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Collaborating to cross subject boundaries with digital technologies: designing a training plan through action research

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Abstract

This study aimed to understand teachers' conceptions and practices concerning collaborative work around planning pedagogical strategies with digital technologies. And to help design a training plan based on the F@R Model (Training-Action-Reflection). This is an innovative piece of work, in terms of methodology, in this area of study and intervention, and corresponds to the first of three action-research cycles designed. The participants were five teachers from the 2nd cycle of basic education in Portugal (equivalent to ISCED 2). Data collection was centred on interviews, with a focus on content analysis. In this study, the importance attributed by the participants to collaborative work, as well as to inter- and transdisciplinary practices, was verified. However, it turned out that these practices have only taken place informally and without planning. Structural and personal challenges and favourable factors for integrating digital technologies were highlighted. Difficulties related to access to technology were the main ones, with the highest number of references. The participants prioritised a collaborative and practical approach to training. In this way, it was confirmed that the approach followed was a promising strategy for planning the work to be done, which supported the design of the training plan.

KEYWORDS: Action Research, Collaboration among Teachers, Inter- and Transdisciplinary Pedagogical Strategies, Digital Technologies, Training Plan.

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1. Introduction

There has been a growing interest in learning processes associated with collaborative models, perhaps because organisations have been under some pressure to change and adapt to the times of digital development and curricular innovation. The answer to these challenges could be encouraging organisational learning, which has been seen as a component of school effectiveness (Fernandes et al., 2022). In this sense, a constructivist approach is favoured, in which learning as a result of interaction among teachers is seen as a collective movement that is essential for the growth and progress of educational organisations.

At the same time, using digital technologies is seen as a means of amplifying meaningful pedagogical experiences, which the collaborative work of professionals with different disciplinary backgrounds can enhance. As Nóvoa and Vieira (2017) suggest, strengthening the collaborative dimension, through the joint intervention of teachers in the search for the best ways to act is an investment of paramount importance for building work networks and training practices. Also, in line with the idea of knowledge built in networks (Salgado et al., 2022), inter- and transdisciplinary pedagogical proposals appear as opportunities for teachers to reconfigure their practices to educate students from an integral perspective. The aim is to

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broaden the focus of pedagogical approaches in a holistic, integrative and meaningful way to prepare students for the challenges of the future (Atkinson-Toal, 2024).

This conjuncture is also set out in the European Framework for the Digital Competence of Educators (Lucas & Moreira, 2018; Redecker & Punie, 2017), which presents professional collaboration as one of the digital competences for educators in the context of professional engagement. It involves using digital technologies to collaborate with other teachers, share and exchange knowledge and experience, and innovate teaching practices in a collaborative way.

Despite the growing space that collaboration among teachers has taken on, and the diversity of work that validates its benefits (Bendtsen, et al., 2022; Díaz-Sacco & Muñoz-Salinas, 2024; Lavonen et al., 2020; Oliveira et al., 2020; Santos et al., 2019; Seabra et al., 2022; Valverde-Berrocoso et al., 2021), recent research reveals that teachers mainly work alone or in small groups, with collaborative experiences being limited to sharing ideas and teaching materials, and on ways to adopt common rules of operation. This pattern is opposed to other deeper dynamics of collaboration, which involve more interdependence among teachers, such as teamwork, reflection on practice, collaborative design of strategies, joint planning, and providing observation-based feedback to colleagues (Flores et al., 2025; OECD, 2020; Rempe-Gillen, 2018; Toikka & Tarnanen, 2022). On the other hand, the scarcity of studies linking collaborative practices among teachers with the planning of pedagogical strategies aimed at integrating digital technologies, particularly in Portugal, highlights the need for scientific production in this area (Lourenço et al., 2023).

To fill these gaps, this work, which is part of a broader research project, aims to contribute to a deeper understanding of how teachers collaborate and learn from each other in their professional contexts, fostering collaborative planning practices that aim to articulate the work of various subject areas with digital technologies.

In this sense, a training programme was planned to involve teachers in working together. Teachers are seen as agents of change, moving in different directions, and it is necessary to provide them with more or less structured moments of work and learning.

Following the F@R Model - Training-Action-Reflection (Costa & Viseu, 2008), one of the strategic objectives of the training is to help create a collaborative attitude among teachers, through communication and sharing, as well as joint reflection on the use of digital technologies.

In this respect, the study by Rodrigues (2020) observed an increase in the participants' technological competencies, as well as opportunities for them to create their own knowledge and reflect on their teaching practices. This emphasises the importance of developing professional development actions in the participants' practice, based on the context and structured holistically, with a view to making significant changes (Bendtsen et al., 2022; Toikka & Tarnanen, 2022).

Therefore, it is assumed that through action research, each teacher can be a researcher and an observer of praxis, through a process centered on critical reflection and practices, which are the starting point for the emergence of possible theories (Coutinho, 2018; Efron & Ravid, 2013; Goodman et al., 2025; Stringer, 2007).

Although the process developed is part of a work plan comprising three cycles of action research (Diagnosis, Intervention and Evaluation), this article only describes the first one. Cycle I sought to understand the teachers' conceptions and practices before the actual training intervention. Cycle II set out to develop a training plan with the teachers, seeking to contribute to a deeper understanding of how teachers collaborate and learn from each other in their professional contexts, fostering collaborative planning practices that aim to articulate the work of the various subject areas with digital technologies. Cycle III aimed to analyse and understand the effects of the plan after six months of intervention.

2. Materials and Methods

This work is anchored in the assumptions of the qualitative and critical paradigms, with action research being the central methodological option. In this way, it aims to understand how participants construct and interpret their experiences, and what meanings and significance they attribute to them (Bogdan & Biklen, 1994; Creswell, 2007).

Like any participatory methodological approach, action research is a dynamic process that takes place with the collaboration of various actors (Kemmis et al., 2014; Stringer, 2007; Stringer, 2024). This study used action research to promote collaborative working dynamics, orientated towards planning pedagogical strategies that include integrating digital technologies in the classroom.

To operationalise the empirical component, the initial cycle, called 'Diagnosis', was guided by two research questions: 1) How do teachers perceive collaborative work with their peers in general and, in particular, when it comes to planning inter- and transdisciplinary pedagogical strategies?; and 2) To what extent and for what purposes do teachers use digital technologies in their teaching and learning practices, particularly when planning collaboratively? The answer to these questions followed a plan structured in four stages - Planning, Action, Observation and Reflection, as described below.

2.1 Planning

At this stage, we started by considering the participants to be involved, namely teachers from the 2nd cycle of basic education in Portugal, corresponding to the International Standardised Classification of Education - Level 2 (ISCED 2), which covers students aged 10-12. As a selection criterion, they had to be from the same

subject group and cover at least two of the subjects Mathematics, Natural Sciences and Citizenship and Development, using an interdisciplinary logic.

It was essential to collect evidence through diagnostic interviews, planning, informal conversations and field diaries, the latter two being complementary information-gathering processes. However, the work here focuses exclusively on analysing the interview. The choice of a semi-structured interview (Amado, 2014) seemed the most appropriate given the diagnostic function inherent in this cycle. To this end, an interview script was devised.

2.2 Action

The invitation to participate in the study was launched at this stage, and five teachers accepted. Data was collected on the characterisation of the participants, with four aged between 41 and 50 and one aged between 26 and 30. In terms of gender, four were female, and one was male. In terms of teaching experience, three had between 7 and 25 years of experience and two between 1 and 3. Regarding academic qualifications, four had a bachelor's degree and one a master's degree. About the years they had been at the same school, two had been there for up to a year, two for between 1 and 3 years, and one for more than 10 years.

At the same time, the research questions were aligned with the planned interview script. Which was operationalised in thematic blocks, objectives, and questions/guidelines. To validate the script, a pilot interview was conducted with a teacher who was not included in the study but whose profile was similar to that of the participants. This instrument underwent a series of revisions and was supported by the scientific coordination team, whose role can be likened to that of judges (Huberman & Miles, 1991).

Once validated by the experts, the interview script was organised into six thematic blocks (Appendix A). The interviews were conducted with five participants online using the *Zoom* platform, recorded and transcribed for interpretation and analysis.

The transcripts were emailed to the participants for ratification, and only one teacher asked to add a sentence to his speech, which was granted.

2.2.1 Ethical issues

This study complied with the General Data Protection Regulation (GDPR), in accordance with Law n. 58/2019 of 8 August (Diário da República, n. 151/2019, Serie I), in line with European Union regulations. In this regard, the participants were asked for their free, informed consent; authorisation was also requested from the institution where the research took place; and an advisory authorisation was sought from the Ethics Committee, which after analysis, considered that the ethical principles, as well as the ethical guidelines for research, are respected.

2.3 Observation

This stage supported the analysis and understanding of the information gathered in the previous stage, favouring content analysis (Bardin, 2011; Esteves, 2006). A matrix was drawn up and dimensions of analysis emerged, and in a linear sequence, each dimension was broken down into categories and each category into indicators. The matrix evolved (Huberman & Miles, 1991) and included categories in line with the literature reviewed and new emerging categories, which wasere validated by three experts.

This stage culminated in a plan organised into four analytical dimensions: Collaborative work; Inter- and transdisciplinary practices; Integration of digital technologies; and Expectations and suggestions. In turn, 16 categories of analysis and 46 indicators were identified. This content analysis plan can be found in a table in the Appendix B.

2.4 Reflection

In the 'reflection' stage, we started with the material gathered and systematised, and opted to carry out an interpretative, inductive and descriptive analysis of the interview data (Bogdan & Biklen, 1994; Creswell, 2007). The content was analysed using categories and frequencies. For ethical reasons, the five participants were identified by codes, consisting of the capital letters A, B, C, D and E.

For each dimension of analysis, the results were organised in frequency distribution tables - absolute (N) and relative (%), of the units of meaning (UM) by category and indicator. The table was also structured considering the position of each of the participants (P - Participants).

For each category of analysis, by dimension, the distribution of coded units of meaning was also analysed Absolute frequency (N), and the respective percentages, by indicator, in relation to the overall total of indicators Relative frequency (%). The relative frequency (%) shown in the 'UM' column (units of meaning) was calculated by reference to the partial total of units of meaning (N Partial total), by category. The relative frequency (%) shown in the 'P' column was calculated by reference to a total of five participants.

3. Results

From an action research perspective, the results were derived from the processing of data carried out throughout the research process, inform subsequent cycles. It therefore resulted in four dimensions, as mentioned above.

3.1 Collaborative work

Regarding how teachers think about, define and value collaborative work, this dimension was organised into five categories: 'understanding', 'valuing',

'implications', 'applications' and 'effects at school level'. Table 1 shows the distribution of meaning units.

With regard to the distribution of units of meaning by category, the analysis revealed that the majority of participants (N=5) presented views related to 'understanding' the concept of collaborative work (with 35.82% of the total references), followed by aspects related to 'implications', which refer to changes and gains on a personal level (with 22.39% of the references), and closely followed by aspects related to 'applications', which translate into changes in working practices and methods (20.90% of the references). The remaining references, fewer in number, were grouped together in the 'valuing' category (with 13.43%), and in the 'effects at school level' category (with 7.46% of the references). Teachers' perceptions about the 'understanding' category, were mainly related to the understanding given to collaborative work as 'sharing' (45.83% of references). This was followed by references to 'joint work' (33.34%). Also noteworthy, with 20.83%, were the references to collaborative work as 'learning'. In the five interviews, references (units of meaning) were found to collaborative work as 'sharing' and 'joint work'. Four participants also highly emphasised collaborative work as 'learning' (80%).

In the 'valuing' category, the importance of collaboration among teachers was emphasised (100% of references in this category). All the participants (100%) gave indications that referred to 'valuing collaboration'.

In the 'implications' category, references to gains in terms of 'self-reflection' stood out (with 26.67% of references), on par with references to 'mutual influence' (26.67%). This was followed by references to 'professional knowledge' (20%). The remaining references, fewer in number, were related to gains in terms of 'trust' and 'motivation' (both 13.33%). Most participants, four of them (80%), emphasised 'self-reflection'. 'Mutual influence' and 'professional knowledge' were other implications highlighted by three participants (both 60%), as were 'trust' and 'motivation', which were mentioned by only two (40%).

In the 'applications' category, references to changes in terms of the 'time organisation' necessary for the use of digital technologies stood out (42.85%). This was followed by changes in terms of diversifying 'work strategies' (with 28.57% of references). In smaller numbers, the remaining references related to changes in terms of 'space organisation', and to contributions to supporting the transition to 'new pedagogical approaches' (14.29% in both cases). References to changes in terms of 'time organisation' were mentioned by four participants (80%). 'work strategies' were also emphasised by three participants (60%). The indicators 'new pedagogical approaches' and 'space organisation' were mentioned by two participants (40% in both cases).

Although fewer references were made, the 'effects at school level' category emerged, referring to 'improving results' (with 60% of references). On the other hand, they pointed to 'initiatives' seen in terms of the school itself (with 40%). We should also highlight the emergence of the indicators 'initiatives' and 'improving results', which were mentioned by two teachers (both with 40%).

3.2 Inter- and transdisciplinary practices

This dimension resulted in four categories: 'curriculum articulation', 'planning', 'challenges' and 'favourable factors'. Table 2 shows the distribution of units of meaning regarding work strategies, challenges and favourable factors.

In terms of the distribution of meaning units by category, the participants mostly addressed aspects related to 'challenges' (with 47.92% of references). This was followed by views related to 'curriculum articulation' (with 27.08% of references). The remaining references, fewer in number, were grouped in the 'favourable factors' category (with 18.75%), and in the 'planning' category (with 6.25% of the references).

About the category 'curriculum articulation', the participants made a lot of reference to aspects related to 'articulation among subjects' (with 76.92% of the references); 'articulation within the subject group' was also mentioned, but to a lesser extent (with 23.08% of references). All five participants (100%) emphasised 'articulation among subjects'. Three participants (60%) also emphasised 'articulation within the subject group'.

Regarding the 'planning' category, only references to 'planning' appeared (100% of references). The emergence of this indicator was noteworthy, although it was only mentioned by two teachers (40%).

Regarding the 'challenges' category, teachers' perceptions referred to challenges related to 'time' (43.48% of references). This was followed by references to challenges arising from individual 'attitudes' in establishing interpersonal relationships (30.43%), and there were also challenges that referred to the 'specificities of each class' (26.09% of references). In this category, the most prominent difficulties were related to 'attitudes' and the 'specificities of each class', both of which were mentioned by four of the participants (80%). The 'time' factor was mentioned by three participants (60%).

In the 'favourable factors' category, references to the 'working environment' (55.56% of references) stood out, followed by 'co-teaching', where two teachers are in the classroom (with 33.33% of references). Fewer references were made to 'remote working' (11.11%). The potential of the 'working environment' and the role of 'co-teaching' were emphasised by three teachers (60% in both cases).

It should also be noted, although only mentioned by one teacher (20%), that 'remote working' was highlighted as a facilitator of inter- and transdisciplinary practices. As for the indicators most often mentioned by the participants in this category, the 'articulation among subjects' (N=5), 'attitudes' (N=4) and 'specificities of each class' (N=4) stood out.

Table 1 – Distribution of meaning units relating to the 'Collaborative work' dimension. Source: Elaborated by the authors.

Categories	Indicators	Participants					UM		P	
		A	B	C	D	E	N	%	N	%
1.1. Understanding	1.1.1. Sharing	4	2	2	2	1	11	45.83%	5	100%
	1.1.2. Learning	1	1	2	1	0	5	20.83%	4	80%
	1.1.3. Joint work	2	1	3	1	1	8	33.34%	5	100%
						Partial total	24	35.82%	-	-
1.2. Valuing	1.2.1. Valuing collaboration	2	2	2	2	1	9	100%	5	100%
						Partial total	9	13.43%	-	-
1.3. Implications	1.3.1. Self-reflection	1	1	0	1	1	4	26.67%	4	80%
	1.3.2. Trust	1	0	1	0	0	2	13.33%	2	40%
	1.3.3. Motivation	1	0	0	1	0	2	13.33%	2	40%
	1.3.4. Mutual influence	1	1	0	2	0	4	26.67%	3	60%
	1.3.5. Professional knowledge	1	1	1	0	0	3	20%	3	60%
						Partial total	15	22.39%	-	-
1.4. Applications	1.4.1. New pedagogical approaches	0	0	1	1	0	2	14.29%	2	40%
	1.4.2. Work strategies	2	1	1	0	0	4	28.57%	3	60%
	1.4.3. Space organisation	1	1	0	0	0	2	14.29%	2	40%
	1.4.4. Time organisation	1	0	1	2	2	6	42.85%	4	80%
						Partial total	14	20.90%	-	-
1.5. Effects at school level	1.5.1. Initiatives	1	0	1	0	0	2	40%	2	40%
	1.5.2. Improving results	0	1	0	2	0	3	60%	2	40%
						Partial total	5	7.46%	-	-
						Grand total	67	100%	-	-

Table 2 – Distribution of meaning units relating to the 'Inter- and transdisciplinary practices' dimension. Source: Elaborated by the authors.

Categories	Indicators	Participants					UM		P	
		A	B	C	D	E	N	%	N	%
2.1. Curriculum articulation	2.1.1. Articulation among subjects	2	4	1	1	2	10	76.92%	5	100%
	2.1.2. Articulation within the subject group	1	1	0	0	1	3	23.08%	3	60%
						Partial total	13	27.08%	-	-
2.2. Planning	2.2.1. Planning	2	0	0	1	0	3	100%	2	40%
						Partial total	3	6.25%	-	-
2.3. Challenges	2.3.1. Attitudes	3	2	1	1	0	7	30.43%	4	80%
	2.3.2. Time	0	1	5	0	4	10	43.48%	3	60%
	2.3.3. Specificities of each class	1	0	2	2	1	6	26.09%	4	80%
						Partial total	23	47.92%	-	-
2.4. Favourable factors	2.4.1. Working environment	1	0	2	2	0	5	55.56%	3	60%
	2.4.2. Co-teaching	1	1	0	1	0	3	33.33%	3	60%
	2.4.3. Remote working	0	1	0	0	0	1	11.11%	1	20%
						Partial total	9	18.75%	-	-
						Grand total	48	100%	-	-

3.3 Integration of digital technologies

Given the results, this dimension was organised into four categories: 'attitudes', 'use', 'potential' and 'challenges'. Table 3 shows the distribution of meaning units about teachers´ use of digital technologies, their use, potential and challenges.

About their experiences of using digital technologies, most of the participants (N=5) responded in terms of 'challenges' (with 50.57% of the total references). In second place came mentions of the aims and objectives of these practices ('use' category), with 26.44% of the references. This was followed by references to the 'potential' of digital technologies (with 13.79% of references). With a residual value of just 9.20%, references to attitudes towards digital integration emerged (category 'attitudes').

Regarding the 'attitudes' category, references to teachers' 'attitudes' towards digital integration stood out (100% of the total references in this category) and come from the discourse of the five interviewees (100% of the teachers).

In the 'use' category, references to the use of digital media to work on 'curriculum content' and to develop 'transversal competences' (both with 39.13% of references) stood out in equal measure. In the first case, the references came from the discourse of five participants (100% of the teachers). In the second case, they came from four of them (80%). Also noteworthy, with 21.74% of the references to 'use', is the view that expresses the use of digital technologies as a 'motivational' purpose, presented by four participants (80%).

In the category 'potential' of digital technologies, aspects of 'pedagogical innovation' (41.67% of the references in this category), 'motivation' students to learn (33.33% of the references) and 'integral development' (25% of the references) were highlighted, each resulting from the discourse of three participants (60%).

In the 'challenges' category, most of the constraints encountered were at the level of 'access to technology' due to limited access to equipment (43.18% of all references in this category), mentioned by all the participants. Some distance away, there were references to challenges around the 'vision of digital technologies' at pupil level (13.64% of references), in the discourse of three participants (60%). This was followed by challenges relating to 'time management' and challenges relating to 'school strategies', both with 11.36% of references. In the first case - 'time management' - the references came from the discourse of all the participants (100%). In the second case - 'school strategies' - the references came from the words of four teachers (80%).

The indicators 'teachers' knowledge', which refers to the degree to which teachers are aware of digital technologies (9.10% of references), and 'support' (6.82% of references), both found in the speeches of two participants (40%), had lower values, but were very close.

Although fewer references were made, the emergence of challenges relating to 'resource selection' and challenges relating to 'technological progress' were noteworthy, both with 2.27% of references in this category, and mentioned by the same teacher (corresponding to 20% of participants in both cases).

3.4 Expectations and suggestions

This dimension was organised into three categories: 'pedagogical aspects', 'social aspects' and 'organisational aspects'. Table 4 shows the distribution of meaning units, which reflect the results on expectations and suggestions for the training intervention.

Most teachers mentioned 'social aspects' (with 47.62% of the total number of references), although this was closely followed by 'pedagogical aspects' (30.95% of references) and to a lesser extent, 'organisational aspects' (21.43% of references).

In terms of pedagogical aspects, the teacher's expectations for a 'link to the curriculum' (53.85% of all pedagogical references) were most visible in the speeches of four participants (80% of them). This was followed by references to expectations regarding the 'diversification of strategies' that digital can enable (30.77%), made by two participants (40% of the participants). Also noteworthy were the references to expectations of 'pedagogical isomorphism' (15.38%), expressed by two participants (40% of participants).

In the social category, the teachers' expectations regarding 'professional development' in context (45% of all social references) were the main ones, which were accepted by all (100% of the participants). This was followed by expectations of 'collaboration with colleagues' (35% of the references), presented by four participants (80% of the participants). The remaining references, fewer in number (20%), were related to suggestions for implementing school dynamics with digital (indicator 'stimulus'), from the speeches of three teachers (60% of the participants).

In the organisational category, suggestions related to the indispensability of access to 'equipment' stood out (100% of all organisational references), made by three participants (60%).

4. Discussion

To address the question -'How do teachers perceive collaborative work with their peers in general and, in particular, when it comes to planning inter- and transdisciplinary pedagogical strategies?', the results revealed the value placed on collaborative work by the teachers themselves. They considered it essential, a form of development where, together, they can plan, observe and reflect on practices (Flores et al., 2025; Rempe-

Table 3 – Distribution of meaning units relating to the 'Integration of digital technologies' dimension. Source: Elaborated by the authors.

Categories	Indicators	Participants					UM		P	
		A	B	C	D	E	N	%	N	%
3.1. Attitudes	3.1.1. Attitudes	2	1	1	2	2	8	100%	5	100%
						Partial total	8	9.20%	-	-
3.2. Use	3.2.1. Curriculum content	3	2	1	1	2	9	39.13%	5	100%
	3.2.2. Transversal competences	1	2	5	0	1	9	39.13%	4	80%
	3.2.3. Motivational	1	1	0	1	2	5	21.74%	4	80%
						Partial total	23	26.44%	-	-
3.3. Potencial	3.3.1. Pedagogical innovation	3	0	1	0	1	5	41.67%	3	60%
	3.3.2. Motivation	2	0	0	2	0	4	33.33%	3	60%
	3.3.3. Integral development	0	1	1	1	0	3	25%	3	60%
						Partial total	12	13.79%	-	-
3.4. Challenges	3.4.1. Access to technology	5	3	1	3	7	19	43.18%	5	100%
	3.4.2. Support	1	0	0	2	0	3	6.82%	2	40%
	3.4.3. Teacher´ knowledge	0	1	3	0	0	4	9.10%	2	40%
	3.4.4. Resource selection	0	0	1	0	0	1	2.27%	1	20%
	3.4.5. Technological progress	0	0	1	0	0	1	2.27%	1	20%
	3.4.6. Time management	1	1	1	1	1	5	11.36%	5	100%
	3.4.7. School strategies	1	0	1	1	2	5	11.36%	4	80%
	3.4.8. Vision of digital technologies	2	3	0	0	1	6	13.64%	3	60%
						Partial total	44	50.57%	-	-
						Grand total	87	100%	-	-

Table 4 – Distribution of meaning units relating to the 'Expectations and suggestions' dimension.Source: Elaborated by the authors.

Categories	Indicators	Participants					UM		P	
		A	B	C	D	E	N	%	N	%
4.1. Pedagogical aspects	4.1.1. Link to the curriculum	3	2	1	1	0	7	53.85%	4	80%
	4.1.2. Diversification of strategies	3	1	0	0	0	4	30.77%	2	40%
	4.1.3. Pedagogical isomorphism	0	0	1	1	0	2	15.38%	2	40%
						Partial total	13	30.95%	-	-
4.2. Social aspects	4.2.1. Collaboration with colleagues	1	3	2	0	1	7	35%	4	80%
	4.2.2. Professional development	2	1	2	2	2	9	45%	5	100%
	4.2.3. Stimulus	0	0	1	2	1	4	20%	3	60%
						Partial total	20	47.62%	-	-
4.3. Organisational aspects	4.3.1. Equipment	6	0	0	1	2	9	100%	3	60%
						Partial total	9	21.43%	-	-
						Grand total	42	100%	-	-

Gillen, 2018). They also saw it as an exchange of knowledge and experiences, acting as a mutual influence and an opportunity for critical reflection (Flores et. al., 2025; Kellner & Attorps, 2024; Nipyrakis et al., 2023).

In addition, collaborative practices have been seen as effective in building professional knowledge (Calderón & Tannehill, 2021; Carroll et al., 2023; Díaz-Sacco & Muñoz-Salinas, 2024); Gueudet et al., 2021; Hendrickx et al., 2025; La Fleur & Dlamini, 2022; Lavonen et al., 2020). And also, a contribution to promoting self-efficacy, in line with the classic work of Rosenholtz (1991) and more current literature (Calderón & Tannehill, 2021; Carroll et al., 2023; Sexton, 2020), as well as enhancing motivation, as participant D said:

> *...I think that when we work collaboratively we also motivate each other, and I think this is extremely important, because if a teacher doesn't feel motivated, then a lot of things won't go well. I'm talking a bit about myself, aren't I? If I'm not motivated, fortunately I always am. And I think that working collaboratively also helps us in this sense, it also motivates us. Because if I can't find a solution to a problem. If my colleague works collaboratively with me, and helps me in that sense, the work will flow and go better. (pp. 7-8)*

The definitions attributed to collaborative work were based on sharing, joint work and learning, and were identified with the seminal study by Little (1990). In terms of effects, the association between improved student results and pedagogical innovation initiatives is noteworthy.

Inter- and transdisciplinary practices have been valued, and there has been a conscious effort to integrate various disciplines into projects, valuing the integration of different types of knowledge (Leite & Relvas, 2022; Salgado et al., 2022).

In turn, structural and personal challenges and favourable factors for inter- and transdisciplinary practices were revealed. The most significant challenges are related to the organisation of time within the curriculum structure, which translates into limited time for collaborative practices (Green, 2024; La Fleur & Dlamini, 2022).

As for favourable factors, they revealed the existence of a good working environment, as well as co-teaching and remote working. Co-teaching, with the presence of two teachers in the classroom, was seen as facilitating these practices, as exemplified in participant A's speech:

> *...it's much easier for two teachers to be able to carry out this activity than just one, because having a group of twenty students with ten or fifteen computers, and only one teacher, becomes very complicated, due to the dynamics that the activity itself requires... (pp. 2-3)*

It was recognised that digital tools could be essential resources for overcoming time constraints and promoting communication among teachers and online collaboration, as participant B expressed it:

> *The factors... The conditions, the conditions we have, not physical, but through Zoom, through e-mail, through computer programmes, through Teams, there are many ways, there are many things that can contribute to this collaborative work, even if we're not there. (p. 6)*

In relation to the question 'To what extent and for what purposes do teachers use digital technologies in their teaching and learning practices, particularly when planning collaboratively?', it was observed that digital technologies were integrated for various aims, such the consolidation of curricular content, the development of transversal competences and motivational issues.

As for opportunities, the transition from traditional teaching methods to innovative methodologies stood out. And challenges were observed, mainly in terms of access to technologies, as participant B revealed:

> *The use of technology can also be a challenge, because the material isn't always available, isn't always the most appropriate, isn't always easily accessible. Sometimes it's a challenge. And the conditions themselves, the state of the equipment, the computer equipment, is also sometimes a big challenge. And there are some limitations, like today, for example, I had to change a lesson because the projector went down, I couldn't project anymore. (pp. 6-7)*

The initial questions also guided the expectations and suggestions for the training intervention, where the teachers prioritised a collaborative and practical approach to training. The model was expected to be centred on digital technologies are closely connected to the curriculum. Also noteworthy is the intention of pedagogical isomorphism, in the sense of transposing the learning that came from the collaborative training context into the classroom. The expectations of professional development in context were unanimously confirmed.

Finally, the teachers suggested that we should discuss together how school organisations could ensure access to the equipment needed to work with digital technologies. One solution was to provide places in the school to store students' personal computers safely.

5. Conclusions

This work analysed the main aspects for understanding teachers' conceptions and practices in relation to collaborative work, around the planning of pedagogical strategies with digital technologies. This helped support

the design and refinement of a training plan to be implemented in the next action research cycle.

The teachers valued collaborative work, as well as inter- and transdisciplinary practices. However, there is a need for intervention, as it was found that these practices have only taken place informally. What's more, the development of pedagogical strategies needs proper planning, with formality and regularity.

As for the integration of digital technologies, it was discovered that the presence of two teachers in the classroom is essential for working together. In this way, it was emphasised that the planning and implementation of strategies of this nature is facilitated with the direct collaboration of another teacher, which could be a determining condition for the continued integration of these tools. This is in line with the work of Valverde-Berrocoso et al. (2021), who concluded that mutual support among teachers facilitates innovation with digital technologies.

For future applications, at the level of school organisation, it is suggested that co-teaching time be considered for inter- and transdisciplinary projects with digital technologies. The proposal is that there should be regular monitoring by a teacher who would become the project coordinator, in some cases taking on the role of e-tutor, to support the integration of digital tools.

The conclusions made it possible to gather information to design the training plan, and to rethink teacher training in the light of changes towards digital development and curricular innovation.

The main limitation of these conclusions is the small number of teachers interviewed, and it is suggested that future studies extend the research to other participants.

As a final point, we would like to emphasise that this study responds to the movement between contextual needs and global trends, showing that reflection in training processes can lead to new needs and new depths, and serve as a lever for social change.

Datasets and reproducibility

The analysis data will be made available to other researchers who wish to replicate the study, upon request, in accordance with the document submitted, and with a favourable opinion from the Ethics Committee.

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Appendix A - Diagnostic Interview Guide (semi-structured interview)

Blocks	Interview objectives	Questions/guidelines
Block 1 Legitimising the interview	- Create a favourable environment for the interview and emphasise the importance of the interviewee's participation in the study.	- Inform the interviewee about the subject and objectives of the interview. - Emphasise the importance of their contribution to the development of the research.
Block 2 Forms of collaboration	- To explore how teachers define and value collaborative work in general terms and in the context of planning pedagogical strategies.	- In very general terms, what comes to mind when we talk about collaborative work among teachers? - How do you see collaborative work among teachers, particularly when it comes to planning pedagogical strategies? What importance do you attach to it? - What place does collaboration among teachers occupy in your school? What forms of collaboration are practised? Can you describe a practice? - Under what circumstances do the collaborative practices you mentioned take place? - How do you see yourself in the collaborative practices in which you participate?
Block 3 Inter- and transdisciplinary pedagogical strategies	- To identify practices, strategies and challenges faced by teachers when working on pedagogical planning, individually and/or collectively, verifying what is done specifically in the inter- and transdisciplinary field.	- What is your experience of planning teaching strategies in collaboration with other teachers? Can you share a specific practice in which you have collaborated with other teachers to plan inter- or transdisciplinary teaching strategies? - What do you see as the potential of collaboration among teachers when it comes to jointly planning teaching strategies? And what are the challenges arising from these practices? - What factors could be favourable to collaboration among teachers in the context of joint planning of teaching strategies? And what are the factors that hinder or prevent these practices?
Block 4 Integration of digital technologies	- Recognise teachers' experiences of using digital technologies in their teaching and learning practices, especially in the collaborative context of pedagogical planning, including the aims and objectives of these practices.	- How would you describe the importance and usefulness of digital technologies in the context of teaching and learning practices? - What digital technologies do you usually use in your professional context? - What kind of use do you make of digital technologies in your teaching practices? What are your practices with digital tools? - What aims and objectives do you try to achieve when using digital technologies, especially in collaborative planning practices? - When planning inter- or transdisciplinary teaching strategies, how do you think we could consider using digital technologies? - What potential, difficulties and/or challenges do you see in integrating digital tools into teaching and learning practices? - What problem situations do you identify (or have you experienced) when planning pedagogical strategies aimed at integrating digital technologies into student learning?
Block 5 Expectations and suggestions	- To consider needs, desires and suggestions for change related to the curricular integration of digital technologies in the planning of inter- and transdisciplinary pedagogical strategies.	- In a training context, what issues would you like to see addressed during this project, related to the curricular integration of digital technologies in the planning of inter- and transdisciplinary pedagogical strategies? - What specific needs do you feel when integrating digital technologies into the planning of pedagogical strategies? - What are your main wishes or expectations regarding the curricular integration of digital technologies in this context? - What suggestions or ideas do you have for improving the effectiveness or efficiency of integrating digital technologies into inter- and transdisciplinary pedagogical planning? - What learnings, developments and/or changes do you hope to achieve by taking part in this research project?
Block 6 Finalising the interview	- To capture the meaning that the interviewee attributes to carrying out this research.	- What do you think this research can bring you? - Is there anything you'd like to add that hasn't been covered here?

Source: Elaborated by the authors

Appendix B - Content analysis plan for the diagnostic interview

Dimensions	Categories	Indicators
1. Collaborative work	1.1. Understanding	1.1.1. Sharing
		1.1.2. Learning
		1.1.3. Joint work
	1.2. Valuing	1.2.1. Valuing collaboration
	1.3. Implications	1.3.1. Self-reflection
		1.3.2. Trust
		1.3.3. Motivation
		1.3.4. Mutual influence
		1.3.5. Professional knowledge
	1.4. Applications	1.4.1. New pedagogical approaches
		1.4.2. Work strategies
		1.4.3. Space organisation
		1.4.4. Time organisation
	1.5. Effects at school level	1.5.1. Initiatives
		1.5.2. Improving results
2. Inter- and transdisciplinary practices	2.1. Curriculum articulation	2.1.1. Articulation among subjects
		2.1.2. Articulation within the subject group
	2.2. Planning	2.2.1. Planning
	2.3. Challenges	2.3.1. Attitudes
		2.3.2. Time
		2.3.3. Specificities of each class
	2.4. Favourable factors	2.4.1. Working environment
		2.4.2. Co-teaching
		2.4.3. Remote working
3. Integration of digital technologies	3.1. Attitudes	3.1.1. Attitudes
	3.2. Use	3.2.1. Curriculum content
		3.2.2. Transversal competences
		3.2.3. Motivational
	3.3. Potencial	3.3.1. Pedagogical innovation
		3.3.2. Motivation
		3.3.3. Integral development
	3.4. Challenges	3.4.1. Access to technology
		3.4.2. Support
		3.4.3. Teacher´ knowledge
		3.4.4. Resource selection
		3.4.5. Technological progress
		3.4.6. Time management
		3.4.7. School strategies
		3.4.8. Vision of digital technologies
4. Expectations and suggestions	4.1. Pedagogical aspects	4.1.1. Link to the curriculum
		4.1.2. Diversification of strategies
		4.1.3. Pedagogical isomorphism
	4.2. Social aspects	4.2.1. Collaboration with colleagues
		4.2.2. Professional development
		4.2.3. Stimulus
	4.3. Organisational aspects	4.3.1. Equipment

Source: Elaborated by the authors