Discover Education

REVIEW Open Access

A systematic review of research on teaching web design to secondary school students through HTML and CSS

Oleksandr Ye. Kharchenko[1] and Serhiy O. Semerikov[1,2,3,4*]

*Correspondence:
Serhiy O. Semerikov
semerikov@gmail.com
[1]Kryvyi Rih State Pedagogical Univeristy, 54 Universytetskyi Ave., Kryvyi Rih 50086, Ukraine
[2]Institute for Digitalisation of Education of the NAES of Ukraine, 9 M. Berlynskoho Str., Kyiv 04060, Ukraine
[3]Zhytomyr Polytechnic State University, 103 Chudnivsyka Str., Zhytomyr 10005, Ukraine
[4]Academy of Cognitive and Natural Sciences, 54 Universytetskyi Ave., Kryvyi Rih 50086, Ukraine

Abstract

Introduction Teaching web design using HTML and CSS is an increasingly important component of secondary education, preparing students for future careers in information technology. This systematic review examines research on methodologies and tools for teaching web design in secondary schools, identifying key effectiveness factors and approaches to overcome learning difficulties.

Methods Following PRISMA methodology, we conducted a systematic review of research published between 2007 and 2024. Initial searches in Scopus and Web of Science were expanded to include Google Scholar and additional databases following reviewer recommendations. Nine studies meeting inclusion criteria were selected from comprehensive searching. Inclusion criteria focused on empirical research involving HTML/CSS instruction in secondary or vocational schools with full-text availability. The limited number of studies despite expanded searching confirms the nascent state of empirical research in this domain.

Results Analysis revealed increasing research interest since 2017, with most studies conducted in Indonesia and the United States. Research predominantly focused on professional technical schools with 10th-grade students. Key findings are organized around three themes: (1) digital tools and platforms supporting web design education, including gamification platforms, learning management systems, and visual programming environments; (2) factors influencing learning effectiveness, including student characteristics, pedagogical approaches, and technical infrastructure; and (3) common learning difficulties and their solutions, particularly regarding complex material comprehension and student motivation. The recent emergence of gamification-based approaches shows particular promise for enhancing student engagement.

Conclusions Effective web design instruction requires a comprehensive approach integrating modern methodologies and tools while addressing student needs and providing adequate support. Project-based learning, gamification, and interactive environments emerged as particularly effective approaches. The scarcity of empirical research, confirmed through expanded searching, highlights the urgent need for additional studies. Future research should compare the effectiveness of different

teaching methodologies and develop evidence-based recommendations for optimizing instruction across various educational contexts.

Keywords Web design education, HTML, CSS, Secondary schools, Vocational education, Systematic review, Teaching methodologies, Gamification

1 Introduction

1.1 Contextualizing web design education

The evolving demands of the 21st-century digital economy have fundamentally transformed educational priorities in secondary schools worldwide. Web design education, encompassing HTML (HyperText Markup Language) and CSS (Cascading Style Sheets), has emerged as a critical component in preparing students for an increasingly digital future. This educational imperative extends beyond technical skill development to encompass problem-solving capabilities, creative expression, and digital literacy competencies essential for modern workforce participation.

The integration of web design into secondary curricula represents a significant shift in educational philosophy, recognizing that digital creation skills are as fundamental as traditional literacy. Students who master web technologies gain not only technical proficiency but also develop computational thinking skills that transfer across disciplines. The ability to structure information hierarchically through HTML and apply visual design principles through CSS cultivates both logical reasoning and aesthetic sensibility.

Despite this growing importance, the integration of web design education into secondary school curricula remains inconsistent and under-researched. While some countries have established comprehensive computer science programs that include web technologies, others lack systematic approaches to teaching these skills [1]. This disparity creates significant inequities in students' preparedness for both higher education and career opportunities in technology-related fields.

1.2 Theoretical perspectives on web design education

Several theoretical frameworks offer valuable perspectives for understanding web design education, though their application in this domain remains largely interpretive rather than empirically validated. Constructivist learning theory suggests that students learn most effectively when actively building knowledge through hands-on experience [2]. This perspective appears particularly relevant to web design, where students create tangible digital artifacts while developing their understanding of underlying concepts.

Cognitive load theory provides insights into the challenges students face when learning web design [3]. The simultaneous demands of understanding syntax, structure, and visual design can overwhelm working memory, particularly for novice learners. Successful instructional approaches often employ strategies such as worked examples and progressive scaffolding to manage this cognitive load [4].

The Technological Pedagogical Content Knowledge (TPACK) framework, while not explicitly measured in most web design studies, offers a useful lens for understanding effective instruction [5]. Successful web design education appears to require integration of content knowledge (HTML/CSS concepts), pedagogical knowledge (effective teaching strategies), and technological knowledge (development tools and platforms).

Universal Design for Learning (UDL) principles suggest the importance of providing multiple means of representation, engagement, and expression in educational contexts

[6]. The diverse learning modalities involved in web design – from logical code structure to visual design aesthetics – naturally align with these principles, though empirical validation in web design contexts remains limited.

Project-based learning emerges consistently in the literature as a promising approach for web design education [2]. By situating technical skill development within meaningful projects, this approach potentially enhances both motivation and deeper understanding, though comparative effectiveness studies remain scarce.

1.3 The imperative of systematic evidence synthesis

Despite the recognized importance of web design education, there exists a notable gap in systematically synthesized evidence regarding effective teaching approaches at the secondary level. Muibi et al. [7] observe that while significant research has explored challenges faced by novice web developers, relatively little attention has focused on evidence-based teaching strategies that address the field's considerable breadth at the secondary level. While numerous educators have developed innovative methodologies and digital tools for HTML and CSS instruction, these efforts often remain isolated within individual classrooms or institutions. The absence of a comprehensive review examining these diverse approaches limits our ability to identify best practices, understand common challenges, and establish evidence-based guidelines for curriculum development.

The need for systematic evidence synthesis becomes particularly acute given the rapid evolution of web technologies and pedagogical approaches. Educational practitioners require consolidated insights from empirical research to inform instructional design decisions, select appropriate digital tools, and address the specific learning needs of secondary students. Without such synthesis, educators risk perpetuating ineffective practices or overlooking promising innovations developed elsewhere.

1.4 Methodological considerations for limited evidence bases

Conducting systematic reviews in emerging educational domains presents unique methodological challenges. When empirical research is scarce, as anticipated in the specialized field of secondary-level web design education, traditional systematic review approaches must be adapted while maintaining rigor and transparency. The value of systematic review methodology in such contexts lies not only in synthesizing existing evidence but also in documenting the extent and nature of research gaps [8].

The systematic approach enables identification of patterns across studies that might otherwise remain obscured, while also highlighting the urgent need for additional research in this domain [9]. Importantly, the scarcity of empirical studies itself constitutes a significant finding. Rather than undermining the value of systematic review methodology, this limitation underscores the importance of rigorously documenting and analyzing the existing evidence base, however modest, to inform both practice and future research directions [10].

1.5 Purpose and research questions

This systematic review aims to synthesize current empirical research on teaching web design to secondary school students using HTML and CSS, identifying effective instructional approaches, challenges, and solutions based on available evidence. While

acknowledging that the limited research base may preclude definitive conclusions, the review provides valuable insights into emerging patterns and promising practices.

The review addresses three primary research questions:

RQ 1: How do digital tools and platforms support HTML and CSS instruction in secondary schools?

RQ 2: What factors influence the effectiveness of web design instruction at the secondary level?

RQ 3: What challenges arise in teaching web design to secondary students, and what strategies effectively address these challenges?

2 Methods

2.1 Review protocol and registration

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology [9]. The review protocol was developed prior to conducting the search but was not registered in a public database due to the educational nature of the project.

2.2 Eligibility criteria

Studies were selected based on the following inclusion criteria:

1. Focus on teaching web design (HTML and CSS) in secondary or vocational technical schools
2. Empirical research including results from experiments, surveys, or case studies
3. Publication in peer-reviewed journals or conference proceedings
4. Full-text availability in English
5. Publication between 2007 and 2024

Studies were excluded if they:

1. Consisted of editorial letters, conference abstracts without detailed methodology
2. Focused on content unrelated to HTML, CSS, or general web design education
3. Targeted primary education or university-level students exclusively

2.3 Information sources

The initial search for relevant studies was conducted on January 19, 2025, using Scopus as the primary source and Web of Science Core Collection for verification. Following reviewer recommendations to ensure comprehensive coverage, an expanded search was conducted on November 15, 2025, utilizing:

- Web of Science expanded databases (including Core Collection, Research Commons, Derwent Innovations Index, MEDLINE, ProQuest Dissertations & Theses, KCI-Korean Journal Database, and Policy Citation Index)
- Google Scholar for identification of non-indexed empirical research

Scopus was selected as the primary database due to its comprehensive coverage of peer-reviewed literature in education and technology fields. The expanded search strategy aimed to identify any empirical research potentially missed in traditional academic databases, particularly studies published in regional journals or conference proceedings not indexed in major databases.

2.4 Search strategy

The search strategy was designed to identify studies focused on web design education in secondary schools. The following search string was used in Scopus:

```
TITLE("web design"OR"web programming"OR"web development"OR "HTML") AND TITLE(student*) AND TITLE-ABS-KEY(school OR teacher)
```

For Web of Science Core Collection, the adapted search string was:

```
"web design"OR"web programming"OR"web development"OR "HTML"(Title) and student* (Title) and school OR teacher (Topic)
```

The expanded Web of Science search utilized all available databases with identical search terms. For Google Scholar, a simplified search strategy was employed due to platform limitations:

```
"web design"OR"web programming"AND student AND school -university
```

These broad search strategies aimed to capture all potentially relevant studies, with the understanding that the limited research in this domain would likely yield a modest number of results. The search terms were deliberately inclusive to avoid missing relevant studies in this emerging field.

2.5 Selection process

The selection process involved multiple stages. Initially, 14 publications were identified through the Scopus search, with 10 additional records from Web of Science Core Collection (all duplicates). The expanded search yielded 25 additional records from Web of Science databases and numerous results from Google Scholar.[1]

Two publications from before 2007 were removed from the initial search, leaving 12 for screening. Titles and abstracts were screened independently by two reviewers to determine potential eligibility. Full texts of all potentially eligible studies were evaluated against the inclusion criteria.

From the initial search, four studies were excluded after full-text assessment: one for topic irrelevance (focused on automated text generation rather than education), two for context irrelevance (targeting university students), and one for both topic and context irrelevance.

The expanded search results underwent similar screening. After removing 7 duplicates with the initial search, 18 new records were assessed. Of these, 17 were excluded: 3 for not being empirical research, 4 for not being in English, 3 for inability to access full text, and 7 for being books or theses rather than peer-reviewed articles or conference papers. This process resulted in 9 studies meeting all inclusion criteria for the final review.

2.6 Data collection process

Data extraction was performed using a standardized form designed to capture relevant information from each included study. The form was pilot-tested on two studies and refined before full implementation. One reviewer extracted the data, and a second reviewer checked the extraction for accuracy and completeness.

[1] Our search was conducted manually; however, we also attempted to automate paper extraction by building Scholar Extractor (https://github.com/ssemerikov/scholarextractor).

2.7 Data items

The following data were extracted from each included study:

- Publication information: document type, title, year, countries of authors
- Study aim and objectives
- Factors influencing web design learning effectiveness
- Teaching methodologies employed
- Digital tools used for instruction
- Difficulties encountered in teaching/learning web design
- Proposed solutions to identified difficulties
- Participant characteristics: type of educational institution, student age/grade, sample size
- Technologies studied (HTML, CSS, JavaScript, other)
- Language of instruction
- Validation methods (for development studies)
- Learning outcomes and effectiveness measures

2.8 Study risk of bias assessment

Given the diverse methodological approaches and predominantly descriptive nature of the included studies, a formal risk of bias assessment using standardized tools designed for experimental studies was deemed inappropriate. Instead, we adapted quality criteria from the Mixed Methods Appraisal Tool (MMAT) [8, 10], focusing on clarity of objectives, appropriateness of methodology, and coherence of findings. This adaptation allowed us to evaluate methodological quality by considering sample size adequacy, clarity of methodology description, and appropriateness of conclusions relative to the evidence presented. While this approach does not provide quantitative quality scores, it enabled systematic consideration of each study's strengths and limitations.

2.9 Synthesis methods

Data synthesis followed a narrative approach, organizing findings thematically according to the research questions. The limited number of studies and their heterogeneous nature precluded meta-analysis or other quantitative synthesis methods. Instead, themes were identified through iterative coding following the six-phase framework by Braun and Clarke [11]: (1) familiarization with data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining themes, and (6) producing the report. This systematic approach ensured rigorous theme development grounded in the available data, while acknowledging the preliminary nature of findings given the limited evidence base.

Quantitative data regarding publication patterns, geographical distribution, and participant characteristics were summarized using descriptive statistics and visualized through charts and tables. The small sample size necessitated cautious interpretation, with patterns described as preliminary observations rather than definitive findings.

2.10 Certainty assessment

Given the limited number of studies and their predominantly descriptive nature, formal certainty assessment using tools like GRADE was not conducted. Instead, we explicitly acknowledge throughout the results and discussion that findings should be considered

preliminary and hypothesis-generating rather than conclusive, pending additional research in this emerging field.

3 Results

3.1 Study selection

The database searches identified 14 potentially relevant studies through Scopus and 10 through Web of Science Core Collection (all duplicates). The expanded search yielded 25 additional records through Web of Science databases and identified one relevant empirical study through Google Scholar after extensive screening.

After removing 2 pre-2007 publications from the initial search, 12 studies were screened. Following full-text assessment, 4 studies were excluded: one for topic irrelevance, two for context irrelevance (university-level focus), and one for both topic and context irrelevance. From the expanded search, after removing duplicates and applying exclusion criteria, only one additional study met all inclusion criteria.

The extensive additional searching yielding only one new empirical study reinforces our initial finding about the scarcity of research in this domain. Despite using broader search filters including Google Scholar, which indexes a wider range of publications, the paucity of empirical research on web design education in secondary schools remains evident. Nine studies met all inclusion criteria for the final review. Figure 1 presents the PRISMA flow diagram illustrating the selection process.

3.2 Study characteristics

Table 1 provides a comprehensive overview of the nine included studies. The limited number of studies meeting our criteria, despite expanded searching across multiple databases including Google Scholar, itself represents an important finding, confirming the nascent state of empirical research in web design education at the secondary level.

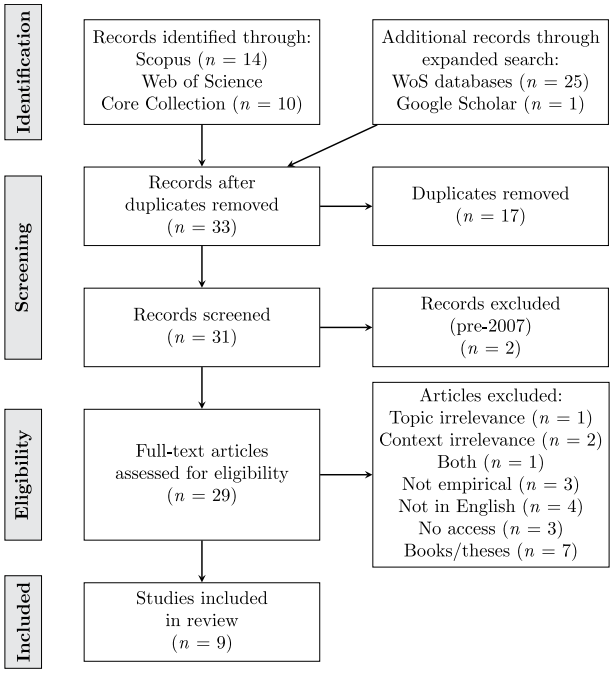

Fig. 1 PRISMA flow diagram illustrating the comprehensive study selection process including expanded searching

Table 1 Summary of included studies in the systematic review

Study	Year	Country	School type	Sample	Key methods/tools	Technologies
Jenq and Bredlau [12]	2007	USA	Secondary	Groups of 5-6	Lab-based learning, Notepad/TextPad	HTML, CSS, Perl, PHP
Rosson et al. [13]	2011	USA	Secondary	∼50 girls	Drupal CMS, wProjects tool	HTML, PHP, CMS
Nashiroh et al. [14]	2017	Indonesia	Vocational	45 (10th grade)	Scientific approach module	HTML
Fitriasari et al. [15]	2018	Indonesia	Vocational	56 (10th grade)	Construct 2, adventure games	HTML
Arif et al. [16]	2019	Indonesia	Vocational	42 (10th grade)	Interactive coding, gamification	HTML, CSS, JavaScript
Huraj et al. [17]	2022	Slovakia	Vocational	16 (3rd year)	Digital escape room, GDevelop 5	HTML, CSS, Networks
Tezer and Çimşir [18]	2018	Turkey	Vocational	70 students	Mobile LMS (Moodle)	HTML
Alsuhaymi and Alotaibi [19]	2023	Saudi Arabia	Secondary	37 (10th grade)	Gamification (Kahoot, Quiz Whizzer)	HTML
Syahri et al. [20]	2024	Indonesia	Vocational	25 (11th grade)	Gamification website, peer review	HTML, CSS, JavaScript

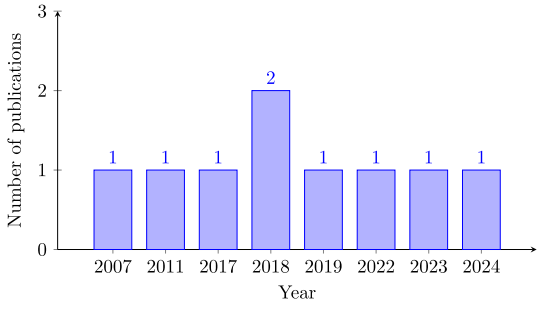

Fig. 2 Temporal distribution of included studies showing renewed interest post-2017

Table 2 Geographical distribution of included studies

Country	Number of studies	Percentage
Indonesia	4	44.4
USA	2	22.2
Slovakia	1	11.1
Turkey	1	11.1
Saudi Arabia	1	11.1

3.2.1 Temporal and geographical distribution

Among the 9 analyzed studies, 6 (66.7%) were published in conference proceedings and 3 (33.3%) in scientific journals. The temporal distribution reveals a gap between early studies (2007, 2011) and renewed interest from 2017 onward, with consistent publication activity through 2024 (Fig. 2). This pattern may reflect the evolution of web technologies and growing recognition of their educational importance.

Geographical analysis reveals concentration in specific regions (Table 2). Indonesia leads with 4 studies (44.4%), followed by the United States with 2 studies (22.2%). This distribution may reflect different educational priorities, research funding availability, or the emphasis placed on vocational technical education in these countries. The

concentration of studies in Indonesia particularly highlights the country's focus on vocational education in technology fields.

3.2.2 Educational contexts and participants

The majority of studies (7 out of 9, 77.8%) were conducted in vocational or technical schools, with only 2 studies (22.2%) in general secondary schools. This distribution suggests that web design education may be more prevalent in specialized technical education programs. Participant demographics reveal a focus on 10th-grade students (5 studies), with sample sizes ranging from 16 to 70 students. Two studies specifically targeted female students, addressing gender gaps in technology education. The most recent study [20] focused on 11th-grade students, suggesting progression in curriculum placement.

3.3 Risk of bias within studies

Quality assessment using adapted MMAT criteria revealed varying methodological rigor across studies. Most studies (6 out of 9) clearly articulated research objectives and employed appropriate methodologies for their stated aims. However, several limitations were identified:

- Sample size constraints – four studies had fewer than 30 participants, limiting generalizability
- Limited control groups – only 3 studies employed comparison groups
- Short intervention periods – most studies conducted interventions lasting less than one semester
- Outcome measurement variability – studies used different assessment methods, complicating cross-study comparisons
- Validation procedures – development studies varied in their validation rigor, though the most recent study [20] demonstrated comprehensive validation with both media (88.18%) and material experts (89.92%)

Despite these limitations, all included studies provided sufficient methodological detail for quality assessment and contributed valuable insights within their specific contexts.

3.4 Results of individual studies

3.4.1 Digital tools and platforms supporting web design education

RQ 1: *How do digital tools and platforms support HTML and CSS instruction in secondary schools?*

Table 3 summarizes the digital tools identified across the included studies. The diversity of tools reflects varied pedagogical approaches rather than consensus on optimal platforms.

All nine studies included HTML instruction, while only three explicitly incorporated CSS [12, 16, 17]. The limited CSS coverage may reflect its perceived complexity or time constraints in curricula. Advanced technologies (JavaScript, PHP, databases) appeared in studies with longer intervention periods or more advanced students.

Table 3 Digital tools and platforms used for web design instruction

Tool category	Specific tools	Studies using tool
Gamification platforms	Kahoot, Quiz Whizzer, Class Dojo, Construct 2, GDevelop 5	Alsuhaymi and Alotaibi [19], Fitriasari et al. [15], Huraj et al. [17], Syahri et al. [20]
Learning management systems	Moodle with mobile support	Tezer and Çimçsir [18]
Content management systems	Drupal, wProjects	Rosson et al. [13]
Development environments	Visual Studio Code, Notepad, TextPad	Jenq and Bredlau [12], Alsuhaymi and Alotaibi [19]
Server technologies	Apache, MongoDB, Node.js	Jenq and Bredlau [12], Arif et al. [16]

Table 4 Factors influencing web design learning effectiveness identified in included studies

Factor category	Specific factors	Supporting studies
Student characteristics	Prior computing experience	Jenq and Bredlau [12]
	Logical thinking ability	Nashiroh et al. [14]
	Motivation and engagement levels	Fitriasari et al. [15], Arif et al. [16], Alsuhaymi and Alotaibi [19], Syahri et al. [20]
	Interest in multimedia	Jenq and Bredlau [12], Fitriasari et al. [15]
Pedagogical approaches	Project-based learning	Jenq and Bredlau [12], Rosson et al. [13]
	Gamification elements	Fitriasari et al. [15], Arif et al. [16], Huraj et al. [17], Alsuhaymi and Alotaibi [19], Syahri et al. [20]
	Scientific/systematic approach	Nashiroh et al. [14]
	Collaborative learning	Huraj et al. [17], Syahri et al. [20]
	Interactive environments	Huraj et al. [17], Tezer and Çimşir [18]
Infrastructure	Hardware and software availability	Jenq and Bredlau [12], Tezer and Çimşir [18]
	Internet connectivity	Tezer and Çimşir [18]
	Adapted learning materials	Nashiroh et al. [14]

3.4.2 Factors influencing learning effectiveness

RQ 2: *What factors influence the effectiveness of web design instruction at the secondary level?*

Analysis of the included studies revealed three categories of factors, though the limited evidence base requires cautious interpretation (Table 4).

Notably, gamification appeared in 5 of 9 studies, suggesting emerging consensus on its potential value, though comparative effectiveness studies are absent from our dataset.

3.4.3 Teaching challenges and solutions

RQ 3: *What challenges arise in teaching web design to secondary students, and what strategies effectively address these challenges?*

Six studies explicitly documented challenges and proposed solutions [12, 14, 15, 18–20]. Table 5 maps identified challenges to proposed solutions.

The consistency of challenges across diverse geographical and educational contexts suggests systemic issues in web design education rather than localized problems. However, the limited number of studies precludes definitive conclusions about solution effectiveness.

3.5 Synthesis of results

3.5.1 Emerging pedagogical patterns

Despite the limited number of studies, clear patterns emerged regarding effective web design instruction:

Table 5 Teaching challenges and corresponding solutions from included studies

Challenge category	Proposed solutions	Studies reporting
Technical complexity (server programming, debugging)	Scaffolded instruction, simple tools initially, continuous support	Jenq and Bredlau [12], Nashiroh et al. [14]
Syntax complexity (HTML/CSS syntax rules)	Visual programming tools, incremental complexity introduction, real-time syntax checking	Jenq and Bredlau [12], Fitriasari et al. [15], Syahri et al. [20]
Maintaining engagement	Gamification, multimedia games, interactive environments	Fitriasari et al. [15], Arif et al. [16], Alsuhaymi and Alotaibi [19], Syahri et al. [20]
Abstract concept comprehension	Visual representations, hands-on practice, immediate feedback	Nashiroh et al. [14], Arif et al. [16], Huraj et al. [17], Alsuhaymi and Alotaibi [19], Syahri et al. [20]
Infrastructure limitations	Mobile solutions, offline capabilities, institutional partnerships	Tezer and Çimşir [18]
Limited prior knowledge	Pre-instruction assessment, differentiated instruction	Jenq and Bredlau [12], Nashiroh et al. [14]
Limited practice opportunities	Mobile learning platforms and web-based systems enabled practice beyond classroom hours	Tezer and Çimşir [18], Syahri et al. [20]
Assessment difficulties	Portfolio-based assessment, automated evaluation systems with peer review provided solutions	Rosson et al. [13], Syahri et al. [20]

1. Progressive complexity emerged as successful interventions introduced concepts gradually, starting with basic HTML structure before advancing to styling and interactivity.
2. Active learning dominated all studies, which emphasized hands-on practice over theoretical instruction, with student engagement directly correlating with learning outcomes.
3. Gamification proved effective, as the four studies implementing gamification elements (44.4% of reviewed studies) consistently reported improved motivation and engagement. The comprehensive implementation by Syahri et al. [20] demonstrates the evolution of this approach.
4. Collaborative learning showed clear benefits when studies incorporated peer interaction, particularly Syahri et al. [20] with structured peer review, which showed enhanced learning outcomes and student satisfaction.
5. Technology-mediated instruction through modern digital tools, from simple text editors to sophisticated gamified platforms, played crucial roles in facilitating learning.

3.5.2 Technological evolution

A temporal analysis reveals evolution in instructional technologies:

- 2007-2011: Focus on basic tools and content management systems
- 2017-2019: Introduction of game-based learning and interactive environments
- 2022-2024: Sophisticated gamification systems with social learning features, comprehensive validation processes, and integrated peer review mechanisms

This progression reflects both technological advancement and growing understanding of effective digital pedagogy.

3.5.3 Cultural and contextual influences

The concentration of studies in specific regions reveals contextual factors influencing web design education:

- *Indonesia:* Strong emphasis on vocational education, with systematic approaches to curriculum development and validation. Recent focus on gamification and peer learning [20].
- *USA:* Early adoption of web technologies in education, focus on addressing gender disparities
- *Middle East:* Recent interest in modernizing technical education through gamification
- *Europe:* Innovative approaches combining multiple technologies (escape rooms, game development)

3.6 Reporting biases

The limited number of identified studies, confirmed through comprehensive searching including Google Scholar, raises concerns about potential reporting biases. Successful interventions may be more likely to be published, while unsuccessful attempts might remain unreported. Additionally, language restrictions excluded potentially relevant studies, though the expanded search attempted to mitigate this limitation.

3.7 Certainty of evidence

Given the small number of studies and their methodological heterogeneity, the certainty of evidence remains low to moderate. While consistent patterns emerged regarding gamification effectiveness and the importance of hands-on practice, these findings should be considered preliminary. The addition of only one study through expanded searching reinforces rather than resolves this limitation, highlighting the urgent need for more rigorous research in this domain.

4 Discussion

4.1 Summary of main findings

This systematic review identified nine empirical studies examining web design education in secondary schools, revealing both promising practices and significant research gaps. The comprehensive searching strategy, including Google Scholar and expanded database coverage, yielded only one additional study beyond initial searches, confirming the scarcity of empirical research in this domain. Despite limited evidence, clear patterns emerged regarding effective instructional approaches, technological tools, and solutions to common challenges.

The dominance of gamification-based approaches in recent studies (2019-2024) represents a significant pedagogical shift. Four of nine studies incorporated game elements, with the most recent study [20] demonstrating sophisticated implementation combining gamification with peer review mechanisms. These approaches consistently showed improved student motivation and engagement, addressing a primary challenge in technical education.

The geographical concentration of research, particularly in Indonesia (4 studies), suggests regional variations in educational priorities and research focus. The prevalence of vocational school settings (77.8%) indicates that web design education may be more

systematically implemented in technical education programs than general secondary education.

4.2 Theoretical implications

The findings align with constructivist learning theories, particularly regarding the effectiveness of hands-on practice and peer collaboration. The success of gamification approaches supports self-determination theory, addressing students' needs for competence, autonomy, and relatedness. The recent integration of peer review mechanisms [20] exemplifies social constructivist principles, where learning occurs through interaction and collaborative knowledge construction.

The evolution from teacher-centered instruction to student-centered, technology-mediated learning reflects broader educational paradigm shifts. The progression from basic text editors to sophisticated gamified platforms with social features demonstrates how technological affordances can reshape pedagogical practices.

4.3 Practical implications for educators

Based on the synthesized evidence, several recommendations emerge for practitioners:

1. *Adopt progressive complexity:* Introduce HTML/CSS concepts gradually, ensuring solid foundation before advancing to complex topics.
2. *Prioritize hands-on practice:* Allocate substantial time for practical coding exercises rather than theoretical instruction.
3. *Implement gamification thoughtfully:* Consider incorporating game elements to enhance motivation, but ensure they align with learning objectives. The comprehensive approach by Syahri et al. [20] provides a validated model.
4. *Facilitate peer learning:* Create opportunities for students to review and provide feedback on each other's work, enhancing both technical skills and collaborative abilities.
5. *Leverage appropriate technology:* Select tools matching students' skill levels and available resources, from simple text editors to comprehensive learning platforms.
6. *Address gender disparities:* Implement targeted strategies to encourage female participation in web design education.
7. *Ensure adequate infrastructure:* Advocate for necessary technological resources and internet connectivity.

4.4 Implications for curriculum development

The findings suggest that effective web design curricula should integrate multiple pedagogical approaches and technologies. The recent trend toward gamification and peer review indicates promising directions for curriculum innovation. However, the scarcity of empirical research highlights the need for evidence-based curriculum design and systematic evaluation of instructional innovations.

Curriculum developers should consider:

- Balancing theoretical knowledge with practical application
- Incorporating formative assessment through peer review and automated feedback
- Designing flexible learning pathways accommodating different skill levels
- Integrating web design with broader digital literacy competencies

- Utilizing validation frameworks to ensure instructional quality

4.5 Research gaps and future directions

The extensive searching yielding only nine empirical studies reveals substantial research gaps requiring urgent attention:

1. *Comparative effectiveness studies:* Limited research directly compares different instructional approaches or technologies.
2. *Longitudinal investigations:* No studies examined long-term learning retention or skill transfer.
3. *Diverse contexts:* Most research concentrated in specific regions and vocational settings, limiting generalizability.
4. *Learning progression:* Insufficient understanding of how students develop web design competencies over time.
5. *Teacher preparation:* No studies examined teacher training or professional development needs.
6. *Assessment methods:* Limited research on valid and reliable assessment of web design skills.
7. *Scalability:* Few studies addressed implementation challenges at scale.

Future research priorities should include:

- Randomized controlled trials comparing instructional approaches
- Development and validation of standardized assessment instruments
- Investigation of teacher preparation and support needs
- Exploration of web design education in diverse cultural and economic contexts
- Examination of relationships between web design skills and broader computational thinking
- Studies on optimal integration of emerging technologies (AI, AR/VR) in web design education
- Research on sustaining motivation beyond initial gamification effects

4.6 Limitations

Several limitations constrain the conclusions drawn from this review:

1. *Limited evidence base:* Despite comprehensive searching including Google Scholar, only nine studies met inclusion criteria, reflecting the nascent state of research rather than search inadequacy.
2. *Methodological heterogeneity:* Diverse research designs and outcome measures complicated synthesis and comparison.
3. *Publication bias:* Successful interventions may be overrepresented in published literature.
4. *Language restrictions:* English-only inclusion may have excluded relevant research from non-English speaking countries.
5. *Temporal limitations:* Rapid technological change means older studies may have limited current relevance.
6. *Context specificity:* Findings may not generalize across different educational systems and cultural contexts.

4.7 Implications for systematic review methodology

This review demonstrates both the value and challenges of conducting systematic reviews in emerging educational domains with limited empirical research. The comprehensive search strategy, expanded following reviewer recommendations, validated our initial finding of research scarcity. This methodological approach – starting with traditional databases then expanding to include grey literature and regional sources – provides a model for reviews in similarly under-researched fields.

The experience highlights that:

- Systematic reviews remain valuable even with limited studies, documenting knowledge gaps as important findings
- Expanded searching may confirm rather than resolve evidence scarcity
- Transparent reporting of search processes and outcomes is crucial for establishing review credibility
- Adaptation of quality assessment tools is necessary for heterogeneous educational research

5 Conclusions

This systematic review synthesized evidence from nine empirical studies on teaching web design to secondary school students, revealing both promising practices and critical knowledge gaps. The comprehensive search strategy, including expansion to Google Scholar and additional databases, confirmed the scarcity of empirical research in this vital educational domain. Despite limited evidence, important patterns emerged regarding effective pedagogical approaches, technological tools, and strategies for addressing learning challenges.

The findings indicate that successful web design education at the secondary level requires thoughtful integration of multiple elements: progressive complexity in content presentation, substantial hands-on practice, appropriate technological tools, and strategies to maintain student engagement. The recent emergence of gamification-based approaches, particularly sophisticated implementations incorporating peer review mechanisms, shows particular promise for addressing motivational challenges while fostering collaborative learning.

The geographical and contextual concentration of existing research – predominantly in Indonesian vocational schools – highlights the need for broader investigation across diverse educational settings. The evolution from basic text editors to comprehensive gamified learning platforms reflects both technological advancement and growing understanding of effective digital pedagogy, yet systematic evaluation of these innovations remains limited.

The scarcity of empirical research, definitively confirmed through expanded searching, constitutes a significant finding itself. This gap is particularly concerning given the increasing importance of web technologies in modern education and employment. The limited evidence base constrains our ability to make definitive recommendations while simultaneously highlighting urgent research priorities.

For practitioners, the available evidence supports adopting student-centered, technology-mediated approaches emphasizing practical application over theoretical instruction. Gamification and peer learning mechanisms show promise but require

careful implementation aligned with learning objectives. Infrastructure requirements and teacher preparation needs demand attention from educational administrators and policymakers.

Future research must address multiple priorities: comparative effectiveness studies, longitudinal investigations of learning retention, exploration of diverse educational contexts, development of valid assessment instruments, and examination of teacher preparation needs. As web technologies continue evolving, research must keep pace to ensure evidence-based educational practices.

This review's contribution lies not only in synthesizing existing knowledge but also in systematically documenting the extent of research gaps. By establishing the current evidence base and identifying critical knowledge needs, this review provides a foundation for advancing both research and practice in web design education. The findings call for coordinated efforts among researchers, educators, and policymakers to develop, implement, and evaluate evidence-based approaches to preparing students for an increasingly digital future.

Acknowledgements
The authors thank the reviewers for their constructive feedback that substantially improved this manuscript.

Author contributions
OK conducted the literature search, data extraction, and initial analysis. SS supervised the research, verified the data extraction, and contributed to manuscript revision. Both authors read and approved the final manuscript.

Funding
This research received no external funding.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 8 August 2025 / Accepted: 19 December 2025
Published online: 24 December 2025

References

1. Gal-Ezer J, Stephenson C. A tale of two countries: successes and challenges in K-12 computer science education in Israel and the United States. ACM Trans Comput Educ. 2014;14(2):8. https://doi.org/10.1145/2602483.
2. Papastergiou M. Learning to design and implement educational web sites within pre-service training: a project-based learning environment and its impact on student teachers. Learn Media Technol. 2005;30(3):263–79. https://doi.org/10.1080/17439880500250451.
3. Chen CY. Effects of worked examples with explanation types and learner motivation on cognitive load and programming problem-solving performance. ACM Trans Comput Educ. 2025;25(2):23. https://doi.org/10.1145/3732791.
4. Stachel J, Marghitu D, Brahim TB, Sims R, Reynolds L, Czelusniak V. Managing cognitive load in introductory programming courses: a cognitive aware scaffolding tool. J Integr Des Process Sci. 2013;17(1):37–54. https://doi.org/10.3233/jid-2013-0004.
5. Fransson G, Holmberg J. Understanding the theoretical framework of technological pedagogical content knowledge: a collaborative self-study to understand teaching practice and aspects of knowledge. Stud Teach Educ. 2012;8(2):193–204. https://doi.org/10.1080/17425964.2012.692994.
6. Barna OV, Kuzminska OH, Semerikov SO. Enhancing digital competence through STEM-integrated universal design for learning: a pedagogical framework for computer science education in Ukrainian secondary schools. Discov Educ. 2025;4(1):357. https://doi.org/10.1007/s44217-025-00821-y.
7. Muibi H, Dorn B, Park TH. Teacher perspectives on web design instruction. In: Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE. 2015; 2015:231–236. https://doi.org/10.1145/2729094.2742606.

8. Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, et al. The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. Educ Inf. 2018;34(4):285–91. https://doi.org/10.3233/EFI-180221.
9. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. https://doi.org/10.1136/bmj.n71.
10. Hong QN, Pluye P, Fàbregues S, Bartlett G, Boardman F, Cargo M, et al. Improving the content validity of the mixed methods appraisal tool: a modified e-Delphi study. J Clin Epidemiol. 2019;111:49-59.e1. https://doi.org/10.1016/j.jclinepi.2019.03.008.
11. Braun V, Clarke V. Thematic analysis. In: Cooper H, Camic PM, Long DL, Panter AT, Rindskopf D, Sher KJ, editors. APA handbook of research methods inpsychology. vol. 2; Research designs: quantitative, qualitative, neuropsychological, and biological. Washington, DC: American Psychological Association; 2012. p. 57–71.
12. Jenq J, Bredlau C. Pre-college student learning of web development technologies. In: IMSCI 2007 - International Multi-Conference on Society, Cybernetics and Informatics, Proceedings. 2007;1:147–152. https://www.iiis.org/p-proceedings/july2007/IMSCI-I/IMSCI-Book-Vol-I.pdf.
13. Rosson MB, Thiry E, Zhao D, Carroll JM. Teachers as designers: enabling teachers to specify dynamic web programming projects for students. In: Costabile MF, Dittrich Y, Fischer G, Piccinno A, editors. End-user development. Berlin: Springer; 2011. p. 233–8.
14. Nashiroh PK, Kamdi W, Elmunsyah H. The effectiveness of web-programming module based on scientific approach to train logical thinking ability for students in vocational high school. AIP Conf Proc. 2017;1887:020068. https://doi.org/10.1063/1.5003551.
15. Fitriasari NS, Ashiddiqi MF, Nurdin EA. Improving student understanding in web programming material through multimedia adventure games. J Phys: Conf Ser. 2018;1013(1):012101. https://doi.org/10.1088/1742-6596/1013/1/012101.
16. Arif RF, Rosyid HA, Utomo P. Design and Implementation of Interactive Coding with Gamification for Web Programming Subject for Vocational High School Students. In: ICEEIE 2019 - International Conference on Electrical, Electronics and Information Engineering: Emerging Innovative Technology for Sustainable Future; 2019. 177–182. https://doi.org/10.1109/ICEEIE47180.2019.8981454.
17. Huraj L, Hrmo R, Sejutová HM. The impact of a digital escape room focused on HTML and computer networks on vocational high school students. Educ Sci. 2022;12(10):682. https://doi.org/10.3390/educsci12100682.
18. Tezer M, Çimşir BT. 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. Interact Learn Environ. 2018;26(3):402–10. https://doi.org/10.1080/10494820.2017.1337037.
19. Alsuhaymi DS, Alotaibi OM. Gamification's efficacy in enhancing students' HTML programming skills and academic achievement motivation. J Educ e-Learn Res. 2023;10(3):397–407. https://doi.org/10.20448/jeelr.v10i3.4738.
20. Syahri EPM, Smaragdina AA, Widyaningtyas T. Development of Gamification-Based Web Programming Educational Website with Peer Review to Increase Student Learning Motivation. In: 2024 IEEE 2nd International Conference on Electrical Engineering, Computer and Information Technology (ICEECIT); 2024. 378–383. https://doi.org/10.1109/ICEECIT63698.2024.10859724.

Publisher's Note