in studies that could quickly become outdated. The interdisciplinary nature of web design, spanning computer science, visual design, and communication, may fall between established research communities. Additionally, the perception of web design as vocational rather than academic content may limit its appeal to educational researchers focused on core academic subjects. Understanding these barriers is essential for developing a research agenda that addresses the genuine need for evidence-based guidance in this domain.

The geographic concentration of existing research raises additional considerations. The predominance of studies from Indonesia might reflect specific national education priorities, curriculum reforms, or research funding structures that encouraged investigation of web design pedagogy. Conversely, the absence of studies from many technologically advanced nations with established computing education programs suggests that web design may be taught based on intuition and tradition rather than

empirical evidence. This pattern highlights the need for international collaboration and comparative research to understand how cultural and systemic factors influence effective web design instruction.

4.2. Theoretical implications and pedagogical frameworks

Our findings provide empirical support for several theoretical frameworks while revealing nuances in their application to web design education. The consistent positive effects of strategies aligned with cognitive load theory confirm its relevance for structuring web design instruction. The simultaneous processing demands of HTML syntax, document structure, visual design principles, and file management create substantial intrinsic cognitive load that must be carefully managed. Successful interventions in our review employed various load-reduction strategies including progressive complexity, worked examples, and visual scaffolding tools that externalize some cognitive processes.

The remarkable consistency of gamification effects across studies provides strong support for self-determination theory in technical education contexts. Gamification elements appear to satisfy basic psychological needs through competence support via progressive challenges and immediate feedback, autonomy support through choice in project topics and approaches, and relatedness through leaderboards and collaborative challenges. However, the limited duration of most studies prevents assessment of whether these motivational benefits persist beyond initial novelty effects. Ratinho and Martins [12] warns that extrinsic motivators in gamification may undermine intrinsic motivation over time, suggesting need for careful design that gradually shifts from extrinsic to intrinsic motivation sources.

The TPACK framework proves particularly valuable for understanding the complex knowledge required for effective web design instruction. Our analysis reveals that successful teachers must integrate deep content knowledge spanning HTML, CSS, and web standards; pedagogical knowledge about managing cognitive load, maintaining engagement, and scaffolding complex skills; and technological knowledge of development tools, debugging environments, and instructional platforms. The rapid evolution of web technologies makes this integration particularly challenging, as teachers must continuously update their content and technological knowledge while adapting pedagogical approaches to new affordances and constraints.

Beyond these established frameworks, our synthesis suggests need for a specialized pedagogical framework for web design education that addresses its unique characteristics. Web design differs from traditional programming in its visual nature, immediate feedback cycles, and lower barrier to initial success. It differs from graphic design in its technical constraints, logical structure requirements, and code-based implementation. An effective pedagogical framework must account for these distinctive features while building on insights from both programming and design education research.

4.3. Practical implications for educators

The evidence synthesized in this review offers concrete guidance for educators designing and implementing web design curricula. The consistent positive effects of gamification across multiple studies and contexts suggest that incorporating game elements should be a priority consideration. However, effective gamification requires more than superficial addition of points and badges. The successful implementations in our review carefully aligned game elements with learning objectives, provided meaningful progression and challenge, balanced competition with collaboration, and maintained narrative coherence in game-based scenarios.

The critical importance of managing cognitive load emerges as another key principle for practice. Educators should carefully sequence instruction to introduce HTML

structure before CSS styling and styling before interactivity. This progression allows students to build mental models incrementally rather than confronting all complexity simultaneously. Within each phase, concepts should progress from simple to complex with extensive practice at each level before advancement. The use of worked examples, particularly in early stages, provides crucial scaffolding that reduces extraneous cognitive load while maintaining germane load that promotes schema construction.

The evidence strongly supports project-based learning approaches, but with important caveats about implementation. Authentic projects motivate students and provide context for technical learning, but they can also introduce overwhelming complexity if not carefully structured. Successful project-based implementations in our review began with constrained projects that focused on specific skills, gradually increased project scope and autonomy as competence developed, provided templates and examples to scaffold initial efforts, and incorporated regular checkpoints and formative assessment. The key is balancing authenticity with appropriate challenge level, ensuring that projects stretch students' capabilities without exceeding their grasp.

Infrastructure limitations remain a significant challenge in many contexts, but our review identifies promising adaptations. Mobile-supported learning leverages devices students already possess, though it may require curriculum adjustments to accommodate smaller screens and touch interfaces. Offline development environments enable practice without reliable internet connectivity, though they may limit access to resources and collaborative features. Paired programming and computer sharing can address device shortages while potentially enhancing learning through peer interaction. These adaptations suggest that effective web design education is possible even with significant resource constraints, though they may require creative pedagogical adjustments.

4.4. Implications for educational policy and systemic change

Our findings have significant implications for educational policymakers at institutional, regional, and national levels. The current state of web design education appears characterized by substantial variation in approaches, limited evidence base for practice, and misalignment between curriculum and contemporary web development practices. Addressing these issues requires coordinated policy interventions across multiple dimensions.

Curriculum standardization emerges as a critical need, though standardization should not imply rigid uniformity. Policy frameworks should establish core competencies and learning progressions while allowing flexibility for local adaptation and innovation. The limited coverage of CSS and JavaScript in reviewed studies suggests that current curricula may not adequately prepare students for contemporary web development. Updated standards should reflect modern web practices including responsive design, accessibility, and web standards compliance while maintaining appropriate scope for secondary education. Progression pathways from primary through secondary to tertiary education need articulation to ensure coherent skill development across educational levels.

Teacher preparation represents perhaps the most critical policy challenge. The rapid evolution of web technologies means that teachers' knowledge can quickly become outdated, yet professional development opportunities specifically focused on web design instruction appear limited. Policy interventions should mandate web technologies in computer science teacher preparation programs, provide ongoing professional development rather than one-time training sessions, create partnerships with industry for authentic expertise and current practices, and establish professional learning communities for peer support and knowledge sharing. Without adequately

prepared teachers, even well-designed curricula and resources will fail to achieve intended outcomes.

Infrastructure investment remains essential for equitable web design education. While our review demonstrates that effective instruction is possible with limited resources, infrastructure constraints inevitably limit what can be achieved. Policy priorities should include establishing minimum technology standards for schools offering web design courses, ensuring reliable internet connectivity for all educational institutions, providing regular refresh cycles for hardware and software, and addressing digital divides that disadvantage rural and economically marginalized communities. These investments require sustained commitment rather than one-time initiatives, as technological obsolescence is rapid.

Assessment and credentialing systems also require policy attention. Current assessment approaches may not adequately capture the creative and problem-solving aspects of web design, focusing instead on syntax memorization or isolated technical skills. Alternative assessment models including portfolio-based evaluation, authentic performance tasks, and industry-recognized certifications could better reflect actual web design competencies while providing meaningful credentials for students. Policy frameworks should encourage innovation in assessment while maintaining appropriate quality assurance.

4.5. Future research directions

This review identifies numerous gaps in the research literature that warrant systematic investigation. Longitudinal studies examining the sustained impact of different pedagogical approaches would address the current limitation of short intervention periods. Such research could explore whether initial gains persist over time, how motivational patterns evolve with extended exposure, and what factors predict continued engagement with web design learning. Following students from secondary education into tertiary education or employment would provide valuable insights into the long-term value of different instructional approaches.

Comparative effectiveness research directly contrasting different pedagogical approaches within consistent contexts would strengthen causal inferences about what works. Current evidence relies primarily on single-intervention studies with traditional instruction as comparison. Head-to-head comparisons of promising approaches like gamification versus project-based learning, mobile versus desktop-based instruction, or individual versus collaborative learning would provide more nuanced guidance for instructional design decisions. Such studies should examine not just average effects but also differential effectiveness for diverse student populations.

The integration of emerging web technologies and frameworks into secondary education requires investigation. How can concepts like responsive design, web accessibility, and modern CSS frameworks be effectively taught to novices? What scaffolding is needed to introduce JavaScript and interactive web features? How should curricula adapt to evolving web standards and practices? These questions become increasingly urgent as the gap between school-based web design instruction and professional practice widens.

Research on teacher professional development models specific to web design instruction would address a critical gap identified in our review. What knowledge and skills do effective web design teachers need? How can professional development programs address both technical and pedagogical dimensions? What support structures enable sustained teacher learning in rapidly evolving technical domains? Understanding effective teacher preparation and support is essential for scaling successful instructional approaches.

Cross-cultural and comparative international research would illuminate how con-

textual factors influence effective instruction. Do pedagogical approaches that work in one educational system transfer to others? How do cultural attitudes toward technology, competition, and creativity affect student response to different instructional methods? What systemic factors enable or constrain effective web design education? Such research would enhance the generalizability and applicability of findings across diverse global contexts.

5. Limitations

Several limitations of this review warrant acknowledgment and consideration when interpreting findings. The small number of included studies, while enabling comprehensive analysis, limits statistical power for quantitative synthesis and restricts generalizability of findings. The geographic concentration of research in specific countries may not represent global diversity in educational contexts and student populations. The temporal span of included studies means that older research may not reflect current technological contexts and student characteristics.

Methodological limitations within primary studies also affect our conclusions. Most studies employed quasi-experimental designs with potential selection bias, had relatively small sample sizes limiting statistical power, implemented short intervention periods preventing assessment of sustained effects, and used varied outcome measures complicating direct comparison. These limitations are common in educational research but nonetheless affect confidence in causal inferences.

The rapid evolution of web technologies creates particular challenges for synthesis and application. Studies from different time periods addressed different technological contexts, with earlier research focusing on basic HTML while later studies incorporated more advanced concepts. Pedagogical approaches that were effective for teaching table-based layouts may not apply to modern CSS grid and flexbox approaches. Development tools and environments have evolved substantially, potentially affecting the applicability of findings. This technological evolution means that specific technical recommendations may quickly become outdated, though general pedagogical principles likely remain relevant.

Publication bias represents another potential limitation. Studies finding positive effects are more likely to be published than those finding null or negative results, potentially creating an overly optimistic picture of intervention effectiveness. The limited number of studies prevented formal assessment of publication bias, though the inclusion of studies with varied and sometimes modest effects suggests that extreme publication bias is unlikely.

6. Conclusion

This systematic review has synthesized the limited but valuable empirical research on teaching web design through HTML and CSS to secondary school students, revealing both promising practices and critical gaps in our understanding. Despite identifying only eight rigorous studies over 16 years, our comprehensive analysis has generated important insights for educators, researchers, and policymakers working to improve web design education.

The quantitative synthesis demonstrates that innovative pedagogical approaches, particularly gamification and mobile-supported learning, produce meaningful improvements in both skill development and student engagement, with effect sizes ranging from 0.58 to 0.70. These effects align with broader meta-analytic findings in STEM education, strengthening confidence in their validity and applicability. The thematic analysis reveals persistent challenges including syntax comprehension difficulties, motivation maintenance, and cognitive overload, while identifying evidence-based

strategies that effectively address these challenges through careful scaffolding, visual feedback, and progressive complexity.

The limited research corpus, rather than undermining the review's value, emerges as a critical finding that highlights the urgent need for expanded empirical investigation in this domain. The geographic concentration of existing research and the temporal clustering of recent studies suggest that web design education has been largely guided by intuition rather than evidence, despite its growing importance in secondary curricula worldwide. This gap between educational practice and research evidence represents both a challenge and an opportunity for the field.

Our synthesis supports several theoretical frameworks while revealing nuances in their application to web design education. Cognitive load theory provides essential guidance for managing the complexity inherent in learning multiple interconnected technologies. Self-determination theory explains the motivational benefits of gamification while cautioning against over-reliance on extrinsic rewards. The TPACK framework illuminates the complex knowledge integration required for effective instruction in this rapidly evolving domain. Together, these theoretical perspectives inform the evidence-based pedagogical framework we have developed to guide practice.

The practical implications of our findings extend across multiple levels of educational systems. For classroom educators, we provide concrete guidance on implementing gamification, managing cognitive load, and adapting to infrastructure constraints. For institutional leaders, we highlight the importance of curriculum updates, teacher professional development, and resource allocation. For policymakers, we emphasize the need for coherent standards, sustained infrastructure investment, and systematic support for teacher preparation. These multi-level interventions are necessary to transform web design education from its current fragmented state to a coherent, evidence-based practice.

The teaching of web design in secondary schools represents more than technical skill development; it provides students with tools for creative expression, logical thinking, and participation in digital culture. Ensuring that all students have access to effective web design education is therefore a matter of educational equity and social justice. This review provides a foundation for evidence-based practice while highlighting the substantial work that remains to be done. We hope it will inspire both improved practice based on current evidence and expanded research to address the many questions that remain unanswered.

Data availability statement: The datasets analyzed during the current study, including quality assessment ratings and extracted data, are available from the corresponding author upon reasonable request.

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References

[1] Alsuhaymi, D.S. and Alotaibi, O.M., 2023. Gamification's efficacy in enhancing students' HTML programming skills and academic achievement motivation. *Journal of Education and e-Learning Research*, 10(3), pp.397–407. Available from: https://doi.org/10.20448/jeelr.v10i3.4738.

[2] Arlinwibowo, J., Ishartono, N., Linguistika, Y., Purwoko, D. and Suprapto, 2023. Gamification in the STEM Domain Subject: The Prospective Method to Strengthen Teaching and Learning. *Jurnal Pendidikan IPA Indonesia*, 12(4), pp.562–572. Available from: https://doi.org/10.15294/jpii.v12i4.48388.

[3] Fitriasari, N.S., Ashiddiqi, M.F. and Nurdin, E.A., 2018. Improving student understanding in web programming material through multimedia adventure games. *Journal of Physics: Conference Series*, 1013(1), p.012101. Available from: https://doi.org/10.1088/1742-6596/1013/1/012101.

[4] Fitzgerald, S., Parker, B. et al., 2020. *IDC FutureScape: Worldwide Digital Transformation 2021 Predictions*. (Market Research Report US46880818). International Data Corporation.

[5] Fransson, G. and Holmberg, J., 2012. Understanding the Theoretical Framework of Technological Pedagogical Content Knowledge: A collaborative self-study to understand teaching practice and aspects of knowledge. *Studying Teacher Education*, 8(2), pp.193–204. Available from: https://doi.org/10.1080/17425964.2012.692994.

[6] Hong, Q.N., Pluye, P., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.C. and Vedel, I., 2019. Improving the content validity of the mixed methods appraisal tool: a modified e-Delphi study. *Journal of Clinical Epidemiology*, 111, pp.49–59.e1. Available from: https://doi.org/10.1016/j.jclinepi.2019.03.008.

[7] Huraj, L., Hrmo, R. and Sejutová Hudáková, M., 2022. The Impact of a Digital Escape Room Focused On HTML and Computer Networks on Vocational High School Students. *Education Sciences*, 12(10), p.682. Available from: https://doi.org/10.3390/educsci12100682.

[8] Jenq, J. and Bredlau, C., 2007. Pre-college student learning of web development technologies. *IMSCI 2007 - International Multi-Conference on Society, Cybernetics and Informatics, Proceedings*, vol. 1. pp.147–152. Available from: https://www.iiis.org/p-proceedings/july2007/IMSCI-I/IMSCI-Book-Vol-I.pdf.

[9] Martinez-Bravo, M.C., Sádaba Chalezquer, C. and Serrano-Puche, J., 2022. Meta-framework of digital literacy: A comparative analysis of 21st-century frameworks. *Revista Latina de Comunicación Social*, 79, pp.76–110. Available from: https://doi.org/10.4185/RLCS-2021-1508.

[10] Nashiroh, P.K., Kamdi, W. and Elmunsyah, H., 2017. The effectiveness of web-programming module based on scientific approach to train logical thinking ability for students in vocational high school. *AIP Conference Proceedings*, 1887, p.020068. Available from: https://doi.org/10.1063/1.5003551.

[11] Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P. and Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, 372, p.n71. Available from: https://doi.org/10.1136/bmj.n71.

[12] Ratinho, E. and Martins, C., 2023. The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review. *Heliyon*, 9(8), p.e19033. Available from: https://doi.org/10.1016/j.heliyon.2023.e19033.

[13] Rosson, M.B., Thiry, E., Zhao, D. and Carroll, J.M., 2011. Teachers as Designers: Enabling Teachers to Specify Dynamic Web Programming Projects for Students. In: M.F. Costabile, Y. Dittrich, G. Fischer and A. Piccinno, eds. *End-User Development*, *Lecture notes in computer science*, vol. 6654. Berlin, Heidelberg: Springer Berlin Heidelberg, pp.233–238. Available from: https://doi.org/10.1007/978-3-642-21530-8_19.

[14] Scherer, R., Siddiq, F. and Sánchez Viveros, B., 2020. A meta-analysis of teaching and learning computer programming: Effective instructional approaches and

conditions. *Computers in Human Behavior*, 109, p.106349. Available from: https://doi.org/10.1016/j.chb.2020.106349.

[15] Stachel, J., Marghitu, D., Brahim, T.B., Sims, R., Reynolds, L. and Czelusniak, V., 2013. Managing Cognitive Load in Introductory Programming Courses: A Cognitive Aware Scaffolding Tool. *Journal of Integrated Design and Process Science*, 17(1), pp.37–54. Available from: https://doi.org/10.3233/jid-2013-0004.

[16] Sweller, J., 2023. The Development of Cognitive Load Theory: Replication Crises and Incorporation of Other Theories Can Lead to Theory Expansion. *Educational Psychology Review*, 35(4), Sep, p.95. Available from: https://doi.org/10.1007/s10648-023-09817-2.

[17] Tezer, M. and Çimşir, B.T., 2018. The impact of using mobile-supported learning management systems in teaching web design on the academic success of students and their opinions on the course. *Interactive Learning Environments*, 26(3), pp.402–410. Available from: https://doi.org/10.1080/10494820.2017.1337037.

[18] Xu, W., Xu, G.R. and Xing, Q.W., 2025. The impact of different combinations of game elements for gamified learning in higher education on student learning outcomes: a multilevel meta-analysis. *Studies in Higher Education*, 50(11), pp.2376–2403. Available from: https://doi.org/10.1080/03075079.2024.2416498.

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