



Open Educational Resources for Teaching Computer Science Pedagogy to Secondary School Computer Science Teachers

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Agenda

- Introduction
- Related Work
- Design of the CS Pedagogy OER Modules
- Results
- Evaluation
- Discussion



Introduction

- Global advocacy for ‘CS for all’ and CS as foundational in general education (Hubwieser et al. 2015)
- In Germany: multiple federal states introduce(d) CS as a compulsory lower-secondary subject; electives in upper secondary remain (GI 2024)
- Critical bottleneck: acute shortage of fully qualified CS teachers and teacher trainers
- Projection (NRW): without intervention, <6% of demand for CS teachers will be met by 2030 (Klemm 2020)
- Comparable international challenges reported (Ramagoni 2023, Williams et a. 2020)
- **Need: rapid + sustainable expansion of teacher-education capacity and high-quality instructional resources**



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Why CS Pedagogy OER are needed

CS Pedagogy in CS Teacher Education

- CS Pedagogy
 - Bridges disciplinary CS knowledge and educational science
 - Supports reconstruction of complex CS concepts for diverse classroom contexts
- Newly established research groups and in-service programs face time-intensive material development if working alone
- Fragmentation leads to redundant efforts and missed opportunities for shared expertise

Why OER?

- Open licensing enables adaptation, translation, remixing without legal/financial barriers
- Accelerates dissemination and fosters collaboration
- Research indicates modular, research-grounded OER lower the ‘finding – getting – using’ threshold. (Dichev / Dicheva 2012)



Objectives and Process

- In NRW (most populous federal states within Germany): eight universities provide CS teacher-degree programs; each offers ≥ 15 ECTS credit points in CS pedagogy
- Five NRW universities + two from other federal states formed the FAIBLE.nrw consortium from 2022-2024
- Aims:
 - openly licensed, modular resources linking CS content, educational science, and pedagogy
 - Support heterogeneous program structures, learner backgrounds, and varied instructional scenarios
- Thematic areas selected collaboratively for broad curricular relevance (not institution-specific)
- Existing digital assets refactored, enriched, and (re)licensed under Creative Commons
- Modules evaluated within university courses at participating institutions



FAIBLE.nrw Consortium (2022-2024; OERContent.nrw)

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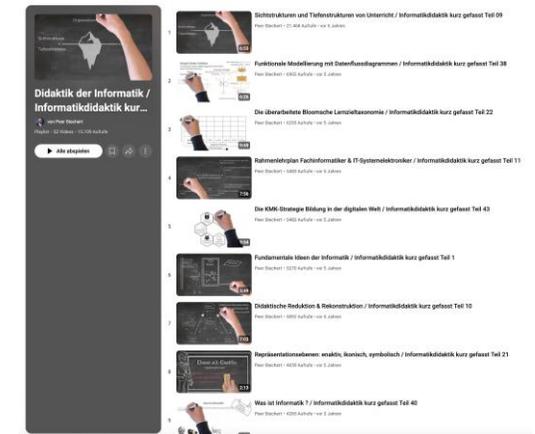


Related Work: CS Pedagogy OER Landscape

- UNESCO recommendation on OER (2019): build capacity, supportive policies, sustainable models for inclusive / equitable education via OER
- CS teacher education:
 - Many repositories exist, often not conceived as OER; many are (mostly) ready-to-use classroom resources
 - International portals: teachcomputing.org, exploringcs.org, ai4k12.org, csunplugged.org, barefootcomputing.org, ...
 - German examples: informatik.schule.de; state servers (e. g., Hamburg); university collections (Wuppertal, FU Berlin, Göttingen, RWTH Aachen, ...)
 - Freely accessible, research-informed course modules on CS pedagogy are rare (e. g., Peer Stechert's YouTube channel on "CS pedagogy in brief")



teachcomputing.org



<https://tinyurl.com/indikuge>

Related Work: Barriers & Developments

- CS instructors survey findings (Dichev & Dicheva 2012):
 - strong interest in OER, but ‘finding-getting-using’ remains difficult
 - further barriers:
 - adaptation effort
 - gaps in topic coverage
 - language barriers (many OER in English)
- DACH development
 - LOG IN → open-access journal IBiS (<https://www.informatischebildung.de/>)
- Recent survey (Rampelt et al., 2025)
 - educators value smaller, modular OER that are high-quality, accessible, and curriculum-relevant
 - source reputation less critical than content fitness
- **Need for (further) OER in CS teacher education**



Design of the CS Pedagogy OER Modules

- Project partners had already accumulated a broad range of teaching and learning material in CS pedagogy and CS education research
- Material tailored to local curricular structures, embedded in institution-specific learning management systems, and not openly licensed
- Originally created for in-person instruction and not developed with interoperability or modular reuse in mind
- Project set out to select a cross-institutional set of topic modules that were pedagogically relevant across sites and amenable to conceptual refinement
- Existing digital artefacts (slides, activities, ...) were systematically reviewed, adapted, and enriched where possible, with licensing barriers removed to ensure compliance with OER standards
- Participating universities differed substantially in their degree programmes, contact-hour models, and school internships integration
 - material needed to be usable in both low- and high-contact scenarios, across undergraduate and graduate levels, and in both university-based and school-centred contexts
 - need for a modular design approach, flexible sequencing



Design Principles (I)

Constructive Alignment

- Each module addresses at least one central didactic dimension (e. g., learning objectives, prerequisites, content selection, methods)
- Expected learning outcomes:
 - classify theoretical constructs
 - apply to authentic classroom scenarios
 - analyse interdependencies
 - derive implications
 - evaluate lessons
 - ...
- Aligned assessment formats: portfolios, written assignments, oral examinations

Accordance with Didactic-Methodological Principles that Support Self-Organised and Self-Directed Learning

- Modules should be usable as stand-alone self-study units and as components in face-to-face teaching
- Support inverted classroom models, lectures, exercises, seminars, labs
- Allows combining several modules into a course



Design Principles (II)

Media Diversity & Accessibility

- Portfolio of media: texts, slide casts, videos, interactive H5P activities, diagrams, interviews, quizzes, self-assessments
- Compliance with Universal Design for Learning guidelines for accessibility
- Inclusion of learner-generated content should be encouraged for feedback and collaborative OER development

Coordinated Workflow & Sustainability

- Each module spans ~1–3 teaching sessions; flexible sequencing into longer units
- Joint instructors' handbook: guidance on dependencies and sequencing strategies
- Coordination via regular project meetings; manage versions for curricular heterogeneity
- Facilitate cross-institutional collaboration: guest contributions
- Metadata for filtering by program type, didactic function, and prerequisites; supports interoperability



Results: Modules (I)

Foundational Perspectives on CS Education

- **What is Computer Science?:** historical and epistemological development; clarifies disciplinary identity
- **Historical Models of CS Education:** hardware-, algorithm-, application-, user-oriented models; analytical tools for design
- **Idea Orientation:** fundamental ideas in informatics; five criteria for content selection and prioritization
- **Model Orientation:** modelling in CS – model theory, subject-specific understandings, and classroom applications (upper secondary)
- **System Orientation:** systems-theoretical approach; computing systems, software as components, socio-technical implications (incl. AI)
- **Digital Education:** contextualizes CS within policy frameworks

Teaching Practice in CS Education

- **Context-Oriented CS Education:** design of context-rich CS learning environments
- **CS Teaching Methods:** toolkit of guiding and phase-specific methods (method cards + script)
- **Educational Reconstruction:** structured process to transform subject matter into teachable content
- **CS-Pedagogical Principles:** links principles to characteristics of effective teaching; supports evaluation and planning
- **Practical Tips:** everyday school challenges – blackboard notes, exam creation, content preparation; bridges to practice



Results: Modules (II)

Subject-Specific CS Content

- **Programming Pedagogy:** core didactic approaches; seven chapters (goals, languages, learning theories, teamwork, assessment, etc.).
- **Physical Computing:** basics of electronics and microcontroller programming (Arduino); 'Smart Home' project
- **Data Awareness:** conceptual model for analysing data-driven artefacts; explanatory models; lower-secondary classroom example

OER Cycle & Infrastructure

- **OER Cycle & Infrastructure:** Full self-study course on the concept, use, and development of OER

Heterogeneity, Inclusion, and Educational Equity

- **Inclusion with a Focus on Visual Impairments:** legal, pedagogical, technical foundations; assistive tech; differentiation strategies; achievement-equivalent learning
- **Inclusion in Practice:** three-phase internship -- theory, teacher support materials, inclusive prototypes; design-based learning
- **Gender:** analyses of gender dynamics in CS learning and participation; integrates multiple data and lenses
- **Discipline-specific Language Education:** role of language in CS; strategies for reading, writing, speaking in CS classrooms



Results

Project Website

- faible.nrw

Automatic Translation (German → English (Google Translate))

- https://faible-nrw.translate.google.com/?x_tr_sl=auto&x_tr_tl=en&x_tr_hl=de&x_tr_pto=wapp



Evaluation (I)

Approach

- Jointly developed evaluation concept combining formative and summative elements
- Components
 - internal ring peer review
 - integration into university teaching with course evaluations
 - expert inspections of usability
- Focus criteria: OER compliance, pedagogical quality, reusability across institutional contexts.

Peer Review Findings

- Each module reviewed by ≥ 2 experts using a standardized rubric (licensing, quality, modularity, usability)
- Confirmation: modules meet core requirements for open licensing and academic integrity
- Strengths noted: didactic structure, clarity of learning objectives, diverse media integration



Evaluation (II)

Challenges: incomplete/inconsistent third-party attributions; layout inconsistencies; limited metadata or orientation aids; occasional misalignment of outcomes and activities; technical issues (e.g., narration quality), missing time estimates.

Two coordinated revision cycles (concluding Q2 2024) addressed feedback:

- harmonized design templates
- corrected licensing attributions
- didactic annotations and example applications
- brief module overviews for onboarding

Pilots & Usability Inspections

- Piloting from winter semester 2022/23 across five participating NRW universities in varied formats (lectures, seminars, practicums)
- Student teacher feedback (local evaluations): requests for shorter videos, more self-checks, clearer curricular contextualization; overall positive on accessibility, relevance, adaptability
- Formal usability testing was substituted by expert walkthroughs/inspections due to decentralized architecture and no dedicated LMS



Discussion

Summary

- Collaboratively developed, openly licensed modules fill gaps in research-grounded CS pedagogy resources
- Alignment of theoretical dossiers with classroom tasks supports immediate adoption
- Ring evaluation confirms OER compliance, reusability across heterogeneous curricula, and sufficient detail for use

Selective Integration in Multiple Contexts

- University programs: embed single modules (e. g., Programming Pedagogy, Physical Computing) or assemble sequences; reflection seminars (CS Teaching Methods)
- Continuing professional development: blended workshops pairing self-study and coaching; use H5P quizzes for formative assessment
- Certificate/extension programs: structured self-learning path for in-service teachers
- Cross-university collaboration: editable source files enable adaptation and sharing of improvements



Discussion

Language & Transfer

- Modules produced in German to meet immediate needs in NRW
- Open licensing permits translation; emerging AI-based translation tools (e. g., DeepL) or general-purpose AI chatbots can assist initial drafts
- Segment-level translation of slide decks is facilitated by modular file structures
- Lays groundwork for international collaboration in CS teacher education

Limitations & Future Work

- Evaluation relied on expert reviews and standard course feedback; no large-scale, cross-site learning-outcome study conducted
- Open tasks
 - quasi-experimental designs to measure gains in pedagogical content knowledge across cohorts
 - Monitoring: systematic tracking of broader adoption and community-driven revisions





Many thanks for your attention!

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