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The Role Of Online Courses And Webinars In Developing The Digital Competence Of A Biology Teacher

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Abstract: This article examines how online courses and webinars contribute to the development of biology teachers' digital competence across pedagogical, technical, and subject-specific dimensions. Anchored in established frameworks (DigCompEdu, TPACK, SAMR) and the science-specific demands of biology education, the study conceptualizes digital competence as an integrated set of knowledge, skills, values, and reflective dispositions that enable teachers to design evidence-based learning with digital tools, orchestrate safe and ethical online practices, and evaluate learning outcomes with data-informed methods. The aim is to determine how instructor-led and self-paced online learning formats influence progression along competence levels from substitution to transformation, and how these formats interact with teachers' prior experience, school ecology, and national curriculum expectations. Methodologically, the paper employs a mixed theoretical synthesis and analytic modeling of program structures commonly found in online professional development for science teachers, including MOOCs, micro-credentials, synchronous webinars, and coaching cycles. The discussion shows that online courses build systematic knowledge and offer reusable artifacts, while webinars catalyze just-in-time adaptation, community validation, and transfer to practice. The combination of asynchronous coursework and synchronous reflection emerges as a robust pathway to sustained change in lesson design, laboratory simulation, fieldwork digitization, formative analytics, and inclusive practices for diverse learners. The conclusion argues that the most effective initiatives are those that embed authentic biology tasks, iterative feedback, classroom trials, and public sharing of outcomes, thereby converting episodic training into durable professional identity growth.

Keywords: Digital competence; biology education; online courses; webinars; DigCompEdu; TPACK; SAMR; teacher professional development.

Introduction: The accelerating digitization of education has expanded the repertoire of tools and practices available to biology teachers, from virtual microscopy and data-logging probes to citizen-science platforms and AI-assisted feedback systems. Yet tools alone do not guarantee meaningful learning; what matters is the teacher's competence in aligning digital resources with biological concepts, inquiry processes, and assessment criteria. Digital competence in this context is not merely technical fluency. It includes the ability to design investigations that reflect the epistemology of biology, to scaffold students' work with multimodal representations of complex systems, to manage privacy and ethical considerations in data-rich environments, and to evaluate evidence of learning with transparent criteria. Traditional workshops provide partial support, but their episodic nature often fails to accommodate the dynamic pace of technological change. Online courses and webinars have emerged as flexible formats capable of meeting teachers where they are, offering layered content with practice-oriented tasks and enabling communities that extend beyond a single school.

Post-pandemic realities have strengthened the perception that biology instruction must operate across modalities without compromising inquiry-based learning. Virtual labs can approximate experimentation when access to physical resources is limited; remote fieldwork can be augmented through geospatial apps and image repositories; and class discussions can be textured by collaborative platforms that track argumentation and evidence. In each case, the teacher's digital competence is decisive. As professional development migrates online, the question becomes not whether to use online courses and webinars, but how these modalities reshape competence development and whether they promote sustainable changes in classroom practice.

The study aims to analyze the contribution of online courses and webinars to the development of biology teachers' digital competence, clarifying the mechanisms by which these modalities support movement from tool adoption toward pedagogical transformation and identifying conditions that maximize transfer, equity, and sustainability in science teaching.

The material for analysis includes widely used competence frameworks and documented features of online professional development formats pertinent to science education. DigCompEdu provides a progression from foundational to innovative practice, specifying areas such as professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating students' digital competence. TPACK articulates the intersection of technological, pedagogical, and content knowledge, while the SAMR heuristic differentiates degrees of technology integration from substitution to redefinition. These models are treated not as static taxonomies but as lenses for examining how professional development activities produce change.

Methodologically, the article uses theoretical synthesis and model-based reasoning. First, it maps online course designs—self-paced modules with multimedia content, assignment banks, and peer discussion—onto competence areas that benefit from deliberate practice, such as resource curation, instructional sequencing, and rubric design for digital tasks. Second, it analyzes webinars—time-bound, interactive sessions often centered on demonstration and Q&A—as catalysts for contextualization, troubleshooting, and community sense-making. Third, the paper models change processes that combine the two modalities into iterative cycles: course-based knowledge acquisition and artifact production, webinar-based reflection and adaptation, classroom trial, peer feedback, and refinement. The analysis pays special attention to biology-specific affordances, including virtual experiments, data literacy in ecology and genetics, and visualization of microscopic and molecular processes. While no new empirical dataset is collected, the method triangulates claims by aligning them with established research on online learning effectiveness, teacher professional development, and cognitive aspects of multimedia learning.

Online courses and webinars address complementary aspects of digital competence for biology teachers. The structure of a well-designed online course affords time-on-task for developing conceptual clarity and producing tangible resources. Modules that sequence video lectures with readings and scenario-based tasks allow teachers to reconstruct their understanding of inquiry, modeling, and argumentation in a digital ecosystem. For example, a course unit on virtual labs does more than list available simulators; it situates them within the logic of experimental design, prompting teachers to plan controls, variables, and data capture strategies that mirror authentic biological investigation. Assignments ask for redesigned lessons that incorporate simulation parameters, data export procedures, and student reflection prompts. Peer forums enable critique that foregrounds conceptual coherence, not just interface proficiency. In this setting, teachers internalize evaluation criteria for digital tools, learning to distinguish between flashy animations and simulations that uphold causality and measure meaningful variables.

Webinars, by contrast, compress expertise into a live, dialogic event that privileges immediacy and contextual relevance. When a teacher encounters an obstacle—students gaming a virtual lab, inequities in device access, or misinterpretation of phylogenetic trees—the webinar offers an opportunity to present the problem, receive targeted suggestions, and observe demonstrations tailored to typical classroom constraints. The temporal pressure of the synchronous format encourages concrete exemplification: presenters share screen-captured workflows, display student artifacts, and model feedback language aligned with scientific practices. What might remain abstract in an asynchronous course becomes vivid and emulable, strengthening the teacher's confidence to enact change in the next lesson cycle. Equally important, webinars cultivate a sense of professional belonging that mitigates the isolation that sometimes accompanies self-paced study. Participants witness a repertoire of solutions arising from diverse school contexts, broadening their imagination of what is possible within their own constraints.

The combination of modalities creates a developmental spiral. Teachers use an online course to construct a lesson plan that integrates, for instance, a population genetics simulator with a collaborative spreadsheet for data aggregation and a visualization platform for allele frequency graphs. After initial classroom implementation, a webinar provides a venue to report anomalies—students' confusion about Hardy–Weinberg assumptions or difficulties interpreting stochastic fluctuations—prompting facilitators and peers to suggest scaffolds such as guided questions, exemplar graphs, and micro-lectures on sampling error. The teacher revises materials, implements the lesson again, and contributes the refined version to the course repository, where others adapt it for different grade levels or curricular standards. In this way, the teacher's digital competence advances not only through exposure to content but through cycles of design, enactment, reflection, and sharing.

Crucial to sustainability is the alignment of online learning with assessment practices. Biology teachers who evaluate digital tasks with transparent rubrics informed by disciplinary practices—defining quality in experimental design, data interpretation, and model construction—are more likely to retain new methods. Online courses can anchor this alignment by providing rubric exemplars and analytics dashboards that visualize student progress on specific criteria. Webinars can then showcase how to interpret these dashboards to inform re-teaching or targeted feedback. When teachers experience assessment as an instructional compass rather than a terminal judgment, digital tools become vehicles for formative insight rather than distractions. Over time, this reorientation reduces cognitive overload because planning coheres around a few stable evaluative anchors.

The ethical dimension of digital competence is equally shaped by online learning. Biology frequently involves sensitive data—health indicators in human physiology labs, location data in field ecology, and images from living organisms. Courses that include modules on privacy, consent, and data minimization, accompanied by scenario-based dilemmas, enable teachers to articulate policies that are both legally compliant and pedagogically transparent. Webinars add lived nuance by surfacing edge cases from classrooms and discussing how to honor student dignity when sharing artifacts or conducting remote assessments. The resulting competence is not only technical or didactic but moral-professional, positioning the biology teacher as a responsible steward of scientific inquiry in digital spaces.

In contexts with uneven infrastructure, webinars can be optimized for low bandwidth and recorded for asynchronous access, while course platforms can offer downloadable content and offline activity guides. These accommodations matter in ensuring equitable participation and preventing the stratification of competence by connectivity. Moreover, the social architecture of online learning environments influences persistence. Courses that incorporate small peer cohorts, coaching checkpoints, and public showcases of classroom products tend to sustain engagement beyond the initial novelty. Webinars that rotate facilitation among practitioners decentralize authority and multiply vantage points, encouraging teachers to move from consumers to contributors.

The science-specific affordances of digital media transform biology instruction when competence is sufficiently developed. Virtual microscopy democratizes access to histological structures; geospatial tools support authentic biodiversity mapping; open datasets from genomics and climate science allow students to practice real analysis; and simulation-based labs make invisible processes manipulable. Yet the threshold for transformation is pedagogical, not merely technical. Teachers must orchestrate sequences that begin with curiosity, proceed through guided exploration with checkpoints for conceptual consolidation, and culminate in artifact creation that makes reasoning inspectable. Online courses provide the architecture for designing such sequences, while webinars supply the micro-moves—question stems, pacing decisions, and feedback routines—that render sequences executable with real students. This symbiosis explains why portfolios emerging from robust programs often show not only new tools but also clearer rationales and stronger student work.

Finally, the identity dimension of competence deserves emphasis. Biology teachers who repeatedly present their classroom inquiries in webinars and publish refined artifacts in course repositories begin to see themselves as designers and researchers of their own practice. This identity shift correlates with resilience in the face of new technologies: rather than waiting for prescriptive guidance, teachers mobilize design principles to evaluate novelty and to iterate responsibly. The professional narrative changes from "learning to use tools" to "cultivating scientific teaching," a stance that aligns with the epistemic aims of biology education and sustains innovation beyond any single platform's lifespan.

Online courses and webinars jointly constitute a powerful ecosystem for developing biology teachers' digital competence when they are designed as complementary engines of knowledge building and contextualized enactment. Courses furnish structured progression, disciplinary alignment, and durable artifacts; webinars provide immediacy, community problem-solving, and adaptive transfer. Together they enable iterative cycles in which teachers design, implement, analyze, and refine biologically authentic learning experiences. The most effective programs embed assessment literacy, ethical awareness, and equity considerations, ensuring that digital transformation advances both scientific rigor and inclusion. As schools continue to navigate hybrid realities, investment in integrated online professional development that honors the specificity of biology as a knowledge-making discipline will be decisive in shaping classrooms where technology deepens inquiry rather than distracting from it. In this vision, digital competence is not an accessory but a core dimension of professional expertise, cultivated through sustained, dialogic, and evidence-oriented engagement across online courses and webinars.

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