

Supplementary Materials

Systematic Review

Table S1. PRISMA checklist Camino et al. (2021).



CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	-
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	5
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	7
	2b	Specific objectives or hypotheses	8
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	8
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	-
Participants	4a	Eligibility criteria for participants	-
	4b	Settings and locations where the data were collected	9
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	10
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	12
	6b	Any changes to trial outcomes after the trial commenced, with reasons	-
Sample size	7a	How sample size was determined	9
	7b	When applicable, explanation of any interim analyses and stopping guidelines	11

Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	11
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	10
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	9
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	11
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	-
	11b	If relevant, description of the similarity of interventions	-
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	12
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	12
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	9
	13b	For each group, losses and exclusions after randomisation, together with reasons	11
Recruitment	14a	Dates defining the periods of recruitment and follow-up	11
	14b	Why the trial ended or was stopped	11
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	-
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	9
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	13
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	14
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	15
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	-
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	18

Generalisability	21	Generalisability (external validity, applicability) of the trial findings	17
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	16
Other information			
Registration	23	Registration number and name of trial registry	5
Protocol	24	Where the full trial protocol can be accessed, if available	-
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	-

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

Table S2. PRISMA checklist Fernández Montalvo et al. (2017).



CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	-
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	1
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	2
	2b	Specific objectives or hypotheses	4
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	4
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	4
Participants	4a	Eligibility criteria for participants	4
	4b	Settings and locations where the data were collected	4
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were	6

		actually administered	
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	6
	6b	Any changes to trial outcomes after the trial commenced, with reasons	-
Sample size	7a	How sample size was determined	5
	7b	When applicable, explanation of any interim analyses and stopping guidelines	7
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	7
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	5
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	5
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	5
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	-
	11b	If relevant, description of the similarity of interventions	-
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	6
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	6
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	5
	13b	For each group, losses and exclusions after randomisation, together with reasons	6
Recruitment	14a	Dates defining the periods of recruitment and follow-up	8
	14b	Why the trial ended or was stopped	8
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	5
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	5
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	9
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	10

Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	10
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	10
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	14
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	13
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	13
Other information			
Registration	23	Registration number and name of trial registry	1
Protocol	24	Where the full trial protocol can be accessed, if available	1
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	28

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming; for those and for up-to-date references relevant to this checklist, see www.consort-statement.org.

Table S3. PRISMA checklist Fuentes-Cancell et al. (2022)



CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	-
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	7
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	8
	2b	Specific objectives or hypotheses	9

Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	9
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	-
Participants	4a	Eligibility criteria for participants	10
	4b	Settings and locations where the data were collected	10
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	15
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	10
	6b	Any changes to trial outcomes after the trial commenced, with reasons	-
Sample size	7a	How sample size was determined	10
	7b	When applicable, explanation of any interim analyses and stopping guidelines	11
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	10
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	10
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	10
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	10
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	-
	11b	If relevant, description of the similarity of interventions	12
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	14
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	15
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	10
	13b	For each group, losses and exclusions after randomisation, together with reasons	-
Recruitment	14a	Dates defining the periods of recruitment and follow-up	14

	14b	Why the trial ended or was stopped	14
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	-
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	10
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	10
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	-
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	19
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	-
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	22
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	21
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	22
Other information			
Registration	23	Registration number and name of trial registry	7
Protocol	24	Where the full trial protocol can be accessed, if available	7
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	23

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

Table S4. Distribution of the analysed interventions included in other previous systematic reviews.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
Prince et al. (2016)												X	X																				
Fernández-Montalvo et al. (2017)							X	X														X											
Gómez-Trigueros et al. (2018)																									X								
Maureen et al. (2018)					X									X	X	X	X					X					X	X					
Guayara Cuéllar et al. (2019)									X																	X							
Aydın et al. (2020)																																	
Benavente-Vera et al. (2020)			X																X														
Romero García et al. (2020)		X				X												X					X		X								
Camino et al. (2021)																																	
Chatwattana (2021)																																	
Ryhtä et al. (2021)																																	
Ugur et al. (2021)																																	
Basantes-Andrade et al. (2022)	X			X																													
Choi et al. (2022)																																	
Fuentes-Cancell et al. (2022)																																	
Garcés et al. (2022)																																	
Javorcik (2022)																																	
Munawaroh et al. (2022)																																	
Nogueira et al. (2022)											X									X				X					X	X	X		
Yelubay et al. (2022)																																	
Calvopiña Herrera (2023)																																	
Dimitri et al. (2023)																																	
Gabarda Méndez et al. (2023)										X																							
Pino (2023)																																	

Note: The number of each review is referenced in the list provided below.

- Basantes-Andrade, A., Casillas-Martín, S., Cabezas-González, M., Naranjo-Toro, M., & Guerra-Reyes, F. Standards of teacher digital competence in higher education: A systematic literature review. *Sustainability*, 2022, 14(21), 13983. <https://doi.org/10.3390/su142113983>

2. Buils Morales, S., Esteve-Mon, F. M., Sánchez-Tarazaga, L., & Arroyo Ainsa, P. Análisis de la perspectiva digital en los marcos de competencias docentes en Educación Superior en España. **2022**. <https://doi.org/10.5944/ried.25.2.32349>
3. Chávarry, E. I. H. Competencias digitales de los docentes de Educación Básica Regular. *Polo del Conocimiento*, **2022**, 7(12), 901-913. <http://dx.doi.org/10.23857/pc.v7i12.5035>
4. De la Cruz Campos, J. C., Santos Villalba, M. J., Alcalá del Olmo Fernández, M. J., & Victoria Maldonado, J. J. Competencias digitales docentes en la educación superior. Un análisis bibliométrico. **2023**. <http://hdl.handle.net/10498/28623>
5. Du, X. A Systematic Literature Review: The Modalities, Pedagogies, Benefits, and Implications of Storytelling Approaches in Early Childhood Education Classroom. **2021**. <https://ir.lib.uwo.ca/etd/8054>
6. García Prieto, F. J., López Aguilar, D., & Delgado García, M. Competencia digital del alumnado universitario y rendimiento académico en tiempos de COVID-19. *Pixel-Bit*. **2022**. <https://doi.org/10.12795/pixelbit.91862>
7. Godaert, E., Aesaert, K., Voogt, J., & van Braak, J. Assessment of students' digital competences in primary school: a systematic review. *Education and Information Technologies*, **2022**, 27(7), 9953-10011. <https://doi.org/10.1007/s10639-022-11020-9>
8. Gunnars, F. A large-scale systematic review relating behaviorism to research of digital technology in primary education. *Computers and Education Open*, **2021**, 2, 100058. <https://doi.org/10.1016/j.caeo.2021.100058>
9. Hernández, E. S., Juarros, V. I. M., & Vásquez, A. R. R. Competencia digital docente de profesores universitarios en el contexto iberoamericano. Una revisión. *Tesis psicológica: Revista de la Facultad de Psicología*, **2022**, 17(1), 11. <https://dialnet.unirioja.es/servlet/articulo?codigo=8480503>
10. Marrero-Sánchez, O., & Vergara-Romero, A. Digital competence of the university student. A systematic and bibliographic update. *Amazonia Investiga*, **2023**, 12(67), 9-18. <https://doi.org/10.34069/AI/2023.67.07.1>
11. Mat Ishah, N. S., Lee, K. L., & Nawani, G. Educational supply chain sustainability. *Asian Education and Development Studies*. **2023**. <https://doi.org/10.1108/AEDS-09-2022-0123>
12. Mendoza, V. R. Habilidades Educativas del Siglo XXI: Un Análisis Sistemático del Periodo 2014-2023. *Revista Boaciencia. Educação e Ciências Sociais*, **2023**, 3(2), 77-100. <https://doi.org/10.59801/ecs.v3i2.136>
13. Monroy, N. E. C., & Villamil, Y. P. R. Competencias del siglo XXI en educación: una revisión sistemática durante el periodo 2014-2023. *Ciencia Latina Revista Científica Multidisciplinar*, **2023**, 7(4), 219-249. https://doi.org/10.37811/cl_rcm.v7i4.6869
14. Parlindungan, F., Rifai, I., Nuthihar, R., & Dewayani, S. Fostering Peace and Harmony Through Indonesian Heroes' Stories: A Systematic Review of Literature. In *4th International Conference on Progressive Education Atlantis Press* **2023** (pp. 349-364). https://doi.org/10.2991/978-2-38476-060-2_32
15. Paul, C. D., Hansen, S. G., Marelle, C., & Wright, M. Incorporating Technology into Instruction in Early Childhood Classrooms: a Systematic Review. *Advances in Neurodevelopmental Disorders*, **2023**, 1-12. <https://doi.org/10.1007/s41252-023-00316-7>
16. Purnama, S., Ulfah, M., Ramadani, L., Rahmatullah, B., & Ahmad, I. F. Digital Storytelling Trends in Early Childhood Education in Indonesia: A Systematic Literature Review. *Jurnal Pendidikan Usia Dini*, **2022**, 16(1), 17-31. <https://doi.org/10.21009/JPUD.161.02>
17. Ramalingam¹, K., & Jiar, Y. K. The Recent Trends on The Speaking Skills with Storytelling Approach. *International journal of special education*, **2022**, 37(3s). <https://doi.org/10.3390/su14138051>
18. Reyes-Argüelles, H., Alanya-Beltran, J., & Caballero, J. E. A. P. Aprendizaje basado en problemas en tiempos de pandemia COVID-19: Revisión sistemática. *Journal of business and entrepreneurial studie*. **2022**. <https://journalbusinesses.com/index.php/revista/article/view/277>
19. Sánchez, J. R. C., & Fernández, C. F. C. Propuestas para el desarrollo de competencias digitales docentes en la Educación Básica. *Revista Científica Emprendimiento Científico Tecnológico*, **2022**, (3), 22-22. <https://doi.org/10.54798/AYIG3665>
20. Şener, Z. T. The impact of technology-mediated applications on mathematics achievement: A meta-analytical review. *International Journal of Education Technology and Scientific Researches*, **2023**, 8(23), 1977-2010. <http://dx.doi.org/10.35826/ijetsar.624>

21. Su, J., & Yang, W. Digital competence in early childhood education: A systematic review. *Education and Information Technologies*, **2023**, 1-49. <https://doi.org/10.1007/s10639-023-11972-6>
22. Tamborg, A. L., Dreyøe, J. M., & Fougst, S. S. Digital literacy-a qualitative systematic review. *Tidsskriftet Læring Og Medier (LOM)*, **2018**, 11(19), 29-29. <https://doi.org/10.7146/lom.v11i19.103472>
23. Tito-Huamani, P., Aponte, S., Custodio, F., Castañeda, T., Garamendi, K., & Soto, E. Universidad virtual y la transformación educativa en el contexto de la pandemia. *Revista Innova Educación*, **2022**, 4(2), 113-131. <https://doi.org/10.35622/j.rie.2022.02.007>
24. Triyana, I. G. N., Candiasa, I. M., Sudatha, I. G. W., & Divayana, D. G. H. Revitalizing digital technology literacy in education: a systematic literature review and framework development. *Synesis (ISSN 1984-6754)*, **2023**, 15(4), 254-272. <https://seer.ucp.br/seer/index.php/synesis/article/view/2798>
25. Velandia Rodriguez, C. A., Mena-Guacas, A. F., Tobón, S., & López-Meneses, E. Digital Teacher Competence Frameworks Evolution and Their Use in Ibero-America up to the Year the COVID-19 Lockdown Began: A Systematic Review. *International Journal of Environmental Research and Public Health*, **2022**, 19(24), 16828. <https://doi.org/10.3390/ijerph192416828>
26. Viñoles-Cosentino, V., Sánchez-Caballé, A., & Esteve-Mon, F. M. Desarrollo de la Competencia Digital Docente en Contextos Universitarios. Una Revisión Sistemática. *REICE*, **2022**, 20(2), 11-27. <https://doi.org/10.15366/reice2022.20.2.001>
27. Wolff, L. A., Skarstein, T. H., & Skarstein, F. The Mission of early childhood education in the Anthropocene. *Education sciences*, **2020**, 10(2), 27. <https://doi.org/10.3390/educsci10020027>
28. Xu, M., & Stefaniak, J. Embracing children's voice to support teachers' pedagogical reasoning and decision-making for technology enhanced practices in early childhood classrooms. *TechTrends*, **2021**, 65(3), 256-268. <https://doi.org/10.1007/s11528-021-00588-7>
29. Ye, H., Liang, B., Ng, O. L., & Chai, C. S. Integration of computational thinking in K-12 mathematics education: a systematic review on CT-based mathematics instruction and student learning. *International Journal of STEM Education*, **2023**, 10(1), 3. <https://doi.org/10.1186/s40594-023-00396-w>
30. Ye, J., Lai, X., & Wong, G. K. W. The transfer effects of computational thinking: A systematic review with meta-analysis and qualitative synthesis. *Journal of Computer Assisted Learning*, **2022**, 38(6), 1620-1638. <https://doi.org/10.1111/jcal.12723>
31. Zahrah, F., & Dwiputra, R. Digital Citizens: Efforts to Accelerate Digital Transformation. *Jurnal Studi Kebijakan Publik*, **2023**, 2(1), 1-11. <https://doi.org/10.21787/jskp.2.2023.1-11>

TableS5. Systematic reviews related to digital competence found on the Sustainability website, including the years covered, number of studies analysed, and the added value our study brings to them.

Article	Studies	Years	Value added of our article
Basantes-Andrade et al., 2022	26	2015-2022	Analyses proposals or models. While our analysis focuses on interventions carried out.
Colás-Bravo et al., 2021	19	2011-2021	Focuses on understanding how sustainability and the use of ICT are applied in education, in relation to teaching. Our analysis also provides completed interventions on students.
De la Calle et al., 2021	22	2015-2021	Evaluates Scopus articles focused on the development of digital competence. This study provides data from other databases and students' competence.
Rakovic et al., 2022	22	2001-2022	Focuses on the role of the Chief Digital Officer in the digital transformation of recent years. Not in the educational field.
Revuelta-Domínguez et al., 2022	26	2015-2021	Includes articles with quantitative or qualitative data related to teacher digital competence. Our analysis focuses on completed interventions.
Satalkina & Steiner, 2020	52	2014-2018	Focuses on digital entrepreneurship, business, and commerce. Outside the educational scope.
Treviño-Elizondo et al., 2023	39	2011-2022	Analyses the digital competence of workers in the industry. Different scope from the one analysed here.
Wang et al., 2022	18	2018-2022	Analyses effects and the development of career management in Asia. This review analyses a completely different field.

Note: The search string entered into the Sustainability website was: "digital competence systematic review" in any type of article and publication date.

1. Basantes-Andrade, A.; Casillas-Martín, S.; Cabezas-González, M.; Naranjo-Toro, M.; Guerra-Reyes, F. Standards of Teacher Digital Competence in Higher Education: A Systematic Literature Review. *Sustainability* **2022**, *14*, 13983. <https://doi.org/10.3390/su142113983>
2. Colás-Bravo, P.; Conde-Jiménez, J.; Reyes-de-Cózar, S. Sustainability and Digital Teaching Competence in Higher Education. *Sustainability* **2021**, *13*, 12354. <https://doi.org/10.3390/su132212354>
3. De la Calle, A.M.; Pacheco-Costa, A.; Gómez-Ruiz, M.Á.; Guzmán-Simón, F. Understanding Teacher Digital Competence in the Framework of Social Sustainability: A Systematic Review. *Sustainability* **2021**, *13*, 13283. <https://doi.org/10.3390/su132313283>
4. Satalkina, L.; Steiner, G. Digital Entrepreneurship and its Role in Innovation Systems: A Systematic Literature Review as a Basis for Future Research Avenues for Sustainable Transitions. *Sustainability* **2020**, *12*, 2764. <https://doi.org/10.3390/su12072764>
5. Raković, L.; Marić, S.; Đorđević Milutinović, L.; Sakal, M.; Antić, S. What about the Chief Digital Officer? A Literature Review. *Sustainability* **2022**, *14*, 4696. <https://doi.org/10.3390/su14084696>
6. Revuelta-Domínguez, F.-I.; Guerra-Antequera, J.; González-Pérez, A.; Pedrera-Rodríguez, M.-I.; González-Fernández, A. Digital Teaching Competence: A Systematic Review. *Sustainability* **2022**, *14*, 6428. <https://doi.org/10.3390/su14116428>

7. Treviño-Elizondo, B.L.; García-Reyes, H. An Employee Competency Development Maturity Model for Industry 4.0 Adoption. *Sustainability* **2023**, *15*, 11371. <https://doi.org/10.3390/su151411371>
8. Wang, Y.; Jiang, S.; Wu, C.; Cai, X.; Wang, F. Impact of the Global Megatrends, COVID-19, and Digital Economy on Professional Career Management Transformation in Asian Countries. *Sustainability* **2022**, *14*, 10981. <https://doi.org/10.3390/su141710981>

Table S6. A comprehensive analysis of the reviewed empirical teaching studies, addressing elements such as the participant subjects, the groups involved, the methodological design, the examined concepts, and the skills developed. Each of these aspects is detailed in the report's content.

Study	Instructional procedure	Instructional techniques and strategies	Research questions and objectives
Prince et al. (2016)	Development of a MOOC, inclusion of an OER, project methodology, and case study..	<p style="text-align: center;">Before COVID-19 lockdown.</p> Initial interview. Analysis of significant documents and teachers' logs, data comparison with grounded theories.	<p>The objective of this analysis is to investigate if the implementation of Open Educational Resources (OER) contributes to the development of basic digital competences, focusing specifically on two key aspects: (i) the ability to analyse information effectively and efficiently, and (ii) the skill to critically evaluate information and its sources, integrating it appropriately into individuals' body of knowledge and values. Particular attention will be paid to the ability to search and filter visual information, as well as the skill to select images accurately and reuse them while respecting copyright.</p> <p>What are the effects of using Open Educational Resources (OER) on the development of basic digital competences in students from three public universities in Mexico, a private university in Venezuela, and self-taught individuals?</p>
Fernández-montalvo et al. (2017)	<p>The experimental group is intervened with, the control group does not receive any kind of intervention.</p> <p>It is carried out in the classroom with the teacher by a psychologist and a pedagogue, the evaluation is conducted by both professionals after each session.</p> <p>It is verified at the end of the sessions and at 6 months.</p>	<p>Comparison of the groups using the Chi-Square test.</p> <p>Diagnostic assessment of both groups with 30 items, development of the three units in the experimental group, and finally summative assessment and comparison with the development experienced in the control group.</p>	Develop and enhance students' digital literacy.
Gómez-trigueros et al. (2018)	<p>Development and creation of the Massive Open Online Course (MOOC) titled "Teaching Geography with Google EarthTM."</p> <p>Implementation through the virtual classroom.</p> <p>Evaluation and examination of the results obtained in the tasks and exams of each module, followed by a detailed analysis of the same.</p>	<p>Analysis of results using a Likert scale.</p> <p>The resolution of practical tasks and final exams for each module will be carried out to verify the level of conceptual and technological knowledge acquired, as well as to assess student satisfaction.</p>	The purpose of this study is to analyse the suitability of the Massive Open Online Course (MOOC) titled "Teaching Geography with Google EarthTM" as a tool for the effective integration of the TPACK Model (Technology, Pedagogy, and Content Knowledge) and for the development of essential competencies among teachers in training.
Maureen et al. (2018)	<p>The initial level is assessed with a pretest. Over the next three weeks, the control group remains the same while the other two groups are told stories, both orally and digitally. In the fifth week, reading and writing skills are measured again with a posttest.</p>	<p>Pretest and posttest for linguistic and digital competence.</p> <p>Evaluation rubric.</p> <p>Storytelling.</p> <p>Creating their own stories, debates, writing postcards or emails, games.</p> <p>Feedback in a roundtable, communicating what has been done to peers and teachers.</p>	<p>Provide a variety of activity proposals to support the growth of reading and writing skills, as well as digital competences.</p> <p>Are oral or digital storytelling activities beneficial for improving literacy and developing digital competences?</p>

<p>Guayara cuéllar et al. (2019)</p>	<p>At the beginning of the procedure, a questionnaire is conducted with the aim of assessing the level of digital competence of the teachers.</p> <p>The course is developed online through Moodle with three modules, each containing various activities.</p> <p>Finally, assessment is done through the resolution of two cases of online crimes and risks, as well as the evaluation of the activities carried out during the course.</p>	<p>Initial questionnaire.</p> <p>Evaluative activities and workshops in each module.</p>	<p>The initiative is based on the conception and execution of an online training program focused on digital literacy, specifically designed for the teachers of the University of the Amazon, located in Florencia, Caquetá, Colombia. The primary purpose of this proposal is to enhance the technological skills of teachers by training them in the effective application of information and communication technologies (ICT).</p>
<p>During COVID-19 lockdown</p>			
<p>Aydin et al. (2020)</p>	<p>A pretest and posttest are conducted, and between these assessments, an 8-week course is developed, which includes the following topics:</p> <p>Internet, Web Browsers, and E-Government</p> <p>Wearable Technologies</p> <p>Social Media</p> <p>Social and Technological Development</p> <p>Ethics</p> <p>Lifelong Learning</p> <p>The Cloud and its Characteristics</p> <p>Computing and its Characteristics.</p>	<p>The 'Digital Citizenship Scale' consists of a Likert scale with 8 factors and 49 items, covering Communication, Rights and Responsibilities, Critical Thinking, Participation, Security, Digital Skills, Ethics, and Commerce.</p>	<p>The aim is to evaluate the effectiveness of the digital literacy course provided to the students.</p> <p>Research questions (i) What is the difference in digital competency scores before and after assessment in future teachers?; (ii) To what extent are disparities observed in communicative competency scores between the pre- and post-assessment of future teachers?; (iii) What is the variation in scores of future teachers in relation to aspects of rights and responsibilities between the pre- and post-assessment?; (iv) To what extent do critical thinking scores of future teachers vary between the pre- and post-assessment?; (v) What is the difference in participation scores of future teachers between the pre- and post-assessment?; (vi) To what extent do safety scores of future teachers change between the pre- and post-assessment?; (vii) What is the disparity in skill scores of future teachers between the pre- and post-assessment?; (viii) To what extent do ethics scores of future teachers differ between the pre- and post-assessment?</p>
<p>Benavente-vera et al. (2020)</p>	<p>A statistical program is applied that allows for descriptive analysis before and after each treatment, as well as inferential analysis using one-way ANOVA.</p>	<p>Correlated experiments in which actions are manipulated to observe their effects on other variables.</p> <p>Survey validated by five experts, conducted before and after each treatment.</p>	<p>Not specified</p>
<p>Romero garcia et al. (2020)</p>	<p>Diagnostic assessment of both groups, program intervention in the experimental group, activity design, and finally summative evaluation and comparison with the progress experienced in the control group.</p>	<p>An initial assessment is conducted for both groups to verify if they are equivalent using a 20-question objective test.</p> <p>Pretest.</p> <p>Two activities are conducted: the design of a mathematical game and a customized workshop. They are assessed through rubrics.</p> <p>Online intervention with the Experimental Group (EG).</p> <p>Final evaluation with the posttest, comparison with the initial pretest, and with the results obtained in the Control Group (CG).</p> <p>Compilation of tables and graphs with the results.</p> <p>Finally, student satisfaction is assessed through ad hoc online questionnaires.</p>	<p>Investigate and compare the effects of implementing an active methodology supported by collaborative activities and technological tools in students' learning procedures, as opposed to traditional approaches. Additionally, it seeks to determine whether this methodology also contributes to the development of digital skills among students.</p>

<p>Camino et al. (2021)</p>	<p>In the educational environment, students are enrolled in a training centre where the teacher serves as a guide. In this context, an active and participatory methodology is implemented, combining various teaching and learning methods, including inquiry, guided discovery, reciprocal teaching, task assignments, promotion of creativity, problem-solving, and group collaboration.</p>	<p>The Basque Government has proposed an update of the measurement of digital competence, using the framework established by the International Society for Technology in Education (ISTE) as a reference. The official document includes annotations and comments related to this proposal.</p>	<p>The objectives of this study are to assess the potential improvement in digital competence as a result of the implementation of the educational project and to examine whether both the student's educational level and the teacher's role have an impact on this increase. Research questions (i) Is there a significant increase in digital competence observed after the implementation of the educational project? (ii) Is there a relationship between the student's educational level and the increase in their digital competence after participating in the educational project? (iii) Does the role played by the teacher influence the increase in students' digital competence following the implementation of the educational project?</p>
<p>Chatwattana (2021)</p>	<p>Systematic review of literature and theories on MOOCs, Self-Directed Learning (SDL), and digital competence. Design and development of the MOOC.</p>	<p>Self-directed learning (SDL) system through the development of a MOOC. Evaluation forms on the quality and efficiency of the MOOC system developed with SDL. Evaluation forms on the perception of the suitability of the MOOC system.</p>	<p>Synthesize the conceptual framework of the MOOC system with SDL; Design and develop it at a Thai university in accordance with the conceptual framework; Evaluate the post-implementation results at the Thai university.</p>
<p>Ryhtä et al. (2021)</p>	<p>A pretest is conducted by all participants to determine their initial level. The BDE course is conducted for six weeks through Moodle, allowing participants to individually organize their work schedules. Once completed, the results are evaluated through the OODI questionnaire again.</p>	<p>"Educators and Educator Candidates' Competence in Digital Pedagogy (OODI)" consists of 32 items on digital competence divided into 6 areas: Self-learning, individualized schedule organization. Problem-solving. Communication with online entities. Content creation. Group work, debates, lectures, individual written assignments, evaluations, and practical work.</p>	<p>Investigate the relationship between an educational intervention and the competence of healthcare educators and aspiring digital pedagogy educators. What is the connection between the educational intervention and the self-assessed competence of healthcare educators and candidates for digital pedagogy educators?</p>
<p>Ugur et al. (2021)</p>	<p>Learning needs assessments were carried out, and based on these assessments, a plan was developed, which was divided into four online modules. The purpose of this plan was to facilitate the acquisition of essential skills for effective use of Information and Communication Technologies (ICT).</p>	<p>Online development and evaluation. Self-assessment and assessment through a questionnaire. Assessment through rubrics by the instructors of the proposed activities.</p>	<p>The purpose of this research is to develop an online professional development program that provides educators with the opportunity to use technology effectively both in the context of an online course for their own learning and in their classrooms. Research questions (i) What is the optimal design of an online professional development program aimed at improving technology integration skills in education?; (ii) What were the self-assessments made by teachers regarding the implementation of technology-enriched lessons?; (iii) What were the final assessments made by teachers at the end of the course?; (iv) What were the final assessments made by the instructors at the end of the course?</p>

Basantes-andrade et al. (2022)	Initial assessment through the pretest. Based on the results, the NANOMOOC course was designed, and once completed by the student, the posttest is conducted.	A pretest is conducted with 33 items covering 6 areas of digital competence, problem-solving, information retrieval, communication, security, and content creation. Posttest after completing the course. Satisfaction survey.	The purpose is to investigate whether nano-MOOC format courses contribute to the improvement of the digital competence of the teaching staff. Research questions (i) What is the level of digital competence of the teachers at the Technical University of the North (UTN)?; (ii) Are nano-MOOC format courses effective in enhancing the digital competence of teachers?
Choi et al. (2022)	Levels are measured with the pretest. After that, the program is introduced, explaining what it consists of, the 10 sessions, their activities, and the final gamification. Finally, the factors are measured again to check the effectiveness of the course.	Completing online activity sheets. Online readings and gamification. The assessment instruments are divided into two areas: recognition and behavior. The subfactors in the recognition area are value, self-efficacy, and emotion. The subfactors in the behavior area are self-regulation, participation, ethics, safety, and critical reading.	Provide assistance to older individuals to acquire the necessary knowledge and adapt to the information age while helping them understand the decision-making procedure.
Fuentes-cancell et al. (2022)	The pretest is conducted to check the initial levels of digital competence and compare them later with the posttest that will be carried out once the MOOC is completed. Once the pretest is completed, the MOOC course is conducted online for 6-8 months through 9 workshops where the 6 indicated factors will be addressed.	A scale composed of 41 items that assesses six different factors: language, technology, interaction procedures, production and dissemination procedures, ideology and values, and aesthetics. Collaborative use of social networks for information exchange. Design, creation, and dissemination of images, videos, hashtags, and more.	The purpose is to assess the effectiveness of Massive Open Online Courses (MOOCs) in strengthening teachers' digital skills, using social networks as a learning tool. What is the influence of MOOC courses organized as virtual workshops in promoting the digital skills of the teaching staff at a university institution?
Garcés et al. (2022)	Development of a Massive Open Online Course (MOOC). Diagnostic, formative, and summative assessment of both learning outcomes and satisfaction through a Likert scale survey and another for Personal Satisfaction. Administering evaluative questionnaires.	Teachers read documents, watch videos, engage in discussions in an interactive manner through Moodle. Development of 7 units in which the course is divided, from its introduction to a reflection on the acquired learning. Topics covered include digital security, international literacy, content creation, and communication.	It is proposed to implement a MOOC designed for participants to acquire digital competencies and apply that knowledge in academic procedures. The goal is to provide an accessible online learning platform to develop relevant technological skills and promote their effective application in the academic environment.
Javorcik (2022)	Through the Moodle platform, students are required to complete the assigned chapters in the course and, upon finishing each one, present a product created using the digital tools taught. After completing the course, they will be asked to fill out a questionnaire to assess its effectiveness.	Editing digital resources, creating online tests, activity sheets, presentations, documents, graphics, or scales. Questionnaire with a Likert scale on digital skills related to teaching, consisting of 18 questions.	The goal is to provide future educators with a demonstration of how digital tools can be beneficial in educational procedures. Research question (i) What digital knowledge and skills do future educators find most challenging to use for educational purposes? (ii) Does a microlearning course help students increase their confidence in their knowledge and skills? (iii) In which of the evaluated areas has there been a change in self-assessment as a result of studying a microlearning course?

Munawaroh et al. (2022)	<p>A sociodemographic study is conducted to select the participants.</p> <p>Subsequently, the pretest is conducted.</p> <p>Once the results are obtained, the experimental group (GE) is intervened with.</p> <p>At the end, the posttest is conducted in both groups to show the differences.</p> <p>After a few weeks, the questionnaire is administered again to check if the results obtained are maintained.</p>	<p>Pretest, posttest, and a one-week follow-up test to confirm results over time.</p> <p>A questionnaire with 60 conceptual, procedural, and attitudinal questions about digital competence.</p> <p>Discussion of what was learned after each session.</p> <p>Videos, discussion forums, simulations.</p>	<p>Promoting the enhancement of teachers' digital competence in primary education involves fostering the growth of their conceptual, procedural, and attitudinal skills.</p> <p>How effective is the training program in improving teachers' conceptual, procedural, and attitudinal aspects regarding technology utilization?</p>
Nogueira et al. (2022)	<p>Before the course begins, a diagnostic evaluation is conducted through a questionnaire, which is repeated at the end of the course.</p> <p>In the second semester, the experimental group is invited to participate in digital literacy classes.</p> <p>During these classes, their performance is assessed through observation scales, and questionnaires are prepared for families and students themselves to understand their daily use of technology.</p>	<p>A test is presented to assess mathematical logical knowledge before and after the course, with 8 questions.</p> <p>Initial, formative, and summative assessment. Hetero-evaluation and self-evaluation through observation scales.</p> <p>Informational questionnaire about the use of technologies in their daily lives.</p>	<p>To conduct a research study to assess the impact of the implementation of digital literacy on the learning of logic and mathematics.</p> <p>Is it feasible that this course generates a positive effect on the development of students' logical reasoning?</p>
Yelubay et al. (2022)	<p>Both groups complete the questionnaire before and after the MOOC, but only the experimental group takes the online course.</p> <p>MOOC: Development of various online skills such as video editing, text, copyright, forum discussion, online education, education trends, or digital communities, and quizzes.</p>	<p>Creation of an online collaboration network, presentations, and visual and auditory resources.</p> <p>Identifying false information or news.</p> <p>Pretest/Posttest evaluation questionnaire with 20 items: motivation, cognition, ethics, and technology.</p>	<p>To evaluate the effectiveness of MOOCs and explore the opportunities they offer in the construction of motivational, technological, cognitive, and ethical components of competence.</p> <p>Can the use of the MOOC approach generate significant differences in the digital competence of future teachers in the experimental groups, as measured through pretest and posttest assessments?</p>
Calvopiña herrera (2023)	<p>The research begins with a pretest to evaluate the initial digital competence of the teachers. Afterward, an instructional procedure is conducted to enhance their digital competencies.</p>	<p>At the end of the instructional procedure, a posttest is administered to measure digital competence. This assessment includes the measurement of digital competence across seven dimensions.</p>	<p>To design a training program aimed at improving digital competencies for teachers in virtual environments at the "Unidad Educativa Tarcila Albornoz de Gross."</p> <p>"How can digital competencies be improved in virtual teaching environments at the "Unidad Educativa Tarcila Albornoz de Gross?"</p> <p>The hypothesis suggests that training in digital competencies strengthens the teaching performance at the "Unidad Educativa Tarcila Albornoz de Gross."</p>
Dimitri et al. (2023)	<p>Initial assessment through a 10-item multiple-choice online questionnaire.</p> <p>Completion of a 4-week MOOC, followed by a re-administration of the aforementioned test.</p> <p>Comparison of the results from both questionnaires.</p>	<p>Online questionnaire consisting of 10 items related to digital literacy in the healthcare field, with multiple-choice format responses.</p>	<p>Enhancing digital health literacy among healthcare professionals caring for patients with GHD (Growth Hormone Deficiency).</p>
Gabarda méndez et al. (2023)	<p>The six phases include:</p> <p>Analysis of the current situation and project design.</p> <p>Selection of assessment instruments.</p> <p>Informing the students.</p> <p>Pretest.</p>	<p>Data collection through a questionnaire for gathering sociodemographic information and an initial assessment of digital literacy.</p> <p>Pretest and post-test conducted through the Virtual Classroom using Google Forms.</p>	<p>The aim of the study is to analyse students' self-perception in the Early Childhood Education and Primary Education degree programs concerning their actual digital literacy, as well as their potential improvement in all areas of digital literacy after participating in a teaching innovation project. Additionally, the study aims to examine the influence of variables such as gender and current academic year on these results.</p>

	<p>Intervention.</p> <p>Post-test.</p>	<p>During the intervention, five activities were developed:</p> <p>(i) Literature search and document sharing.</p> <p>(ii) How to access and participate in a blog.</p> <p>(iii) Conducting a seminar on gamification in addressing diversity.</p> <p>(iv) Focusing on cybersecurity.</p> <p>(v) Problem-solving practical exercises.</p>	
Pino (2023)	<p>Identifying prior knowledge and presenting models.</p> <p>Completing a case study resolution task, which is repeated after instruction.</p> <p>Reflecting on and discussing what has been learned.</p>	<p>Data collection includes verbalization and metacognitive discussion of pre- and post-activity ideas and resources, as well as the resolution of a case study.</p>	<p>To implement intervention programs and analyse their impact on teacher training.</p>
Wang et al. (2023)	<p>A pretest on digital well-being is conducted as an initial assessment.</p> <p>Next, an introduction on the same. While the experimental group learns how to control Internet addiction through a video game, the control group receives conventional classes.</p> <p>Upon completion, a posttest is conducted to measure the motivation, engagement, and digital well-being of both groups.</p>	<p>Likert scale questionnaire with 29 items for well-being, 6 items for motivation, and 12 items for engagement.</p>	<p>Research questions: (i) Do students engaged in game-based learning demonstrate higher digital well-being literacy compared to those who receive traditional education?; (ii) Do students participating in game-based learning exhibit higher levels of learning and greater motivation compared to those learning through traditional methods?; (iii) Do students engaged in game-based learning show greater levels of commitment and involvement in the learning procedure compared to those learning through traditional methods?</p>
Zhang et al. (2023)	<p>A pretest is conducted to check the initial levels of digital literacy and compare them with the posttest that will be carried out once the DML course is completed.</p> <p>Both groups take the tests, but only the experimental group participates in the DML.</p> <p>The mentioned course lasts for 10 weeks.</p>	<p>A 5-point Likert scale questionnaire with 37 items is used to collect personal data and information about the participants' digital literacy.</p>	<p>The objective is to introduce a Digital Media Literacy (DML) course and explore its impact on the digital media proficiency of primary education students. Research questions: (i) Does the DML course influence students' proficiency in DML, encompassing technical skills, critical comprehension, creative expression, and civic engagement?; (ii) Does the DML course alter the dynamics among students' DML skills, teacher guidance, and students' outcomes?</p>

Note: The data extracted from the analysed study is included within the appropriate section or, if necessary, outside of it.

Table S7. Evaluation tools used in the educational implementation of the analysed studies are described in detail in the report, presenting a comprehensive comparison among the various instruments and their application.

Study	Timing of the application of each instrument.	Assessment of intervention effects	Comments	Individual	Group
					Before COVID-19 lockdown.
Prince et al. (2016)	Pre-interview, case study, and assessment of the MOOC during and post-intervention.	Performance and acquisition of digital competencias. MOOC design.	Assesses digital competence and MOOC design but does not evaluate aspects like motivation or satisfaction.		
Fernández-montalvo et al.	Assessment through a 30-question questionnaire before the intervention. The same instrument, reduced to 20 questions, is used during (quarterly) and after the intervention.	Corroborate the effectiveness of the course, assessing the development experienced by the participants in the experimental group in comparison to the diagnostic	This is a very comprehensive intervention, assessing digital competence in primary school students, with a large sample and two study groups. However, it does not include psychological variables such		

(2017)		evaluation and the control group.	as motivation or satisfaction.
Gómez-trigueros et al. (2018)	In this course, formative assessment of tasks and practical tests with assessment rubrics has been carried out. As a final evaluation, an online questionnaire about the acquired digital competencies was conducted.	To assess the suitability of the MOOC course, as well as the use of the Google Earth tool, its didactic use related to the performance and acquisition of digital competences of teachers and students.	This intervention only reflects the results after the course, which is its main limitation.
Maureen et al. (2018)	Diagnostic and final assessment, with pretest and posttest, using assessment rubrics to measure digital and linguistic competencies.	Evaluate the development in linguistic and digital literacy after the intervention. Comparison of the results obtained in assessments of the experimental group (EG) and the control group (CG).	This is an original intervention in terms of its instructional procedure and evaluation, as it assesses two competencies.
Guayara cuéllar et al. (2019)	A diagnostic assessment is conducted prior to the course design, followed by monitoring and task evaluation upon completion.	Technological performance acquired after the course and its application in real problem-solving.	This intervention primarily focuses on how to design and implement an online course, the characteristics of its platform, and its development, while leaving out the details of the assessment instrument and results.
During COVID-19 lockdown			
Aydin et al. (2020)	Pre-intervention and post-intervention diagnostic assessment. Questionnaire with 49 items, consisting of 8 factors that make up digital competence.	Comprehensive analysis of each of the variables of digital competence assessed, their development through the implementation of the MOOC.	The developed MOOC program provides a detailed view of various factors of digital competence that have been developed and evaluated, without including psychological constructs among them.
Benavente-vera et al. (2020)	Application of a pre- and post-intervention questionnaire.	Performance and acquisition of competencies through course completion.	This assessment focuses on the development of competency acquisition, without using formative assessment or evaluating aspects like motivation or satisfaction.
Romero garcía et al. (2020)	An objective test is conducted to assess if both groups are equivalent. Subsequently, the completion of two tasks is evaluated using rubrics. A pre- and post-intervention questionnaire shows the development experienced. Satisfaction is assessed with a survey.	Development experienced by participants in terms of the 5 dimensions of digital competence, their academic performance in the assigned tasks, and differences between the control and experimental groups.	This intervention provides a detailed analysis of the collected data for each dimension, differences between both groups, and participant satisfaction. Very comprehensive.
Camino et al. (2021)	Utilization of a pretest and posttest, as well as formative assessment by the teachers.	Level of performance and observed achievement in relation to the use of ICT, digital competencies, and the development of autonomy in their usage.	Once again, this study focuses on quantitative results related to digital citizenship and competence, excluding the evaluation of psychological aspects.
Chatwattana (2021)	The MOOC students take tests after each unit. Both forms, digital competencies, and satisfaction, were conducted after completing the course.	Performance Quality of the MOOC. Development of digital literacy.	The study does not provide detailed information on the various evaluation instruments mentioned.
Ryhtä et al. (2021)	Diagnostic and final assessment through questionnaires with 32 items on digital competence divided into 6 areas.	Performance experienced by participants in the different areas that make up digital competence, the difference between pre and post-intervention results.	The added value of this intervention lies in the evaluation of different areas of digital competence. However, it does not include psychological variables related to digital competence.
Ugur et al. (2021)	Online assessment before, during, and after the course.	Quality and effectiveness of the course. Satisfaction.	This is an ambitious instructional and evaluative project, but with a less representative sample size.
Post COVID-19 lockdown			
Basantes-andrade et al. (2022)	Assessment at the beginning and end using questionnaires with 33 items to measure digital competence, divided into 6 areas.	To assess the effectiveness of the NANO MOOC, evaluating each of the areas into which digital competence has been divided, checking the development and performance experienced during the intervention.	It evaluates various areas of digital competence but does not include psychological variables.
Choi et al. (2022)	As a diagnostic assessment, a self-assessment of digital literacy is conducted before the intervention, divided into two factors.	To evaluate the performance and development of digital skills in older adults.	The significant contribution of this study lies in the use of a sample of older individuals who have limited digital competence. Additionally, it highlights the implementation of gamification as a strategy

	At the end of the program, the same questionnaire is administered again, along with another one to assess satisfaction.		for developing and enhancing digital competence in this specific group.
Fuentes-cancell et al. (2022)	Evaluation is conducted through a questionnaire administered before the intervention, consisting of 41 items divided into 6 factors. The same questionnaire is administered once the online course is completed to assess the differences pre and post.	To verify the effectiveness of the designed MOOC, assessing the development achieved in digital competence through the evaluation of pre- and post-intervention results.	This study presents the design of a MOOC capable of developing the digital competence of its participants, but it does not include instruments to measure the psychological constructs involved.
Garcés et al. (2022)	An initial self-assessment is conducted through a survey. Hetero-evaluation is performed using tasks and assignments as formative and summative assessments or as final assessments. Additionally, a final satisfaction survey is administered.	The evolution experienced in digital literacy due to the completion of the course.	It details the evaluation procedure followed but does not specify the reliability of the instruments or show them.
Javorcik (2022)	Autoevaluation is done through questionnaires assessing digital skills in university students, both before and after the microlearning course. During the course, feedback is provided on the tasks completed.	To assess the effectiveness of microlearning courses in developing digital skills closely related to digital competence.	This intervention primarily focuses on assessing digital skills, without mentioning psychological constructs.
Munawaroh et al. (2022)	A 60-item questionnaire to assess digital competence is conducted at three different points in time: before the intervention, once it is completed, and a few weeks later to check if the results remain consistent over time.	Evaluate the performance and development of digital competence based on previous evidence and subsequent results, comparing the EG (intervention group) and CG (control group).	The intervention involves a large sample, comprehensive analysis, and pre-test and post-test comparisons. The main limitation is the absence of psychological constructs.
Nogueira et al. (2022)	Digital literacy is assessed through a questionnaire before and after the course. During the course, tasks are evaluated using observation scales. Finally, participants complete a survey about their daily use of new technologies.	Comparative evaluation of the EG (intervention group) and CG (control group), as well as the development of logical-mathematical and digital competencies, with the goal of confirming the course's effectiveness through the results.	The study includes consistent assessment throughout the course, allowing for a detailed analysis of the data obtained and comparison between both groups. The main limitation is the absence of psychological constructs related to digital competence.
Yelubay et al. (2022)	Both the control and experimental groups complete a pre-intervention and post-intervention questionnaire.	Development experienced in the mentioned components of competence after the intervention.	The intervention assesses various psychological aspects related to digital competence, including motivational, technological, cognitive, and ethical components.
CalvoPiña herrera (2023)	Evaluation of the seven dimensions of digital competence through a 35-item questionnaire before and after the instructional procedure.	Development experienced in the mentioned components of competence after the intervention.	This study demonstrates continuous, diagnostic, and detailed evaluation, divided into blocks and sessions. It also analyses each of the mentioned variables and explains the results obtained.
Dimitri et al. (2023)	Diagnostic and final assessment through a 10-item multiple-choice questionnaire. The instructional procedure takes place between these two assessments.	Development achieved after completing the MOOC, applied to healthcare.	This program has an ambitious goal of developing digital literacy in professionals beyond the education sector. However, the assessment instrument used is limited in terms of the items evaluated.
Gabarda méndez et al. (2023)	Self-assessment questionnaire of digital competence before and after the intervention.	Level of performance and acquisition of digital competencies in the different areas that make up the intervention program as a result of participating in it.	The study examines the progress made in different areas, but it does not provide specific results of the tasks carried out during the course and does not include an evaluation of psychological aspects related to digital competence.
Pino (2023)	Continuous assessment of responses obtained in a case study and those verbalized during pre- and post-intervention idea discussions. Self-assessment.	Development experienced in relation to pre- and post-intervention responses, related to the use of tools and the justification of such usage.	The qualitative and quantitative assessment adds value to this study by introducing case study analysis and metacognitive discussion rather than pre- and post-intervention questionnaires. However, it lacks a comparison between the control group (CG) and experimental group (EG).

Wang et al. (2023)	Assessment of digital well-being through a questionnaire before the intervention. After the intervention, another questionnaire is administered to measure commitment, motivation, and digital well-being.	Evaluate the development experienced by the participants in relation to digital well-being before and after the intervention. Compare the results obtained in motivation and commitment between the control group (CG) and experimental group (EG).	The study's originality lies in the use of gamification and the comparison between the control group (CG) and experimental group (EG), as well as pre- and post-tests of various psychological and educational variables.
Zhang et al. (2023)	A 37-item Likert scale questionnaire is used for initial and final assessment to evaluate the development experienced in digital literacy after the instructional procedure.	Assessment of the performance achieved in relation to digital literacy due to the instructional procedure.	The evaluation covers various aspects of digital literacy as well as tasks performed during the 10-week course. One evaluative limitation is the absence of a satisfaction survey.

Note: The data extracted from the analysed study is included within the appropriate section or, if necessary, outside of it

Table S8. Treatment fidelity refers to the consistency of implementing the educational approach. The report provides a comprehensive description of each control element and indicator, detailing their comparative application across the various studies. Additionally, it includes the measurement factors and adjustment variables used in the pedagogical intervention in the analysed studies.

Study	Time	Control group comparison	Instructional sequence	Uniform and standardized application
Before COVID-19 lockdown.				
Prince et al. (2016)	Pre-implementation diagnosis: Needs assessment, surveys, meetings with industry experts, and prior literature review. In-MOOC activities: Interviews and case studies during the MOOC. Subsequent evaluation.	Single group: Participants take a pre- and post-instruction test to assess its effectiveness.	Observational and instructional sequence monitoring to verify the course's effectiveness in improving digital competencies.	Uniform program implementation for all students, with identical duration, the same sequence, consistent intensity, and identical tasks for all participants.
Fernández-montalvo et al. (2017)	Systematic review, analysis of internet usage patterns and risks among adolescents. Intervention with three instructional and evaluative sessions, followed by an evaluation at 6 months.	The study design involves creating two or more groups. The intervention group, which receives a specific program, will be evaluated and compared to an equivalent control group that follows the regular curriculum.	Observational and instructional sequence monitoring during the three sessions.	The program is implemented equitably for all students in the intervention group, with uniform duration, an identical sequence, consistent intensity, and the same tasks for all participants. The control group is evaluated but does not receive the same instruction.
Gómez-trigueros et al. (2018)	A literature review is conducted, and lectures are given beforehand. During the intervention program, instruction is delivered through the MOOC, followed by evaluation.	A single group undergoes both a pre-instruction and post-instruction test to assess its effectiveness.	Observational and instructional sequence monitoring across 6 modules.	The program is implemented equitably for all students, with uniform duration, an identical sequence, consistent intensity, and the same tasks for all participants.
Maureen et al. (2018)	A literature review is conducted beforehand. During the online course, the instructional procedure is carried out with both EG and CG. Once completed, participants are evaluated.	The design of this study involves the formation of two or more groups. An evaluation will be conducted on the intervention group, which will receive a specific program, and it will be compared with another equivalent control group that follows the regular curriculum.	Observational and instructional sequence monitoring during the 3 sessions.	The program is implemented equitably for all EG students, with uniform duration, an identical sequence, consistent intensity, and the same tasks for all participants. The CG is evaluated but does not receive the same instruction.
Guayara cuéllar et al. (2019)	Diagnostic evaluation and research focused on problem identification are conducted before the program. A literature review is also performed. During the program, instruction is delivered, and after it is completed,	There is a single group that undergoes a pre- and post-instructional test to check its effectiveness.	Not specified.	The program is implemented equitably for all students, with uniform duration, an identical sequence, consistent intensity, and the same tasks for all participants.

During COVID-19 lockdown				
	a follow-up assessment takes place.			
Aydin et al. (2020)	A literature review is conducted beforehand. During the online course, the instructional procedure takes place. Upon completion, participants are assessed.	There is a single group that undergoes a pre- and post-instructional test to check its effectiveness.	The instructional sequence is observed and monitored for 8 weeks.	The program is implemented equitably for all students, with uniform duration, an identical sequence, consistent intensity, and the same tasks for all participants.
Benavente-vera et al. (2020)	A previous literature review is conducted. The study indicates that an instructional procedure was carried out during the treatments applied to the group, with pre- and post-evaluation.	Four treatments are applied to the same group to verify the effectiveness of instruction in developing digital competencies.	The instructional sequence is observed and monitored through the intentional manipulation of experiments and treatments.	The program is implemented uniformly for all students, with identical duration, an equal sequence, consistent intensity, and the same tasks for all participants, involving the same four treatments.
Romero garcía et al. (2020)	A prior literature review is conducted. During the online course, the instructional procedure is carried out. Upon completion, participants from the experimental group (EG) and the control group (CG) are evaluated.	The study involves the formation of two or more groups. An evaluation will be conducted on the intervention group, which will receive a specific program, and it will be compared with another equivalent control group that follows the regular curriculum.	The instructional sequence is observed and monitored throughout 12 sessions, and a satisfaction survey is conducted.	The program is applied equitably to all students in the EG, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants. The control group (CG) is evaluated but does not receive the same instruction.
Camino et al. (2021)	A prior literature review is conducted. During the course, participants attend a training center where they receive instruction, followed by a subsequent evaluation.	A single group, which takes a pre- and post-instruction test to assess its effectiveness.	The instructional sequence is observed and monitored, with the teacher serving as a guide using active and participatory methodology.	The program is applied equitably to all students, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants.
Chatwattana (2021)	A prior systematic review is conducted before designing the MOOC. Monitoring occurs during the course's development. Subsequent evaluation of the construct and satisfaction.	The study's design involves forming two groups, evaluating the intervention group that receives a specific intervention, and comparing it with another control group to check the intervention's effectiveness.	It is a self-paced MOOC where the developers upload and monitor content, activities, tools, and tests on the platform. Users are responsible for organizing their work, promoting their autonomy. A satisfaction survey is conducted at the end.	The program is applied equitably to all students, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants.
Ryhtä et al. (2021)	A systematic review and expert meetings are conducted for course design. Instruction takes place over 6 weeks with subsequent evaluation.	A single group, which takes a pre- and post-instruction test to assess its effectiveness.	Observation and tracking of the instructional sequence divided into 6 areas.	The program is applied equitably to all students, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants.
Ugur et al. (2021)	Prior needs analysis for course development. Monitoring indicators during the course and subsequent evaluation.	A single group that takes a pre- and post-instruction test to check its effectiveness.	Observation and tracking of the instructional sequence to assess the course's effectiveness in improving digital competencies and satisfaction after completing the modules.	The program will be implemented uniformly for all students, with identical duration, an equal sequence, constant intensity, and the same tasks for all participants.
Post COVID-19 lockdown				
Basantes-andrade et	A prior literature review and evaluation for program design.	A single group takes a pre- and post-instruction test to check its	Observation and tracking of the instructional	The program will be implemented uniformly for all students, with identical duration, an

al. (2022)	During the online course, the instructional procedure is conducted. Upon completion, participants are evaluated.	effectiveness.	sequence and a final satisfaction survey.	equal sequence, equal intensity, and the same tasks for all participants.
Choi et al. (2022)	A literature review and instructor training are conducted beforehand. During the online course, the instructional procedure takes place, concluding with gamification. Once finished, the participants are evaluated.	The study's design involves the formation of two or more groups. An evaluation will be conducted on the intervention group, which will receive a specific program, and it will be compared to another equivalent control group following the standard curriculum.	Observation and monitoring of the instructional sequence through activities and gamification. A final satisfaction survey is administered.	The program will be implemented uniformly for all students in the intervention group, with the same duration, an identical sequence, equal intensity, and the same tasks for all participants. The control group is evaluated but does not receive the same instruction.
Fuentes-cancell et al. (2022)	Previously, a literature review is conducted. During the online course, the instructional procedure takes place. Once it's completed, the participants are evaluated.	Design of two or more groups that take a pre-test and post-test to assess its effectiveness.	Observation and tracking of the instructional sequence during 9 workshops.	The program will be applied equally to all students, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants.
Garcés et al. (2022)	Previously, a literature review is conducted. During the online course, the instructional procedure takes place. Once it's completed, the participants are evaluated.	A single group, which takes a pre-test and post-test to assess its effectiveness.	Observation and tracking of the instructional sequence, formative assessment of autonomous work and collaborative tasks.	The program will be applied equally to all students, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants.
Javorcik (2022)	A prior literature review is conducted. During the online course, the instructional procedure is carried out. Once completed, participants are evaluated.	A single group takes a pre-test and post-test to assess the effectiveness of the instruction.	Observation and tracking of the instructional sequence during the 5 chapters of the program.	The program will be applied equally to all students, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants.
Munawaroh et al. (2022)	A prior literature review is conducted. During the online course, the instructional procedure is carried out with both the experimental (EG) and control (CG) groups. Once completed, participants are evaluated.	The design of this study involves the formation of two or more groups. An evaluation will be conducted on the intervention group, which will receive a specific program, and will be compared to another equivalent control group that follows the regular curriculum.	Observation and tracking of the instructional sequence over 6 months.	The program will be applied equally to all students in the experimental group, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants. The control group is evaluated but does not receive the same instruction.
Nogueira et al. (2022)	Literature review and researcher meetings prior to the intervention. During the program, instruction is developed, and after its completion, a follow-up assessment is carried out.	The design of this study involves the formation of two or more groups. An assessment will be conducted for the intervention group, which will receive a specific program, and it will be compared with another equivalent control group following the regular curriculum.	Observation and sequential instructional monitoring during the 8 sessions, continuous contact with families.	The program will be applied equally to all students in the intervention group, with a uniform duration, an identical sequence, equal intensity, and the same tasks for all participants. The control group is assessed but does not receive the same instruction.
Yelubay et al. (2022)	Previously, a literature review is conducted. During the online course, the instructional procedure takes place. Once completed, participants are evaluated.	Two groups are designed, EG (Experimental Group) and CG (Control Group), to verify the differential effectiveness compared to a standard curriculum.	The instructional sequence is observed and followed with constant feedback, discussion in forums, and online information exchange.	The program is applied equitably to all EG students, with a uniform duration, identical sequence, equal intensity, and the same tasks for all participants. The CG is evaluated but does not receive the same instruction.
Calvopiña herrera (2023)	Previously, a literature review is conducted. During the in-person course, an initial assessment is performed, and the instructional procedure takes place.	A single group, which completes a questionnaire before and after the instruction to verify its effectiveness.	Observation and tracking of the instructional sequence to assess the course's effectiveness in improving digital competencies and	The program will be applied equitably to all students, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants.

	Once completed, participants are evaluated again.		satisfaction after the sessions.	
Dimitri et al. (2023)	Literature review. Diagnostic assessment followed by the completion of a 4-week MOOC, concluding with a final evaluation using the same questionnaire as the initial assessment.	A single group, which completes a questionnaire before and after the instruction to verify its effectiveness.	Online instructional sequence observation and monitoring through constant feedback and forum discussions.	The program will be applied equitably to all students, with uniform duration, an identical sequence, equal intensity, and the same tasks for all participants.
Gabarda méndez et al. (2023)	Literature review and meetings among teachers before the intervention. During the program, instruction is delivered in six phases, and upon completion, an assessment is conducted.	A single group takes a pre- and post-instruction test to measure its effectiveness.	Observation and monitoring of the instructional sequence, both in-person and online, including activities and feedback.	The program is applied uniformly to all students, with consistent duration, an identical sequence, equal intensity, and the same tasks for all participants.
Pino (2023)	Previously, a literature review is conducted. Sharing of previous ideas and inspiring models. During the program, the instructional procedure, initial and final assessments are carried out.	A single group conducts a case study before and after instruction to check its effectiveness.	Observation and monitoring of the instructional sequence, in person, with the resolution of case studies.	The program is applied uniformly to all students, with consistent duration, an identical sequence, equal intensity, and the same tasks for all participants.
Wang et al. (2023)	Prior systematic review. Meeting with participants in a session prior to the start of instruction. Development of the program and evaluation of EG and CG.	The design of this study involves the formation of two or more groups. An evaluation will be conducted for the intervention group, which will receive a specific program, and it will be compared with another equivalent control group that follows the regular curriculum.	Observation and monitoring of the instructional sequence, gamification, and satisfaction assessment.	The program will be applied uniformly to all students in the intervention group, with consistent duration, an identical sequence, equal intensity, and the same tasks for all participants. The control group is evaluated but does not receive the same instruction.
Zhang et al. (2023)	Pre-course literature review for course design. Conducting a pre-assessment. Followed by an intervention for the EG but not for the CG. Final evaluation of both groups and a comparison.	The design of this study involves the formation of two or more groups. An evaluation will be conducted for the intervention group, which will receive a specific program, and it will be compared with another equivalent control group that follows the regular curriculum.	Observation and monitoring of the instructional sequence, both in-person and online, with the completion of assignments and discussions.	The program will be applied uniformly to all students in the intervention group, with consistent duration, an identical sequence, equal intensity, and the same tasks for all participants. The control group is evaluated but does not receive the same instruction.

Note: The data extracted from the analysed study is included within the appropriate section or, if necessary, outside of it.

Table S9. Limitations of the educational strategies addressed in the examined empirical studies. Each of these areas is detailed extensively in the main report.

Study	Instruments	Discussion and conclusions	Comments
			Before COVID-19 lockdown.
Prince et al. (2016)	Reliance on self-reports, no direct observation Lack of tasks Incomplete intervention recording Unspecified instruments and no attachment provided	No evidence based on data No explicit limitations	No use of pre-tests, only interviews to gather participants' perspectives and opinions about the MOOC. It is recommended to include pre and post measurements to assess improvements.
Fernández-montalvo et al. (2017)		No indication of the response to the research question	It is true that the theoretical framework relies on non-current studies, but it's worth noting that this is an intervention from 2017. Nonetheless, it is a very comprehensive intervention with a thorough analysis and presentation of the procedure followed and the results.

Gómez-trigueros et al. (2018)	No validation and reliability of instruments with own data Reliance on self-reports only, no direct observation Unknown instruments, not provided in an annex	No evidence based on data No indication of the response to the research question	The development of digital competence takes a back seat in this study; it focuses on learning to use Google Earth through a MOOC course and the results of the course exams.
Maureen et al. (2018)			Results are observed in the pretest and posttest for each of the three groups, although the sample is slightly small and divided by classes.
Guayara cuéllar et al. (2019)	Lack of validity and reliability of instruments with proprietary data Reliance on self-reports, no direct observation Unknown instruments not provided in an annex	There is a lack of data-based evidence in the study. The study does not compare its findings with existing or previous research. The limitations of the study are not explicitly stated. The study fails to address the research question adequately. Practical and theoretical applications of the findings are not discussed.	The study lacks key information, such as the analysed results after the course, and it lacks a representative sample, information on duration, and the pretest assessment instrument.
During COVID-19 lockdown			
Aydina et al. (2020)		No explicit limitations	At the end of the article, there are suggestions for further research in the study's research line, which is interesting because it lays the groundwork for future research with CG and GE, the main weakness found in this study.
Benavente-vera et al. (2020)	Relying solely on self-reports, no direct observation No tasks Incomplete intervention recording Unknown instruments, not provided in the appendix	The study does not clearly outline its limitations. The research question is not effectively addressed, and the study does not provide a clear indication of its answer.	Despite comparing pre and post results, the instructional procedure is not detailed, only the results and their analysis are presented.
Romero garcía et al. (2020)		Lack of explicit limitations No indication of the answer to the research question	While the study presents very detailed and in-depth results along with a comprehensive discussion, it does not explain the instructional procedure during the intervention or details about the sampling, such as groupings.
Camino et al. (2021)			It's a fairly comprehensive study, presenting the procedure followed and pre-post test results in detail. However, it could benefit from explaining the sample used, its selection criteria, and any groupings.
Chatwattana (2021)	Reliance on self-reports, no direct observation	No explicit limitations Doesn't indicate the research question's answer	The study doesn't discuss the groups' prior levels; it primarily focuses on demonstrating the performance achieved after the intervention by comparing both groups.
Ryhtä et al. (2021)	Reliance on self-reports, no direct observation	Doesn't indicate the research question's answer	The main limitations of this study are related to the unrepresentative sample, which hinders the ability to create control and experimental groups.
Ugur et al. (2021)		Not compared with current previous studies No explicit limitations Doesn't indicate the research question's answer	The study's primary limitation is its very small and unrepresentative sample.
Post COVID-19 lockdown			
Basantes-andrade et al. (2022)	Only self-reports, no direct observation		The study includes a thorough analysis of the variables, a detailed intervention program, and well-explained discussions, conclusions, and limitations.
Choi et al. (2022)		Doesn't interpret results No explicit limitations No indication of the answer to the research question No practical and theoretical applications	This article primarily focuses on result analysis, with limited interpretation and theoretical or practical contributions.
Fuentes-cancell et al. (2022)		The response to the research question is not provided.	The primary added value and innovation of this program is the central use of social networks for the development of digital competence.
Garcés et al. (2022)	Lack of validity and reliability of instruments	Failure to interpret results.	This study primarily focuses on teacher satisfaction, opinions, and acceptance of the MOOC rather than the results related to digital competence improvement.

	with self-collected data. No tasks. Unknown instruments, and they are not provided in the annex.	Lack of evidence based on data. No comparison with current previous studies. No explicit limitations. No conclusions. The answer to the research question is not indicated.	
Javorcik (2022)	Lack of validity and reliability of instruments with self-collected data. Reliance solely on self-reports without direct observation. Unknown instruments, and they are not provided in the annex.	No evidence based on data. No explicit limitations.	The primary limitation of this study is the instrument used, for which there is limited information, making it difficult to replicate the intervention.
Munawaroh et al. (2022)	Unknown instruments, and they are not provided in the annex.		Despite not explicitly showing the measurement instrument used, this intervention has a fairly large sample size, as well as a detailed procedure and results analysis.
Nogueira et al. (2022)			Despite the small sample size, the intervention presented is very comprehensive. Without explaining the procedure in great detail, it manages to assess the functionality of the intervention through a simple pretest and posttest.
Yelubay et al. (2022)	Only self-reports, no direct observation	No evidence based on data No explicit limitations No indication of the research question answer	In this study, the added value of measuring factors related to motivation, ethics, cognition, and technology is emphasized.
Calvopiña herrera (2023)		No evidence based on data Not compared with current previous studies No explicit limitations No indication of the research question answer	Despite detailing the entire instructional and evaluative procedure, there are limitations in the conclusions and discussions. In fact, there is no section for discussing the results, and the conclusions are presented in a summarized and very brief manner.
Dimitri et al. (2023)		No evidence based on data Not compared with current previous studies No indication of the research question answer	This study has evident limitations in the sample size, as well as in the evaluation instrument, which includes only 10 items for assessment.
Gabarda méndez et al. (2023)	Only self-reports, no direct observation	No indication of the research question answer	An evaluation of the procedure through observation scales could add extra value to this study, although the results obtained for each variable are very comprehensive.
Pino (2023)		No indication of the research question answer	The main limitations related to this study pertain to the omission of hypotheses and research questions, as well as the need for a more in-depth explanation of the instructional procedure followed.
Wang et al. (2023)			The main innovation of this intervention is the use of gamification for the development and measurement of constructs such as motivation, engagement, well-being, and digital competence.
Zhang et al. (2023)			The main limitations found in this study are related to the instructional procedure outlined. It is presented in a schematic manner without detailing the activities or materials used.

Note: The data extracted from the analysed study is included within the appropriate section or, if necessary, outside of it.

Refs [119-124] are cited in supplementary materials.