Open Science: Interdisciplinarity, ICT in the Education of Teacher Education Students at UPTC

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Abstract
In the current context of Open Science and Open Education, a participatory and constantly evolving space is taking shape, in which Knowledge Management (KM), supported by ICT, enables the construction of inclusive learning experiences within interdisciplinary environments. From this perspective, in December 2022, the Faculty of Education Sciences (FCE) of the Universidad Pedagógica y Tecnológica de Colombia (UPTC) endorsed the interdisciplinary elective KM with ICT, which has been offered to teacher education programs since 2023. The research sought to determine how ICT-mediated KM, from an interdisciplinary perspective, contributes to the development of Open Science practices in teacher education. To this end, the study explored its contribution to implementing Open Science and Open Education practices among future teachers. A descriptive qualitative approach was adopted under the pragmatic paradigm, through which eight classroom projects developed by 18 students from the Computer Science Education program (LI) were documented in collaboration with basic and secondary education institutions in Tunja, Boyacá. The findings show effective interdisciplinarity among the areas of languages, computer science, history, psychology, and technology, as well as a significant relationship between digital resources created with freely accessible tools and the principles of Open Science. In conclusion, the integration of KM, ICT, and interdisciplinarity strengthens Open Science and Open Education in initial teacher education.
Keywords: Knowledge Management; Open Science; Open Education; interdisciplinarity; ICT; teacher education.

1. INTRODUCTION

Open Education and Open Science are becoming two of the most relevant transformations in contemporary higher education, as they expand access to knowledge and promote more collaborative, transparent, and contextualized teaching and research practices (Ramírez-Montoya, 2022). At the same time, higher education institutions continue to consolidate their role as catalysts for an innovative culture, articulated through constructive processes that

connect teaching, research, and social engagement (Gárnica Estrada & Franco Calderón, 2021).

In November 2024, during the UNESCO World Congress on Open Educational Resources (OER), held in Dubai, United Arab Emirates, the Dubai Declaration on OER was adopted, focusing on digital public goods, open solutions, and artificial intelligence for inclusive access to knowledge, in accordance with the UNESCO Recommendation (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2019, 2024). This global commitment is also aligned with Sustainable Development Goal 4, which seeks to ensure inclusive, equitable, and quality education (United Nations General Assembly, 2015), as well as lifelong learning opportunities (UN & UNESCO, 2019).

In this scenario, KM in education and Open Science constitute strategies aimed at optimizing the acquisition, creation, storage, distribution, and application of knowledge in educational environments. From a multidisciplinary perspective, KM articulates elements of planning, management, and control in educational institutions with cultural dimensions related to the appropriation of ICT, technologies that have substantially transformed the ways of teaching and learning (Palacio Sprockel et al., 2022).

Nevertheless, a gap persists between the declarative principles of Open Science and Open Education—free access, collaboration, and transparency—and their effective translation into concrete curricular experiences in initial teacher education that intentionally integrate Knowledge Management, ICT, and interdisciplinary work. Authors such as Vallejo-Sierra and Pirela Morillo (2023) point out that, although Open Science is proposed as a relevant alternative for achieving higher levels of educational quality, significant challenges remain regarding its practical appropriation in faculties of education. This research addresses this gap through the analysis of a specific curricular experience: the interdisciplinary elective KM and ICT was proposed on December 5, 2022, as part of the elective offerings of the LI School, approved by the FCE Council in session 28 on December 21, 2022, and offered in the first semester of 2023 under code 8107580 (Universidad Pedagógica y Tecnológica de Colombia, Faculty of Education Sciences, 2022).

The proposal was presented to and approved by the FCE Council during Meeting 28, held on December 21, 2022, and was offered beginning in the first academic semester of 2023, under code 8107580, to the Faculty's 13 teacher education programs. The syllabus proposed the consolidation of an institutional educational system oriented toward KM with ICT, with the intention of developing new knowledge during the learning process and strengthening the digital capabilities of students, teachers, and the educational community in general.

Based on this context, the study was guided by the following research question: How does ICT-mediated KM, from an interdisciplinary approach, contribute to the development of Open Science practices in teacher education?

To answer this question, the general objective was to analyze the contribution of ICT-mediated KM, implemented through Interdisciplinary Elective I, to the development of Open Science and Open Education practices in the initial teacher education of students enrolled in the FCE teacher education programs at UPTC. Three specific objectives were derived from this general objective: (a) to describe the process of designing and implementing the KM with ICT course as an interdisciplinary educational space; (b) to characterize the interdisciplinarity achieved in the classroom projects developed from Nonaka and Takeuchi's (1995) knowledge-creation spiral model; and (c) to establish the relationship between the products generated by the classroom projects and the principles of Open Science and KM.

The article is organized as follows: first, the theoretical framework supporting the relationship among Knowledge Management, interdisciplinarity, ICT, and Open Science and Open Education is presented; second, the descriptive qualitative methodology employed is described; subsequently, the results are presented, including the relationship between the projects developed and the principles of Open Science; and finally, the findings are discussed and the conclusions of the study are presented.

2. THEORETICAL FRAMEWORK

2.1 Knowledge Management in educational contexts

KM can be understood as the recognition of the value of knowledge both as an intangible resource collectively produced by individuals in society and as one of the most important assets that organizations can possess and cultivate (Enríquez, 2019). In the university context, KM is grounded in conceptual and analytical frameworks that view the university as an entity whose fundamental purpose is the research, teaching, dissemination, and application of knowledge for the benefit of society (Enríquez, 2019).

A central reference for understanding the processes of knowledge production and transformation in organizations is the spiral model proposed by Nonaka and Takeuchi (1995), known as the SECI model, which represents four cycles of knowledge transformation: socialization, through which individual tacit knowledge becomes collective tacit knowledge when shared; externalization, through the conversion of tacit knowledge into explicit knowledge; combination, in which explicit knowledge is transformed into new and improved explicit knowledge; and internalization, through the transformation of explicit knowledge into tacit knowledge. These four cycles form a continuous spiral of knowledge creation and transformation that is particularly relevant for analyzing project-based classroom learning, as it makes it possible to describe how students transform experiences, observations, and pedagogical practices into explicit and shareable educational resources.

Having teachers with competencies and resources related to KM and ICT is essential for effectively integrating concepts and skills into pedagogical practice. Although digital resources are widely available, not all of them are appropriate for every context and stage of curricular development; therefore, it is necessary to understand their characteristics and the strategies for their optimal use (Okoye et al., 2020; Veytia Bucheli et al., 2020).

2.2 Interdisciplinarity in teacher education

Interdisciplinarity in education constitutes a pedagogical orientation that seeks to integrate different disciplines and fields of knowledge into the learning process, fostering an understanding of each reality as a whole and deepening students' engagement with problems and challenges encountered in real contexts. From this perspective, interdisciplinarity can be understood as a process of initiation and variation in relationships among the sciences, established both between different disciplines and within a single science, whose central element is dialogue among forms of knowledge (Varona, 2022).

Interdisciplinarity stimulates creativity by allowing students to explore connections among concepts and disciplines, generating new ideas and perspectives. It can therefore be understood as a pedagogical strategy in teacher education that integrates disciplines through a dialogue among forms of knowledge aimed at generating new knowledge, and should not be

understood as individual work, since it arises from the combined efforts and collaboration of its members (González & Pérez, 2018; UNIR México, 2024).

At UPTC, the interdisciplinary area refers to the integration of knowledge and practices from diverse disciplines, including the natural and social sciences, the arts, and technical fields, with the purpose of complementing the comprehensive, axiological, and pedagogical education of students. The interdisciplinary and advanced studies area of the FCE therefore constitutes an academic space that integrates different disciplines to enrich pedagogical practice and enable future educators to address educational challenges from a broader and more contextualized perspective (Red Académica, 2022).

From an epistemological perspective, addressing complexity in the field of Education Sciences requires simultaneously considering epistemological, methodological, and ontological aspects, recognizing that it is not possible to work exclusively from disciplinary perspectives, but rather that the interdisciplinary dimension must be addressed through studies of research activity (Alonso, 2020).

2.3 Open Science, Open Education, and ICT

Open Science enables shared co-construction and the generation of open innovation in public and private contexts; however, important challenges remain in open-access practices, particularly in education (Ramírez-Montoya & García-Peñalvo, 2018). Open Education, for its part, facilitates access to knowledge through practices, resources, and technologies aimed at its creation and dissemination, and constitutes a fundamental pillar for the future of education by promoting inclusive and collaborative learning (Ramírez-Montoya, 2022).

ICT and higher education institutions have become a cross-cutting component of curricular plans across different fields of knowledge, as they are considered generators of relevant digital competencies for teachers and students (Politécnico Grancolombiano, 2024). The KM process advances more rapidly through the contribution of ICT, particularly because of the growing convergence of computing, telecommunications, and data processing, which expands opportunities for application and optimizes KM models (Venegas & Proaño, 2021).

ICT are fundamentally connected with Open Science and Open Education by facilitating global and democratized access to knowledge, promoting collaborative pedagogical methodologies, and enabling students and teachers to access online educational resources and participate in virtual learning communities. This integration accelerates educational innovation, reduces geographical and economic barriers, and strengthens the education of critical and participatory citizens (Soares et al., 2023; Gil-Álvarez et al., 2023).

The articulation of KM, ICT, interdisciplinarity, and Open Science and Open Education consequently constitutes a relevant conceptual framework for analyzing curricular experiences aimed at strengthening the sustainability and social impact of initial teacher education, insofar as knowledge generated through classroom projects is conceived as a shared, replicable resource available to educational communities (De Giusti, 2022; García-Peñalvo, 2022).

3. METHODOLOGY

The research was conducted using a qualitative approach with a descriptive scope, grounded in the pragmatic paradigm, which allows for a realistic and contextualized reading of reality by focusing on the practical usefulness of knowledge for understanding complex phenomena from different perspectives (Pontificia Universidad Católica del Perú, 2022). The descriptive approach sought to provide a detailed and precise characterization of the phenomenon studied

in its natural context, without attempting to establish causal relationships or manipulate variables, based on the collection of data reflecting participants' perceptions, behaviors, and experiences (QuestionPro, 2023).

From this approach, an articulated dialogue was promoted among KM, Nonaka and Takeuchi's (1995) spiral model, and ICT-mediated work (Hernández-Sampieri et al., 2018). Strengthening KM through ICT and interdisciplinarity was proposed as a strategy for generating social impact in Open Science and Open Education among students from different programs in the Faculty.

3.1 Participants and context

The KM and ICT course began in the first academic semester of 2023 with 18 students from the LI, the program used as the reference for this study, although the course is offered in all 13 teacher education programs of the Faculty. The students were organized into groups of two, and each group identified a basic and secondary education institution near the municipality of Tunja (Boyacá) where they developed their project, after obtaining the respective approval from the institutional administrators. As a result, eight classroom projects were developed during the first semester of 2023 and presented at the end of the academic period.

3.2 Process stages

Stage 1. Painting workshop on KM and ICT. A didactic strategy that made it possible to construct the concept of KM from students' prior knowledge through the exchange and collective interpretation of drawings, which were subsequently uploaded to the Moodle platform. The sharing activity demonstrated the importance of "building together" and promoted collective learning.

Stage 2. Development of the syllabus and project formulation. The requirements for the final project, aimed at a basic and secondary education institution, were established. The groups selected the institution, obtained administrative approval, and conducted direct observations supported by questionnaires or semi-structured interviews in order to identify needs and formulate a proposed solution.

Stage 3. Initial presentation and feedback. The groups presented their initial proposals; the teacher guided the delimitation of topics, pedagogical strategies, and the incorporation of ICT. Most groups proposed digital educational resources, blogs, websites, and ICT-mediated workshops.

Stage 4. Development of the research project. This was the longest phase, during which the groups designed the solution and constructed the educational resource by applying Nonaka and Takeuchi's (1995) spiral model, considering the processes of knowledge creation, structuring, transformation, transfer, storage, and incorporation. Subsequently, the students returned to the educational institutions to implement the resource with basic and secondary education students.

Stage 5. Presentation of the research project. This stage made it possible to demonstrate students' appropriation and empowerment regarding the progress of their proposals and to observe how knowledge about KM with ICT was collaboratively constructed at each stage of the project.

The intervention carried out by the teacher education students with basic and secondary education students lasted 20 hours, with the support of the course instructor. The analysis relied on documentary review of the projects, observation of the presentations, and

systematization of the digital resources produced, which made it possible to establish the relationship between the projects and the principles of Open Science presented in the following section.

4. RESULTS

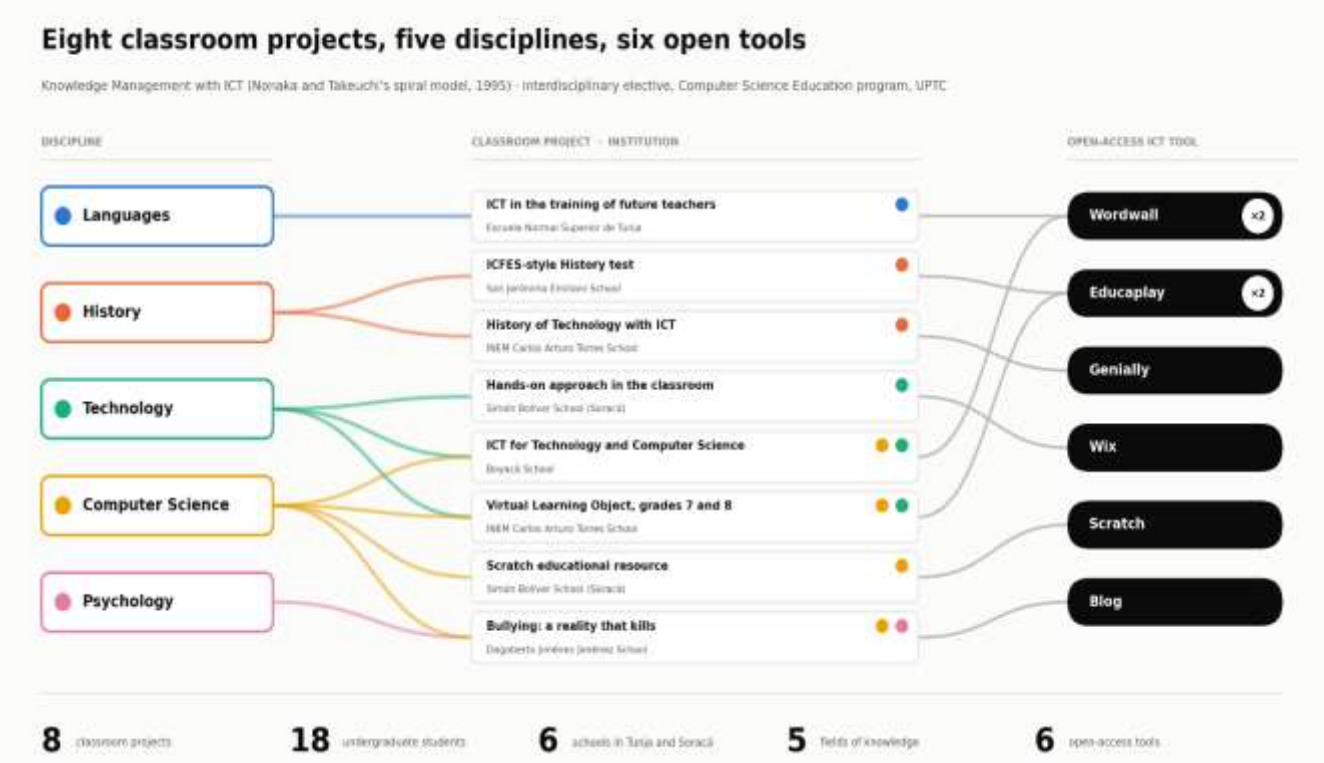
4.1 Approval and curricular implementation of the elective

The approval of Interdisciplinary Elective I, KM with ICT, constitutes a relevant milestone in the curricular innovation process of the institution's teacher education programs. This result should not be understood as a simple administrative procedure, but rather as the institutional materialization of a pedagogical commitment that recognizes KM as one of the most valuable resources of higher education institutions, insofar as its systematic development promotes educational quality, institutional innovation, and research competitiveness (Díaz Rojas et al., 2024). In this sense, the incorporation of the course under code 8107580 in the first semester of 2023, and its simultaneous offering to the Faculty's 13 teacher education programs, demonstrates institutional recognition that KM should be understood as an integrated strategy encompassing the creation, organization, dissemination, and application of knowledge, which, supported by advanced technologies and efficient information systems, enables universities to organize and make available to their communities both the tacit and explicit knowledge they produce (De La Cruz Medina, 2024). The selection of the LI group, consisting of 18 students, as the reference for this study is relevant because this program has a direct disciplinary affinity with the technological component of the course, allowing a deeper exploration of the articulation between KM processes and the pedagogical use of ICT, as noted by Pulido Huertas and Najar Sánchez (2015), who point out that, although educational institutions often have the technological infrastructure they need, genuine school transformation is possible only when such infrastructure is articulated with systematic KM processes and the ongoing professional development of educational actors. This articulation is particularly relevant considering that a substantial part of recent scientific production on KM in higher education comes from countries such as Brazil, Spain, Cuba, and Colombia, demonstrating both regional interest in the topic and the relevance of generating situated empirical evidence, such as that provided by this study, on its concrete curricular implementation in teacher education programs (Díaz Rojas et al., 2024). These results allow us to state that the approval and implementation of the elective not only responds to a specific curricular need of the Faculty, but also forms part of a broader trend among higher education institutions toward strengthening ICT-mediated KM through formal academic spaces as a skill for pedagogical innovation and the development of competencies in teacher education.

4.2 Interdisciplinarity achieved in the classroom projects

One of the main results was the interdisciplinarity achieved in the development of the eight classroom projects, in which KM involved areas as diverse as languages, computer science, history, psychology, and technology (Figure 1). KM acted as a strategic mechanism that facilitated the integration and exchange of knowledge from different disciplines, promoting active, collaborative, and contextualized learning and fostering the development of intellectual, methodological, and social competencies (González & Pérez, 2018).

Figure 1. Knowledge Management and ICT projects developed



Source: Authors' own elaboration, based on the systematization of the projects from Elective I (2023). ICT tools implemented, supported by AI.

Initially, the thematic axis of convergence for each project was established and, subsequently, the lines of work specific to each discipline predominated, so that the interdisciplinary dimension emerged through approaches that overlapped as "layers" around a specific object of study, integrating contributions around a central axis (Alonso, 2020). Thus, the problem related to the impact of KM was addressed by articulating theory and practice and supporting the educational process of future teachers.

The classroom projects developed by LI students within the framework of Interdisciplinary Elective I, KM with ICT, constitute relevant empirical evidence of how project-based learning can operate as a catalyst for interdisciplinary competencies in higher education. In this sense, the findings are consistent with those reported by Melguizo, Garín and García-Cid (2024), who, using a pre-post design applied to university students, found that project-based learning significantly improves students' perceptions of their own learning, generating notable gains in autonomy, communication, leadership, and group belonging; these competencies are essential for a group of students to effectively articulate knowledge from KM with ICT-specific tools and languages within the same classroom project. This interpretation is reinforced by De La Cruz Medina (2024), who argues that project management strategies in higher education function as an effective pedagogical tool that allows students to apply theoretical knowledge in practical and collaborative contexts, comprehensively developing both technical and professional competencies and skills for addressing contemporary challenges; this is precisely the dynamic observed in the classroom projects analyzed, in which students had to combine conceptual foundations of KM with their practical application through ICT tools. Complementarily, the results can also be interpreted in light of the findings of Santoyo Mercado et al. (2024), who, when analyzing an ICT-mediated collaborative work experience

among students from different disciplines, found that all participants considered information and communication technologies to have strengthened their learning by improving communication, research capacity, and collaborative efficiency across different areas of knowledge, while also reporting predominantly positive interpersonal dynamics within the work teams. This perspective is particularly relevant for interpreting the classroom projects, insofar as ICT not only served as an instrumental means of support for academic activities, but also as a functional bridge that helped overcome the barriers associated with disciplinary fragmentation, enabling students to integrate technological, pedagogical, and knowledge management competencies into a common academic product. These references support the view that the interdisciplinarity achieved in the classroom projects was not incidental, but rather the expected consequence of a didactic approach based on project-based learning and ICT-mediated work which, according to recent evidence, consistently promotes the articulation of knowledge, collaborative work, and the acquisition of competencies in university contexts.

4.3 Relationship between the classroom projects and Open Science from the perspective of Knowledge Management

To address the third specific objective of this study, a relationship was established between the products generated by the eight classroom projects and the principles defining Open Science: open access, transparency, collaboration, and knowledge reuse (De Giusti, 2022; Vallejo-Sierra & Pirela-Morillo, 2023). This relationship is supported by three converging pieces of evidence.

First, all digital educational resources produced by the students using tools such as Wordwall, Educaplay, Wix, Scratch, blogs, and Genially were built on freely accessible and widely available platforms, ensuring that the participating educational institutions could appropriate and continue using these resources without economic or technical restrictions, in accordance with the accessibility principle that guides Open Science and Open Education (Ramírez-Montoya, 2022).

Second, the knowledge-creation cycle applied in each project—socialization, externalization, combination, and internalization (SECI)—according to the Nonaka and Takeuchi (1995) model, reproduced at classroom scale the logic of openness and co-construction that characterizes Open Science: the tacit knowledge of students and educational institutions was externalized into explicit resources, combined with the curricular content of the elective, and finally transferred and internalized in the educational institutions through the formal delivery of the projects and digital educational resources. This transfer process constitutes, in itself, a practice of open socialization of the knowledge produced in the classroom, insofar as the results ceased to be the exclusive property of student groups and became resources available to teachers and students in basic and secondary education (Ramírez-Montoya & García-Peñalvo, 2018).

Third, the relationship is evident in the collaborative nature of the process: the projects were not developed in isolation, but through sustained interaction among peers, teachers, and external educational communities, which is consistent with the shared co-construction promoted by Open Science (Ramírez Montoya & García-Peñalvo, 2018) and with the idea that educational innovation emerges from the combined efforts and collaboration of the members of an educational process (UNIR México, 2024).

Thus, a positive relationship can be established between the degree of interdisciplinarity achieved by the projects and their proximity to the elements of Open Science: projects that

integrated a greater number of disciplines, such as Bullying: una realidad que mata, which brought together Psychology and Computer Science, were also those that generated resources with greater potential for reuse and adaptation by other institutions. This suggests that interdisciplinarity, mediated by KM and ICT, acts as a catalyst for knowledge-opening practices in initial teacher education.

4.4 Social impact and sustainability of the proposal from the perspective of pedagogical development

Addressing issues related to the future of education in the field of KM, centered on teacher education through an interdisciplinary approach, contributed to the sustainability and social impact of Open Science and Open Education. This led to transformations in the production and distribution of knowledge, with implications for the sustainability and social equity of undergraduate programs. The experience shows that Open Science and Open Education not only contribute to academic quality, but can also reconfigure the social contract of knowledge by considering it a common good oriented toward collective well-being (Vallejo-Sierra & Pirela-Morillo, 2023).

The sustainability of this approach is supported by the curricular policies of the Faculty's programs and by their ratification by the Faculty Council, facilitating the incorporation of elements such as open access, citizen participation, and epistemic justice into undergraduate education. Likewise, it was established that, in the context of science, education, and research, an interdependent relationship exists when actors and educational communities interact, with pedagogical practice constituting a favorable space for inquiry, exploration, and validation of explanations that strengthen scientific vocations and teachers' research trajectories (Alonso, 2020).

From a pedagogical development perspective, the sustainability and social impact of the curricular proposal analyzed are strengthened to the extent that universities are able to incorporate sustainability principles transversally into their curricula through multidisciplinary approaches, as proposed by Pacheco Barros et al. (2024), who argue that such incorporation not only constitutes a pedagogical response to global challenges but also strengthens the social responsibility of academic programs by educating professionals with the capacity to intervene critically and collectively in their environment. This orientation is consistent with the commitment embodied in Interdisciplinary Elective I, KM with ICT, insofar as its didactic development goes beyond the transmission of specific disciplinary content to foster, through classroom practice, the education of teachers capable of understanding knowledge as a common good oriented toward collective well-being. Nevertheless, the social sustainability of this type of curricular proposal cannot be separated from critical reflection on curricular justice, understood as the set of conditions of affordability, accessibility, adaptability, and acceptability that guarantee equitable education; in this regard, Marín Che and Pinto Sosa (2024) warn that, even in institutional contexts with formally established curricular policies, gaps may persist between policies and the social and pedagogical reality of educational actors. This demonstrates the insufficiency of higher education institutions merely accompanying their commitments to open access and Open Education with situated pedagogical strategies that respond to the particular conditions of their academic communities and avoid reproducing inequalities under a discourse of openness. When these references are considered together with the results of the present inquiry, it becomes evident that the pedagogical development of the elective not only contributed to the curricular sustainability of the program

through its institutional ratification by the Faculty Council, but also, by incorporating principles of epistemic justice and social equity into teacher education, contributed to consolidating ICT-mediated KM as a pedagogical practice oriented toward collective well-being, in line with contemporary demands for sustainability and social impact in Latin American higher education.

4.5 Curricular integration of ICT

Another relevant finding was the integration of ICT into curricular processes, insofar as these technologies were effectively incorporated into the educational practices of the participating institutions. The articulation of ICT inclusion with the project or pedagogical practice generated an educational policy orientation that contributed to improving educational quality, for which systematic planning is required (UN & UNESCO, 2019). In developing their projects, students recognized that the human factor constitutes a fundamental and irreplaceable component of the learning ecosystem (García, 2018).

The curricular integration of ICT was not limited to the instrumental incorporation of technological tools into the classroom, but rather responded to a coherent process of pedagogical and didactic articulation between the curricular design of the course and its practical application in the projects developed by students. This interpretation is consistent with Núñez Padrón et al. (2024), who state that effective technological integration requires jointly considering the didactic, technological, cognitive, and attitudinal dimensions of the educational process, so that technology is not merely juxtaposed with the curriculum but substantially enriches its content through a student-centered orientation that promotes collaborative and meaningful learning; these elements are clearly identifiable in the way LI students articulated the conceptual foundations of KM with the situated use of ICT resources and platforms within their classroom projects. Along the same lines, the results align with the findings of Santiago Trujillo and Garvich Ormeño (2024), who, based on a systematic review following the PRISMA protocol, conclude that teachers' digital competencies and the curricular incorporation of ICT in higher education have provided significant support for educational processes, making it essential for both teachers and students to become empowered in the use of digital resources to improve the quality of teaching and learning processes in contemporary university contexts; in the elective analyzed, this empowerment translated into students' ability to move beyond the instrumental use of technology and employ it as a mediator of higher-order cognitive processes associated with the management, systematization, and socialization of knowledge. This is complemented by the perspective of Macías Villarreal et al. (2024), who, when analyzing the challenges and opportunities of ICT integration in educational processes in the post-pandemic context, warn that such integration continues to face challenges related to technology access gaps and the need to strengthen teachers' digital training. These aspects are relevant for contextualizing the results of the present research, insofar as the sustainability of ICT curricular integration in the Faculty's teacher education programs depends not only on the existence of a specific elective course, but also on a broader institutional commitment to the permanent technological and pedagogical updating of the teaching staff. These references allow the curricular integration of ICT observed in the elective to be interpreted not as an end in itself, but as an articulating means that, when grounded in coherent instructional design and the development of digital competencies among both teachers and students, effectively contributes to the evolution of pedagogical practices and KM in higher education.

5. DISCUSSION

One of the findings that merits discussion concerns the difficulties evidenced during the post-pandemic period and the need to strengthen graduates' training in the appropriation and use of ICT in the Colombian context, which has revealed an increase in educational difficulties associated with the unequal range of capacities and resources available among families and educational institutions (Leiva Guerrero & Villarroel Montaner, 2021; Palacio Sprockel et al., 2022).

In this regard, one of the challenges faced by researchers in the field of education, in the context of open practices, is acquiring digital competencies that support the formulation of an educational science grounded in principles and support structures. These components are essential for bringing together open creation and fostering greater interaction between schools and socio-educational and cultural sectors (García, 2022).

Although the KM and ICT course was approved for teacher education, it is important to discuss the structural and dynamic complexity of the problems addressed, both in basic and secondary education institutions and in higher education, a complexity that affects knowledge, processes, and values and is manifested in the reality under investigation (Alonso, 2020). Consequently, when analyzing complexity in Education Sciences, it is essential to consider epistemological and methodological aspects, as well as those situated within the ontological framework, and to understand that interdisciplinarity is fundamental to educational development because it is not possible to work exclusively from disciplinary perspectives.

The relationship established between the classroom projects and the principles of Open Science, presented in the results section, should be interpreted with caution: although the resources produced were created with freely accessible tools and formally transferred to the receiving institutions, the study did not include quantitative indicators of subsequent reuse of these resources by other institutions. This constitutes a methodological limitation and, at the same time, a relevant avenue for future research to deepen the link between KM and Open Science indicators in basic and secondary education.

One of the distinctive contributions of Open Science lies in its impact on educational and training methods, insofar as it can function as an integrated strategy for promoting a culture of openness. It is therefore essential to have an educational process that prepares future generations and encourages the integration and transformation of Open Science into the usual practices of inquiry and education (García, 2022). In this context, educational researchers need to incorporate into their research agendas the development of a renewed model of scientific practice aimed at examining the role of education in promoting Open Science and the pedagogical practices developed by professionals in the field.

From the perspective of Open Science itself, it is useful to broaden the discussion toward the difficulties faced by educational institutions when they fail to fully assume this paradigm as an axis of their research and pedagogical culture. In this regard, a recent study conducted with more than 500 researchers from Spanish institutions found that, despite growing interest in Open Science, nearly one third of the academic community still lacks clarity about its principles and practices, resulting in concrete barriers such as financial limitations for covering open-access publication costs, lack of training in data management, and uncertainty regarding confidentiality and privacy guarantees for the information generated (Universitat Oberta de Catalunya [UOC], 2024). These difficulties are not exclusive to universities: when basic and

secondary education institutions do not explicitly assume the role of Open Science, the resources and learning generated in experiences such as Elective I risk remaining confined to the classroom, without extending to the educational community or becoming integrated into an institutional culture of knowledge sharing.

Along these lines, Valencia Bonilla et al. (2024) indicates that the lack of institutional appropriation of Open Science limits its potential contribution to quality management and innovation in higher education, insofar as successful implementation depends on institutions incorporating openness, collaboration, and transparency as cross-cutting principles of academic management, rather than merely as isolated initiatives by some teachers or researchers. This situation is relevant to the case analyzed in this study because, although the classroom projects generated freely accessible resources, their sustainability and capacity for reuse ultimately depend on basic and secondary education institutions—not only the Faculty responsible for initial teacher education—assuming the elements of Open Science institutionally as part of their pedagogical culture. If this does not occur, there is a risk that Open Science will remain a declaration of principles rather than an effective practice, reproducing the gap identified between declarative policies and their actual appropriation in educational contexts.

6. CONCLUSIONS

ICT-mediated KM generated a significant impact on the teacher education programs of the FCE at UPTC by contributing to the optimization of learning processes and the use of available technological resources. The incorporation of these strategies across different disciplines in basic and secondary education institutions contributed to strengthening educational quality and better preparing students to face present and future challenges.

In response to the research question posed, the findings support the conclusion that the implementation of ICT-mediated KM, from an interdisciplinary approach, contributes to the construction of Open Science practices in initial teacher education, insofar as the projects developed using Nonaka and Takeuchi's (1995) spiral model generated freely accessible, collaborative, and transferable educational resources for the participating educational communities. This constitutes empirical evidence of the relationship among KM, interdisciplinarity, and Open Science explored in this study.

Interdisciplinarity in education constitutes a fundamental tool for preparing undergraduate students to face complex and versatile challenges; it promotes a deeper understanding of the world around them and strengthens the competencies needed to work as teachers or knowledge managers. The integration of approaches such as Open Science and Open Education enhances this process by promoting free and collaborative access to knowledge, the exchange of knowledge across disciplines, and the participation of students and teachers in global learning communities.

By promoting free access to data, publications, and scientific resources, Open Science facilitates teachers' and students' access to knowledge and their contribution to its construction, fostering transparency, interdisciplinary collaboration, and exploration-based learning. Open Education, supported by digital platforms, open educational resources, and virtual communities, expands opportunities for autonomous and personalized learning, allowing each student to construct an educational pathway according to their interests, pace, and context.

Finally, future research is recommended to incorporate quantitative indicators of the reuse and dissemination of digital educational resources produced in similar experiences, in order to strengthen, through additional empirical evidence, the relationship identified among KM, interdisciplinarity, and Open Science in teacher education.

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