

DESIGNING AND VALIDATING A MULTI-LEVEL STRATEGY SYSTEM FOR DEVELOPING DIGITAL COMPETENCIES AMONG UNIVERSITY STUDENTS IN GUANGDONG PROVINCE*

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Abstract

This study developed and validated a DigComp 2.2-aligned, multi-level strategy system for improving undergraduates' digital competencies in three private universities in Guangdong Province, China. An explanatory sequential mixed-methods design was employed. Survey data from 1,092 students were first analyzed to identify competence profiles and key gaps. Findings revealed a moderate overall digital competence level; information and data literacy scored relatively highest, while problem solving scored lowest. To explain these results, structured interviews were conducted with nine key informants, including experts, administrators, and teachers. Thematic analysis identified three core categories and 15 themes, indicating students managed routine digital tasks but lacked higher-order abilities. Major constraints included uneven teacher capacity, weak platform integration, limited incentives, and insufficient student agency. Integrating these findings, 12 strategies were developed across student, teacher, university, and government levels. A nine-member expert panel evaluated the

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system using a 5-point Likert scale. Overall feasibility was rated at the highest level ($\bar{x} = 4.72$, $SD = 0.08$), with teacher-level strategies receiving the top score ($\bar{x} = 4.89$, $SD = 0.17$). The findings suggest that strengthening digital pedagogy, reducing teachers' implementation burden, and integrating learning platforms are key to developing higher-order digital competencies in this context.

Keywords: Digital Competence, Strategy System, Higher Education

Introduction

Digital technologies now shape how knowledge is produced, assessed, and shared, making digital competence a core higher education outcome rather than an optional skill. It entails using technologies effectively, critically, creatively, and safely across contexts (Vuorikari et al., 2022). In digital economies, this extends beyond routine tool use to data-informed problem solving, collaborative knowledge construction, and responsible participation, all closely tied to employability and lifelong learning (OECD, 2019). Frequent device exposure does not automatically yield strong digital competence. International evidence reveals large disparities in higher-order digital abilities across education systems, often reflecting unequal learning opportunities rather than access alone (Fraillon et al., 2020). This challenges the "digital native" assumption: familiarity does not guarantee critical evaluation, creative production, or safe online behaviour (Kirschner & De Bruyckere, 2017).

Digital competence is also dynamic. As data-driven platforms, algorithmic systems, and generative artificial intelligence reshape learning and work, DigComp 2.2 retains five domains—information and data literacy, communication and collaboration, digital content creation, safety, and problem solving—while updating examples for emerging technologies and risks (Vuorikari et al., 2022). Higher education reviews similarly confirm that competence development is multidimensional, shaped by discipline, institution type, and learning design

(Zhao et al., 2021). The central question is how universities can foster digital competence systematically and sustainably. Stand-alone digital skills courses rarely produce lasting gains because competence emerges from interactions among students, teachers, institutions, and policy environments. This multi-level perspective aligns with ecological theory and implementation research, both of which stress alignment across learners, organisations, and policy contexts.

These issues are especially visible in Guangdong Province, a key part of the Guangdong-Hong Kong-Macao Greater Bay Area. Although national initiatives such as the Education Informatization 2.0 Action Plan support technology integration in higher education (Ministry of Education of the People's Republic of China, 2018), private universities in Guangdong still face uneven teaching capacity, fragmented platforms, limited incentives, and heavy workloads. The main gap is therefore not the absence of frameworks, but the lack of empirically grounded and feasible strategy systems. This study addresses that gap by designing and validating a DigComp 2.2-aligned multi-level strategy system for undergraduate students in Guangdong's private universities.

Objective

This study aims to design and validate a feasible, DigComp 2.2-aligned multi-level strategy system for developing digital competencies among undergraduate students in private universities in Guangdong Province by integrating competence diagnostics, stakeholder perspectives, and expert feasibility judgements.

Methodology

This section outlines the design, sampling, instruments, data collection, and analysis procedures. The study employed an explanatory sequential mixed-methods design (Creswell & Plano Clark, 2018).

Table 1 Overview of study phases, data sources, and outputs

Phase	Data source(s)	Analytic purpose	Key output(s)
1	Student survey (N=1,092)	Baseline diagnosis of digital competence (domain & item levels)	Competence profile; priority gaps
2	Structured interviews (N=9)	Explain gaps; identify constraints and enabling conditions	Core categories & themes
3	Integration and framework mapping	Translate evidence into actionable multi-level strategies	Strategy system (S1–S12)
4	Expert feasibility ratings (N=9)	Validate implementability; refine strategies	Feasibility scores; refinement notes

1. Research design

The study followed a four-phase sequential explanatory mixed-methods design (Table 1). Phase 1 produced a baseline competence profile and priority gaps. Phase 2 used structured interviews to interpret these patterns and identify contextual constraints. Phase 3 integrated the findings through framework mapping to draft the strategy system. Phase 4 used expert ratings and comments to assess feasibility and refine the final set (Creswell & Plano Clark, 2018).

2. Setting and participants

The study took place in three private undergraduate universities in the Guangdong-Hong Kong-Macao Greater Bay Area, with a target population of approximately 95,000 full-time students. Universities are anonymised as GDUST, ZCST, and GZIST. Quantitative sampling followed a four-stage stratified random procedure by institution, grade, and major category. After screening, 1,092 of 1,128 distributed questionnaires were retained (effective response rate 96.81%; see Table 2). For the qualitative phase, nine key informants were purposively selected to represent institutional leadership, academic and student affairs

administration, and frontline teaching. All were directly involved in digital education initiatives and possessed extensive higher education experience. The validation phase used a nine-member expert panel with the same role distribution to balance perspectives.

3. Instruments

Three instruments were employed: a student survey, a structured interview protocol, and an expert feasibility rating form. The survey measured digital competence with a 21-item self-report scale aligned to DigComp 2.2, covering information and data literacy, communication and collaboration, digital content creation, safety, and problem solving (Vuorikari et al., 2022). Items used a 5-point Likert scale; the instrument was localised through framework mapping, expert review, and pilot testing. Psychometric validation is reported elsewhere; the present study uses the final scale for diagnostic targeting and strategy design. The interview protocol addressed competence strengths and weaknesses, curricular arrangements, major constraints, and candidate strategies. The expert form required panel members to rate each strategy (S1–S12) on implementation resources, organisational conditions, and development prospects, with space for revision comments.

4. Data collection procedures

The survey was administered online and on site following institutional protocols. Responses were screened for duplicates, incomplete submissions, and inattentive responding via completion-time and response-pattern checks. Interviews occurred after preliminary survey analysis, allowing questions to target observed gaps and contextual constraints. Each interview lasted 45–60 minutes, was audio-recorded with consent, transcribed verbatim, de-identified, and assigned a pseudonym. The expert review took place after strategy consolidation; all experts completed ratings independently to minimise conformity effects.

5. Data analysis and mixed-methods integration

Descriptive statistics (means, Standard Deviations [SD], rank orderings) generated domain- and item-level competence profiles and identified priority gaps for strategy design. One-way ANOVA was applied where subgroup differentiation was needed, but the analysis remained design-oriented rather than causal. Interview transcripts were examined through reflexive thematic analysis, combining deductive codes derived from DigComp domains and multi-level governance logic with inductive coding for emergent contextual factors (Braun & Clarke, 2006). NVivo supported coding, audit trails, and cross-case comparison. Credibility was strengthened through peer debriefing and member checking with a subset of interviewees.

Mixed-methods integration proceeded in two stages. First, survey findings informed interview prompts by highlighting weak domains and items with high variance. Second, quantitative diagnostics and qualitative themes were merged in joint displays to generate meta-inferences about actionable levers (Fetters et al., 2013). Each proposed strategy was subsequently mapped to target DigComp outcomes, implementation level, change mechanism, and feasibility constraints identified in the interviews. Expert ratings were summarised via means and SD at the strategy and implementation-cluster levels, with dispersion treated as an indicator of agreement. Open-ended comments were analysed through content analysis to refine wording, clarify prerequisites, and adjust the granularity of action items.

6. Quality assurance

Standard screening and instrument-administration procedures were followed in the quantitative phase. For the qualitative phase, an audit trail documented codebook development, analytic memos, and major decisions, supporting dependability and confirmability. Credibility was further strengthened through triangulation across survey findings, interview themes, and expert feedback.

7. Ethical considerations

Ethical protocols were followed throughout. Participation was voluntary; all participants received an information sheet, gave informed consent, and could withdraw at any time without penalty. Data were anonymised, stored on password-protected devices, and used solely for research purposes, complying with institutional requirements and relevant research ethics standards (American Educational Research Association, 2011).

Table 2 Sample characteristics (N = 1,092)

Variable	Category	n	%
University	GDUST	408	37.36
University	ZCST	341	31.23
University	GZIST	343	31.41
Gender	Male	591	54.12
Gender	Female	501	45.88
Grade	Freshman	280	25.64
Grade	Sophomore	215	19.69
Grade	Junior	310	28.39
Grade	Senior	287	26.28
Major category	Science and Engineering	323	29.58
Major category	Humanities and History	265	24.27
Major category	Economics and Management	169	15.48
Major category	Art	167	15.29
Major category	Medicine	116	10.62
Major category	Others	52	4.76
Family location	Urban	742	67.95
Family location	Rural	350	32.05
Annual household income (RMB)	Below 50,000	160	14.65
Annual household income (RMB)	50,000–100,000	364	33.33
Annual household income (RMB)	100,000–200,000	414	37.91
Annual household income (RMB)	200,000–500,000	126	11.54

Variable	Category	n	%
Annual household income (RMB)	Above 500,000	28	2.56

Results

The baseline survey indicated a moderate overall digital competence level ($\bar{x}$ = 3.00, SD = 0.94). Information and data literacy scored highest ($\bar{x}$ = 3.06), while problem solving scored lowest ($\bar{x}$ = 2.97). Students generally managed routine ICT tasks but demonstrated weaker readiness for higher-order applications such as data-informed inquiry, integrated task performance, and troubleshooting in ill-structured contexts. Detailed psychometric and item-level results appear in the companion study; here, survey findings primarily identify priority gaps for strategy design.

1. Core categories and themes from structured interviews

Reflexive thematic analysis of nine structured interviews yielded three core categories and 15 second-level themes, with high cross-case convergence suggesting a shared diagnosis across institutions. Table 3 summarises categories, themes, and case frequencies. Interviewees consistently portrayed students as possessing strong basic skills but weak higher-order abilities. Routine digital tasks were manageable; however, sustained inquiry, critical evaluation, integrated data work, and complex digital production remained challenging. Substantial within-cohort variation underscored the need for staged targets, differentiated pathways, and structured scaffolding rather than a single-track model.

Regarding the support ecosystem, private universities' practical orientation and university-enterprise collaboration were seen as strengths that could generate authentic digital practice opportunities. Yet implementation lagged despite comprehensive digital education policies. Weak platform integration, heavy teacher workloads, uneven digital pedagogy, inadequate evaluation and incentive mechanisms, and limited student motivation repeatedly surfaced as barriers. Several Interviewees linked low student satisfaction to

shortcomings in teaching quality, curriculum structure, and alignment among general ICT learning, disciplinary application, and practice-based experience. The third category addressed a multi-stakeholder development pathway, with strong agreement on four priorities: modular, staged curriculum reconstruction; tiered teacher professional development; expanded university-enterprise practice bases; and structured student learning support. Collectively, the interviews frame digital competence development as system-level capacity-building demanding coordinated action across government, universities, teachers, and students.

Table 3 Core categories and themes from interview analysis (N = 9)

Core category	Theme (second-level)	Cases with theme
Competency structure and developmental constraints	Good basic abilities but insufficient higher-order abilities	8
	Significant internal differences in students' digital competencies	9
	Advantages of practical orientation and university-enterprise collaboration in private universities	9
	Comprehensive digital education policies and plans but implementation gaps	9
	Good digital infrastructure but insufficient platform integration	9
Support ecosystem and institutional environment	Teachers' time, energy, and burden as major obstacles to digital teaching	9
	Uneven digital teaching capabilities and concepts among teachers	9
	Inadequate digital education evaluation and incentive mechanisms	9
	Insufficient student learning motivation and agency	6
	Reasons for students' low satisfaction with	9

Core category	Theme (second-level)	Cases with theme
A multi-stakeholder collaborative pathway for digital competency development	teachers' digital education	
	Digital education resources and curriculum structure need optimization	9
	Strategic suggestion: Curriculum system and modular construction	9
	Strategic suggestion: Teacher professional development and communities of practice	9
	Strategic suggestion: University-enterprise collaboration and practice bases	9
	Strategic suggestion: Students' self-improvement and learning support	9

2. Construction of the multi-level strategy system (S1–S12)

The strategy system integrates survey diagnostics with interview themes, aligning intervention targets with DigComp 2.2. Twelve strategies span four levels: student (S1–S3), government (S4–S6), university (S7–S9), and teacher/programme (S10–S12). Design follows two principles: vertical alignment linking macro-level standards, funding, and regional coordination to institutional governance, curriculum design, and classroom practice; and horizontal collaboration clarifying stakeholder roles and coordination mechanisms to reduce fragmentation and implementation burden. Figure 1 maps the strategy package to five mediating mechanisms—learner agency and self-regulated learning, competence-oriented curriculum and instructional quality, authentic opportunity-to-learn intensity, digital support and resource ecosystems, and governance, assessment, and implementation sustainability—showing how the set addresses higher-order competence gaps, support-system bottlenecks, and long-term sustainability. Table 4 presents strategies with key operational measures.

Table 4 Multi-level strategy system for developing student digital competencies in Guangdong (S1–S12)

ID	Level	Strategy	Key operational measures (summary)
S1	Student	Personal digital competence development plan	Use self-assessment diagnostics to identify strengths/weaknesses; set semester goals linked to academic/career plans; track progress via learning portfolios and reflective logs.
S2	Student	Project-based and interdisciplinary learning for advanced competence	Organize interdisciplinary digital practice projects (e.g., data analysis, digital creation); require real-world data collection–analysis–visualization; emphasize team collaboration and public presentation.
S3	Student	Enhance learning motivation and agency	Build learning communities/interest clubs and online check-ins; connect digital-competence performance to credits, scholarships, honors, and innovation/entrepreneurship opportunities to sustain engagement.
S4	Government	Establish hierarchical standards and evaluation framework	Develop provincial digital-competence standards aligned with DigComp 2.2; specify indicators by institution type/major/grade; build monitoring tools to guide talent-training program revision and QA.
S5	Government	Improve policy and special funding support	Create provincial special projects for private universities; prioritize curriculum reform, virtual simulation, smart learning spaces, and student practice; use reward-based subsidies and policy incentives.
S6	Government	Build regional collaboration and resource-sharing platform	Leverage Greater Bay Area networks to co-build/share courses, MOOCs, practice bases, and assessment tools; publish periodic regional monitoring reports to support targeted

ID	Level	Strategy	Key operational measures (summary)
			polycymaking. Embed competence goals into programs using a spiral structure (general–disciplinary–professional–practice/innovation); optimize general ICT/information literacy; integrate data thinking, discipline software, and industry cases into majors.
S7	University	Reconstruct a modular digital-competence curriculum system	Integrate LMS/teaching platforms, academic affairs systems, and data centers; build unified authentication and learning-data middle platform; construct discipline resource repositories and learning analytics for recommendations and early warning.
S8	University	Develop an integrated digital learning platform and resource ecosystem	Include digital competence in program QA and student development files; add process products (digital works, data reports, collaboration performance) to assessment; reward colleges/teachers contributing to reform and practice guidance.
S9	University	Improve competence-oriented assessment and incentive mechanisms	Design stage-based PD (‘basic application–teaching integration–innovation leadership’); use workshops, mentoring, and class observation; focus on learning analytics, blended design, and online assessment; institutionalize certification/credit recognition.
S10	Teacher	Construct a tiered pathway for teachers’ digital teaching competence	Form communities including teachers, administrators, and tech support; run regular open lessons and case sharing; co-develop project tasks and rubrics targeting weak competence areas; support experience transfer and pedagogical innovation.
S11	Teacher	Build cross-disciplinary digital teaching communities	Adopt teaching teams and assistants; reform
S12	Teacher	Implement	

ID	Level	Strategy	Key operational measures (summary)
		burden-reduction and efficiency-support arrangements	workload recognition to include digital course/resource development and online guidance; provide technical services to reduce transaction costs of digital teaching.

3. Expert feasibility evaluation of the strategy system

A nine-member expert panel rated each strategy on a 5-point rubric. The overall mean feasibility score reached 4.72 (SD = 0.08), placing the package in the "Highest" category (Table 5). Teacher-level strategies received the top rating ($\bar{x}$ = 4.89, SD = 0.17), followed by government-level ($\bar{x}$ = 4.81, SD = 0.29), university-level ($\bar{x}$ = 4.63, SD = 0.31), and student-level strategies ($\bar{x}$ = 4.56, SD = 0.41). Wider dispersion at the student level signals greater sensitivity to local support conditions. Eleven strategies fell in the "Highest" band; only S1 rated "High" ($\bar{x}$ = 4.44, SD = 0.73), indicating personal development planning depends on adequate scaffolding, portfolio tools, and advising support.

Table 5 Feasibility evaluation results of strategies (expert panel N = 9)

Level	Strategy	$\bar{X}$	S.D.	Feasibility level
Student	S1 Personal development plan	4.44	0.73	High
Student	S2 Project-based/interdisciplinary learning	4.56	0.53	Highest
Student	S3 Learning motivation and agency	4.67	0.71	Highest
Government	S4 Standards and evaluation framework	4.78	0.44	Highest
Government	S5 Policy and special funding	4.89	0.33	Highest
Government	S6 Regional collaboration platform	4.78	0.44	Highest
University	S7 Modular curriculum reconstruction	4.56	0.73	Highest
University	S8 Integrated learning platform/ecosystem	4.78	0.44	Highest
University	S9 Assessment and incentive mechanisms	4.56	0.73	Highest
Teacher	S10 Tiered teacher competence pathway	4.89	0.33	Highest

Level	Strategy	$\bar{X}$	S.D.	Feasibility level
Teacher	S11 Cross-disciplinary communities	4.89	0.33	Highest
Teacher	S12 Burden reduction support	4.89	0.33	Highest
Overall	All strategies	4.72	0.08	Highest

Discussion

1. Interpreting the competence profile

Students showed a moderate overall competence level, with relatively stronger information and data literacy and weaker problem solving. Interviewees characterised this as strong basic skills but insufficient higher-order abilities, noting substantial within-cohort variation. Routine ICT use proved common, yet transfer to complex tasks remained uneven. This aligns with prior research: the "digital native" assumption explains advanced competence poorly (Kirschner & De Bruyckere, 2017), and frequent ICT use does not automatically produce stronger computer and information literacy or problem solving (Fraillon et al., 2020). For Guangdong's private universities, higher-order opportunity-to-learn (OTL) must be strengthened through staged targets, differentiated pathways, and structured supports rather than stand-alone courses or single-track interventions (Vuorikari et al., 2022).

2. Why the strategy system must be multi-level

The central challenge is not absent policy or infrastructure but weak alignment across governance, platforms, incentives, and teaching workflows. Workload pressure, uneven digital pedagogy, fragmented platforms, and underdeveloped evaluation mechanisms constrain implementation. This system-level reading draws support from ecological theory, implementation research, and educational change scholarship, all stressing that sustainable reform depends on fit across individual, organisational, and policy environments rather than isolated interventions (Fullan, 2007). The proposed strategy system

addresses this by aligning government-, university-, teacher-, and student-level actions into coherent implementation design.

3. What feasibility validation implies for implementation

The expert panel rated the strategy package highly feasible, with teacher-level strategies receiving the strongest ratings, underscoring teachers' central role in translating policy into students' OTL. Effective digital teaching depends on integrated technological, pedagogical, and content knowledge alongside competence-oriented assessment (Redecker, 2017). Burden reduction and efficiency support also received very high ratings, confirming organisational readiness as a prerequisite. When workload recognition, support services, and platform usability do not match reform demands, implementation rarely lasts (Weiner, 2009). The strong rating for communities of practice aligns with evidence that collaborative, practice-embedded professional development improves coherence while reducing individual workload (Darling-Hammond et al., 2017). Student-level strategies, particularly S1, were rated slightly lower with greater dispersion, suggesting self-directed planning requires guided autonomy supported by feedback, structure, and mentoring (Zimmerman, 2000).

4. Practical implications for a sequenced roadmap

A sequenced roadmap would likely strengthen implementation. At the macro level, standards, evaluation, and targeted funding can reduce fragmentation and establish shared progression language, consistent with national priorities in education informatization and system-capacity building (Central Committee of the Communist Party of China & State Council of the People's Republic of China, 2019). At the university level, curriculum, assessment, and incentives should form a single reform bundle; at the teacher level, professional learning must pair with workload recognition, staffing support, and redesign time; at the student level, higher-order OTL should expand through interdisciplinary projects and real-world data work. Across levels, guided rather

than unstructured autonomy better supports sustained competence development.

5. Research contributions

This study contributes threefold. First, it demonstrates how DigComp 2.2 translates into a coordinated strategy package backed by feasibility evidence. Second, it provides a clear logic model linking inputs, mechanisms, and outcomes. Third, it showcases a sequential mixed-methods design connecting diagnosis, explanation, integration, and validation (Vuorikari et al., 2022; Creswell & Plano Clark, 2018). Together, these contributions narrow the gap between framework adoption and implementable design.

6. Limitations and future research

Three limitations warrant mention. The study examined three private universities in the Greater Bay Area; transferability to public universities or other provinces requires testing. Feasibility ratings reflect perceived implementability, not observed impact, and data relied on self-reports and interviews. Future research should incorporate performance tasks, portfolios, platform analytics, and classroom observation to examine competence growth, subgroup equity, and cost-effectiveness more robustly (Anderson & Shattuck, 2012).

Recommendation

1. Start with teacher enablement and workload support

Implementation should begin with teacher enablement and workload support, rated most feasible and likely to reduce transaction costs while improving digital pedagogy. Universities should establish tiered professional development tied to real teaching tasks, protect course redesign time, provide instructional and technical support, and sustain cross-disciplinary communities through mentoring, open lessons, case sharing, and appropriate recognition such as workload credits or promotion evidence (Fullan, 2007).

2. Implement competence development as a curriculum-assessment-platform package

Competence development should proceed as an integrated curriculum-assessment-platform package. A modular, spiral curriculum can progressively embed information and data literacy, safety, data thinking, discipline-specific digital tasks, and capstone application. Rubrics, portfolios, and micro-credentials make growth visible, while stronger integration among LMS, e-portfolio, assessment tools, and analytics dashboards supports timely guidance, provided governance addresses data minimisation, consent, access control, and feedback for action (Biggs & Tang, 2011; Nicol & Macfarlane-Dick, 2006; Slade & Prinsloo, 2013).

3. Use standards, targeted funding, and regional collaboration to support scale-up

Province-level support remains essential for scale-up. Guangdong can localise DigComp 2.2 into hierarchical standards and evaluation indicators, provide targeted funding for curriculum reform, integrated platforms, practice bases, and teacher enablement, and build a Greater Bay Area collaboration and resource-sharing platform for co-developed courses, assessment tools, benchmarking, and policy adjustment (Vuorikari et al., 2022; Ministry of Education of the People's Republic of China, 2018).

References

- American Educational Research Association. (2011). Code of ethics. *Educational Researcher*, 40(3), 145–156.
- Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher*, 41(1), 16–25.
- Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university*. (4th ed.). Open University Press.

- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
- Central Committee of the Communist Party of China, & State Council of the People's Republic of China. (2019, February 23). China's education modernization 2035.
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.
- Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute.
- Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed methods designs—Principles and practices. *Health Services Research*, 48(6 Pt 2), 2134–2156.
- Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Duckworth, D. (2020). *Preparing for life in a digital world: IEA International Computer and Information Literacy Study 2018 international report*. Springer.
- Fullan, M. (2007). *The new meaning of educational change* (4th ed.). Teachers College Press.
- Kirschner, P. A., & De Bruyckere, P. (2017). The myths of the digital native and the multitasker. *Teaching and Teacher Education*, 67, 135–142.
- Ministry of Education of the People's Republic of China. (2018, April 25). *Education informatization 2.0 action plan*.
- Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2), 199–218.
- OECD. (2019). *OECD skills outlook 2019: Thriving in a digital world*. OECD Publishing.
- Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu*. Publications Office of the European Union.

- Slade, S., & Prinsloo, P. (2013). Learning analytics: Ethical issues and dilemmas. *American Behavioral Scientist*, 57(10), 1509–1528.
- Vuorikari, R., Kluzer, S., & Punie, Y. (2022). DigComp 2.2: The digital competence framework for citizens—With new examples of knowledge, skills and attitudes. Publications Office of the European Union.
- Weiner, B. J. (2009). A theory of organizational readiness for change. *Implementation Science*, 4, 67.
- Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp.13–39). Academic Press.