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4Cs Competences and Teacher Self-Efficacy in Elementary Education (2020–2030 Report and Foresight)

Kompetencje 4K a poczucie skuteczności nauczycieli edukacji wczesnoszkolnej (raport i prognoza na lata 2020–2030)

KEYWORDS

4Cs competences, teacher self-efficacy, elementary education, STEAM, 21st Century Skills, competences, ICT, AI

ABSTRACT

The aim of the article is to examine how the 4Cs – Critical Thinking, Creativity, Communication, and Collaboration – are embedded in elementary education between 2020 and 2030, with a particular focus on Poland in comparison to selected international cases. The research addresses the problem of uneven policy traction and classroom practice, exploring how national strategies, professional development systems, and technology initiatives shape both pupil competences and teacher self-efficacy. Methodologically, it adopts a narrative literature review, drawing on OECD data, international policy documents, and empirical studies in English and Polish. The analysis progresses through four stages: (1) mapping policy frameworks, (2) assessing links between 4Cs and teacher self-efficacy, (3) evaluating pedagogical models such as STEAM and project-based learning, and (4) analyzing the impact of ICT, AI, and post-pandemic realities. Results show that jurisdictions embedding explicit 4Cs standards and sustained professional development (e.g. Finland, Korea) report higher teacher self-efficacy, while discretionary uptake leads to fragmented practice (e.g. Poland, several U.S. states). The article concludes with recommendations for statutory 4Cs descriptors, STEAM-oriented professional development, digital infrastructure,

and well-being supports, thus contributing new evidence-based perspectives to pedagogical thought. The self-efficacy is highest when 4Cs training permeates both pre- and in-service programmes which introduces new research areas focusing on the education of future early childhood teachers to prepare educators and learners for a complex, technology-rich future by 2030.

SŁOWA KLUCZE

kompetencje 4K, poczucie własnej skuteczności nauczycieli, edukacja wczesnoszkolna, STEAM, kompetencje XXI wieku, TIK, AI

ABSTRAKT

Celem artykułu jest zbadanie, w jaki sposób kompetencje 4K – myślenie krytyczne, kreatywność, komunikacja i kooperacja – są wdrażane w edukacji podstawowej w latach 2020–2030 w Polsce w porównaniu z innymi krajami. Badania poruszają problem nierównomiernego wdrażania założeń 4K do praktyki szkolnej. Analizują, w jaki sposób strategie krajowe, systemy rozwoju zawodowego i inicjatywy technologiczne kształtują kompetencje uczniów i poczucie własnej skuteczności nauczycieli. Zastosowano narracyjny przegląd literatury, opierając się na danych OECD i badaniach empirycznych w języku angielskim i polskim z lat 2020–2025. Analiza obejmowała cztery etapy: (1) mapowanie ram polityk oświatowych, (2) ocena powiązania 4K z poczuciem własnej skuteczności nauczycieli, (3) ewaluacja modeli pedagogicznych, takich jak STEAM, i uczenie się oparte na projektach oraz (4) analiza wpływu ICT, AI i realiów postpandemicznych. Wyniki pokazują, że wdrożenie jasno określonych standardów 4K i stały rozwój zawodowy (np. w Finlandii, Korei) sprzyja wyższemu poczuciu własnej skuteczności nauczycieli, podczas gdy dyskrecjonalne wdrażanie prowadzi do fragmentacji praktyki (np. w Polsce, USA). Artykuł kończą rekomendacje dotyczące ustawowych deskryptorów 4K, rozwoju zawodowego zorientowanego na STEAM, infrastruktury cyfrowej i wsparcia dobrostanu, wnosząc tym samym nowe, oparte na badaniach perspektywy do refleksji pedagogicznej. Poczucie własnej skuteczności jest wyższe, gdy szkolenia 4K obejmują obecną i przyszłą kadrę, co sugeruje dalsze badania kształcenia przyszłych nauczycieli wczesnej edukacji, tak aby do 2030 roku przygotować edukatorów i uczniów do złożonej, bogatej w technologie przyszłości.

Introduction

Education reformers argue that schooling must do more than transmit facts; it must enable young learners to navigate a technology-saturated world. The competences cited as critical for such navigation are the 4Cs – Critical Thinking, Creativity, Communication and Collaboration. Routine cognitive work is shrinking as AI automates rule-based tasks, while jobs requiring creativity and interpersonal problem-solving are

expanding (OECD, 2024). In parallel, the World Economic Forum's skills surveys place analytical thinking, flexibility and teamwork as the top future work attributes (WEF, 2023). Yet naming the 4Cs in policy documents does not guarantee classroom uptake (So et al., 2017). Teachers act as linchpins: their willingness and capability to redesign lessons around open-ended inquiry, peer dialogue and prototyping determines the 4Cs implementation (Patston et al., 2021). Teacher self-efficacy – rooted in Bandura's (1977) social-cognitive theory – emerges as a determinant (Holzberger & Prestele, 2021). Higher self-efficacy implies greater use of student-centred methods and resilience (Barni et al., 2019).

The article asks: How do national strategies, professional-development systems and technology initiatives cultivate both the 4Cs in learners and teachers' self-efficacy? The analysis pays attention to STEAM-based pedagogies, the digitalisation forced by the COVID-19 pandemic, and the diffusion of AI, which shape primary schooling to 2030. The review is also situated within the BANI (Brittle, Anxious, Non-linear, Incomprehensible) paradigm, which posits that volatility may break systems in unexpected places. The goal is to generate evidence-based insights and recommendations for preparing educators and students.

Research Methods

To address the research questions, a narrative literature review was undertaken. This approach was selected as particularly suitable for mapping complex educational, sociocultural, and technological phenomena, while allowing for a combination of theoretical insights and empirical evidence (Sukhera, 2022). Moreover, in a narrative literature review, relevant documents containing ideas, data, and opinions are selected to identify the main issues and debates surrounding the topic under study. This allows potential gaps in policy or literature to be identified and highlighted, and suggests directions for future research (Creswell, 2009).

Unlike systematic reviews, narrative reviews are not constrained to a pre-defined methodology for selecting and assessing studies. However, the initial stage of this analysis involved systematic searches across Scopus, ERIC, Google Scholar, and institutional portals (OECD, UNESCO, Eurydice), covering sources in English and Polish. The inclusion criterion was to accept only texts that 1) explicitly refer to the 4Cs concept and/or teacher self-efficacy in primary education, with optional references to STEAM, ICT, or AI; 2) were published from 2020 to 2025 and thus reflect post-pandemic transformations and AI adoption trends.

This study explores global frameworks for the future international education and case-based analysis of Polish and chosen educational policies in the world. First, texts

were subjected to thematic coding, whereby recurring issues such as policy frameworks, professional development, pedagogical models, technology integration, and teacher well-being were identified. Second, the material was categorised into analytical clusters aligned with the article's objectives: (1) policy recognition and curricular embedding of the 4Cs; (2) professional preparation and self-efficacy; (3) pedagogical innovations (STEAM, PBL, inquiry-based learning); (4) technological and post-pandemic challenges; and (5) cross-national comparative insights. Finally, a process of synthesis and interpretation was undertaken, linking evidence to the conceptual frame of teacher self-efficacy and to foresight scenarios extending to 2030.

This layered procedure ensured not only a comprehensive overview of the literature but also a structured categorisation of findings, enabling the identification of gaps, recurrent patterns, and actionable recommendations.

4Cs in Education Policy

Education policy increasingly foregrounds "whole-child" competences. Since routine tasks are automated, schooling must prioritise creativity and critical thinking (Vincent-Lancrin et al., 2019). Forecasts rank creativity, critical thinking, communication, and collaboration among the foremost skills for tomorrow's workforce (World Economic Forum, 2023), the transversal competences. Most EU states embed them in primary syllabi, whereas Poland references them only indirectly, leaving enactment to individual schools (European Agency for Special Needs and Inclusive Education, 2023). In contrary, South Korea's 2015 curriculum prescribes "creative thinking competency" and "communication competency" as obligatory outcomes (Jeong, 2020). Finland's core curriculum similarly threads equivalent skills through phenomenon-based modules, supplying teachers with detailed rubrics, while the United States relies on the voluntary Partnership for 21st Century Skills framework, yielding heterogeneous uptake. Thus, policy recognition is universal, yet while 4Cs may be on the educational agenda, guidance in some countries or states is lacking on pedagogy and assessment (Lucas, 2022). Where 4Cs are codified (e.g. Korea's "creative experiential learning" hours) teachers receive clearer directives and resources to integrate them across subjects (KERIS, 2021).

4Cs and Teacher Self-Efficacy

Teacher self-efficacy predicts instructional innovation and perseverance with SEN pupils (Bandura, 1977; Barni et al., 2019). Evidence indicates a reciprocal relationship: confident, comprehensively trained teachers tend to embed the 4Cs regularly

which consolidates professional competence. Sutjonong et al. (2022) showed that efficacy partially mediates the link between creative pedagogy and perceived pupil creativity. Likewise, TALIS respondents with cross-curricular training reported superior efficacy in creativity and critical-thinking instruction (OECD, 2020).

Analyses confirm that professional development targeting 21st-century skills elevates both individual confidence and collegial collaboration (Vincent-Lancrin et al., 2019). Conversely, curricula overloaded with factual content or absent scaffolded inquiry depress efficacy – particularly among novices unfamiliar with STEAM approaches. Consistent with Bandura's "mastery-experience" mechanism, both initial preparation and in-service programmes must integrate 4Cs pedagogy (Long et al., 2024). Collaborative school cultures intensify these gains: teacher teams and learning communities focused on 4Cs projects strengthen collective efficacy (Wullschleger et al., 2025). Hence, developing students' 4Cs and sustaining innovative practice depend on systemic provision of training, resources and structured peer support (Holzberger & Prestele, 2021).

Educational Models and 4Cs Implementation

Certain pedagogical models (Montessori, Waldorf) cultivate the 4Cs by emphasizing learner agency, hands-on inquiry and socio-emotional growth – qualitative studies report elevated teacher confidence in facilitating open-ended tasks (Lucas, 2022). Likewise, schools organising interdisciplinary projects demanding communication, teamwork and critical problem-solving usually provide high teacher autonomy and collective morale.

Cross-national evidence corroborates the pattern: Finland's phenomenon-based modules and Singapore's inquiry cycles coincide with higher self-efficacy for student-centred strategies (Schaffar & Wolff, 2024). In the United States, sustained participation in professional learning communities (PLCs) similarly raises self-efficacy and uptake of innovative practice (Anderson & Olivier, 2022). In sum, interdisciplinary, learner-centred formats most reliably advance 4Cs, provided teachers obtain specialised preparation and ongoing support.

Optimal Practices for 4Cs

Project- and inquiry-based formats (PBL, IBL) constitute the most consistently documented conduits for 4Cs integration (Vincent-Lancrin et al., 2019). Elementary PBL studies register measurable gains in communication and creative problem-solving (Lucas, 2022), while a meta-review of STEM/STEAM initiatives shows that

well-scaffolded projects enhance creativity and critical thinking, contingent on teacher guidance (Kwon & Lee, 2025). In a 16-week professional-learning community, 49 in-service teachers who co-designed hands-on STEAM tasks reported substantial growth in interdisciplinary self-efficacy, though design-specific confidence required continued support (Gülhan, 2024). This suggests that intensive STEAM-focused professional development can strengthen teacher beliefs in their ability to teach 4Cs.

Additional practices include integrated thematic units linking science with visual or performing arts, maker education that embeds digital fabrication, and structured collaborative groups followed by guided reflection. Each approach demands explicit scaffolding: facilitation protocols, formative rubrics, and portfolio assessment are pivotal for teachers to feel capable of sustaining open-ended inquiry. Therefore STEAM and PBL are the most promising practices for cultivating the 4Cs (Tran et al., 2021), provided that the pedagogy is genuinely inquiry-driven and inclusive of creativity. Accordingly, schools with exemplary 4Cs outcomes typically pair PBL/STEAM curricula with ongoing coaching or mentorship, enabling continuous reflection and confidence building.

Technology, AI, and Post-COVID Realities

ICT and AI present ambivalent prospects for 4Cs education. Virtual collaboration suites, creative-design software and serious games can broaden communication and creativity; digital storytelling (Churchill, 2020) and coding simulations illustrate such affordances. AI-driven tutors likewise personalize critical-thinking practice by adaptive questioning. However, research cautions that technological benefits for 4Cs depend entirely on how it is used by teachers (Kim et al., 2022).

The COVID-19 lockdowns exposed this contingency. Emergency remote schooling revealed stark digital divides – devices and bandwidth were scarce in disadvantaged communities – and many Polish teachers, with limited ICT training, struggled to transpose collaborative projects online. Studies reported reduced engagement and fewer 4Cs activities, attributable to screen fatigue and social isolation (Plebańska et al., 2020). Nevertheless, inventive educators used breakout rooms for peer debate and maker apps for at-home prototyping (Squire, 2021); teachers with higher tech-efficacy sustained 4Cs practice despite constraints.

Post-pandemic agendas thus emphasise blended provision and "smart education" initiatives (Jeong, 2020; García-Tudela et al., 2021) and infrastructures (Wang et al., 2021). OECD systems now pilot AI laboratories and digital-skills frameworks, trends accelerated by COVID-19 (European Commission, 2020). Poland's rapid-response webinars seeded competence but long-term integration remains uneven. Research

consequently urges robust professional development: teachers require design heuristics, data-ethics guidance and scaffolded communities of practice to translate ICT and AI into 4Cs gains.

The volatility of a BANI world amplifies this imperative (Taguma et al., 2024). Adaptable, tech-savvy educators are essential for future disruptions provided that training is available. Teacher well-being and self-efficacy therefore constitute critical mediators (Kim & Asbury, 2020). Future shocks will demand educators who can pivot to new methods while still fostering critical thinking, creativity, communication, and collaboration.

Comparative Perspective: Poland and International Trends

Poland. The primary curriculum references autonomy, communication and creativity, yet concrete 4Cs progression and the national cross-curricular mandate remain absent. Implementation rests on local discretion and isolated initiatives such as mandatory coding. Reforms introduced active-method courses, but classroom practice often leans on traditional techniques – worksheets – especially during remote instruction (Plebańska et al., 2020). TALIS places Polish self-efficacy near the OECD mean, supported by optional CPD modules and occasional 4Cs criteria in internal evaluations.

Polish teachers often report that they enjoy creative teaching but cite a lack of time, training, or resources as barriers (Baran-Łucarz & Klimas, 2020). A key challenge is addressing rural-urban disparities in resources and training, despite strong PISA scores. Participation in Erasmus+ networks modestly boosts collaboration and collective efficacy, yet a coherent national strategy is still required.

Finland. Phenomenon-based learning and transversal competences sit at the core of the Finnish curriculum (Lucas, 2022). Teachers enjoy high autonomy and routinely engage in collaborative planning (e.g. team-teaching), which aligns with the high teacher self-efficacy and professional satisfaction. Teacher education emphasizes educational psychology and innovative pedagogy (Schaffar & Wolff, 2024). Finnish schools commonly integrate critical thinking and creativity across subjects, supported by assessments that value student self-reflection and metacognition. Continuous peer inquiry sustains an ecosystem where 4Cs flourish.

United States. State-level variability defines K-5 provision: Common Core embeds communication, while NGSS promotes inquiry. Numerous districts run PBL or STEM academies, and nationwide coding initiatives expand problem-solving opportunities. Teacher preparation, however, is uneven; high-stakes testing and resource disparities constrain inventive practice (Lucas, 2022). Districts investing in tech

coaching and collaborative planning show heightened efficacy (Reimers & Opertti, 2021), whereas underprivileged schools often default to traditional methods (Ingersoll & Tran, 2023). Pandemic-driven remote learning accelerated digital competence for some teachers, yet exposed persistent support gaps.

South Korea. Reforms stressing "creative convergence education" embed Creative Thinking and Communication in the 2015 curriculum (Jeong, 2020). Weekly Creative Experiential Learning (CEL) sessions promote self-directed projects, but exam culture tempers risk-taking (So et al., 2017). Large-scale workshops and guidebooks elevate efficacy (KERIS, 2021). Teachers report strong classroom-management efficacy, although implementing innovative techniques remains uneven amid time constraints and pressure to cover tested content.

Cross-model insights. Alternative environments – U.S. charter "design schools," democratic schools – link small classes, coaching and autonomy with robust 4Cs implementation and teacher morale. Collectively, the comparative evidence indicates that explicit curricular anchoring, systemic PD, and adequate resources consistently predict higher teacher self-efficacy and stronger 4Cs outcomes, whereas reliance on local initiative alone yields fragmented practice.

Results of the Comparative Analysis

Cross-system comparison exposes challenges and divergences. Every jurisdiction formally endorses the 4Cs, yet policy traction and pedagogical depth differ. Framework-rich systems – Finland and South Korea – provide teachers with descriptors, exemplar tasks and funded professional development, whereas Poland and many U.S. states depend on individual initiative and local interpretation. Empirical studies confirm that self-efficacy is highest where 4Cs training permeates both pre- and in-service programmes (Gülhan, 2024). TALIS evidence that cross-curricular PD elevates efficacy (OECD, 2025) accordingly implies that Polish academies should embed more competence-oriented modules.

The synthesis indicates several patterns:

1. Resource constraints. Polish teachers voice enthusiasm for creative methods but cite lack of time and materials; OECD surveys record lower preparedness scores than Finnish or Korean peers (Madalińska-Michalak, 2020).
2. Collaboration–efficacy nexus. Structured teaming and peer observation predict collective efficacy and richer 4Cs practice. EU networks enhance collaboration, yet coverage remains uneven.
3. Digital resilience gap. COVID-19 accelerated ICT uptake, but transition was varied: Finland and Korea leveraged prior investment, whereas Poland experi-

enced an early decline in student engagement, which impacted teacher confidence. As systems recover, digital readiness is an area of focus.

4. STEAM activator. Programmes coupling STEM projects with teacher training correlate positively with student competences and educator confidence (Gülhan, 2024). The reinforcing cycle between teacher self-efficacy and 4Cs integration leads to better student outcomes and further validating the approach.

Despite limited cross-country measures of teacher self-efficacy in teaching 4Cs, some indicators (e.g. PISA "learning environment" and TALIS "teacher innovation" items) suggest that Poland is mid-range internationally, with considerable room for growth through targeted reforms (OECD, 2019).

Conclusions and Recommendations

This review highlights 4Cs competences as increasingly central in primary education goals. Their effective implementation is strongly linked to teacher self-efficacy. This leads to several key conclusions and recommendations:

Embedding 4Cs in Policy. Systems with statutory 4Cs descriptors (Finland, South Korea) furnish schools with clear expectations, assessment criteria and textbook alignment. Poland's autonomy model, while flexible, risks under-prioritising these competences; curriculum documents should therefore articulate explicit cross-curricular 4Cs objectives and assessment rubrics. Such codification signals to publishers, exam designers and teacher-education faculties that 4Cs are integral.

Teacher Education and Professional Development. Empirical studies demonstrate that dedicated training in creativity and critical thinking elevates self-efficacy (Gülhan, 2024). Pre-service programmes should benchmark Finnish micro-teaching, collaborative lesson-study and U.S. 21st-century-skills modules. For in-service staff, ministries should fund iterative CPD around STEAM, inquiry and ICT, preferably organised as Professional Learning Communities. Policymakers should consider incentives for teachers to engage in such collaborative PD.

STEAM and Innovative Pedagogy. Authentic STEAM, integrating the arts into STEM inquiry, simultaneously advances student 4Cs and re-engages teachers. Authorities should pilot weekly interdisciplinary blocks, supply coaching for novice facilitators and disseminate curated lesson templates aligned with national goals.

ICT and AI Integration. Hardware alone is insufficient; targeted PD in collaborative platforms, creative software and data ethics is required. By 2030, baseline AI literacy will be indispensable (European Commission, 2024). Ministries should commission guidelines and modular training on adaptive tutoring systems, creative co-authoring tools and algorithmic bias, thus safeguarding teacher agency while exploiting AI's personalisation potential.

Resilience in a BANI world. The 4Cs constitute a curricular antidote to volatility, yet educators need parallel supports. Policymakers ought to integrate well-being services, peer counselling and flexible timetabling into reform packages. Scenario-based contingency planning – project-based learning that migrates online during crises, community collaboration protocols – should be embedded in school emergency procedures, ensuring the 4Cs remain "non-negotiable" under stress.

Cross-National Collaboration. Erasmus+ exchanges, participation in eTwinning projects and EU competence clusters accelerates policy diffusion and nurtures professional solidarity. Bilateral research projects – e.g. Polish-Finnish collaborations on creative problem-solving – can test and iterate implementation models.

In sum, fulfilling the promise of the 4Cs in primary education requires aligning curriculum, pedagogy, and teacher support. By strengthening teacher self-efficacy through targeted educational reforms and innovative professional practices, Poland and other systems can better equip both teachers and learners for the challenges of 2030 and beyond. Teachers who believe in their capacity to teach in new ways are the pillars of any 21st-century skills initiative. Supporting them with clear policies, training, technology, and trust will pay dividends in the form of more engaged students, more creative classrooms, and more resilient educational communities.

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