

## Teachers' personal network analysis reveals two types of pioneers in educational digitalization: Formal and informal intermediaries at schools

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### ABSTRACT

SELFIE is a tool of the European Commission designed to support schools in developing their digital capacity. Schools across Europe have used SELFIE as a diagnostic tool. However, participating schools expressed a need for external guidance in the implementation of digital education transformation, including the exchange of expertise and inspiring practices with other educational centers. In this research we explore what are the key factors in the creation of collaborative networks between teachers. As a case study, we focus on the first steps of building a network of schools to promote digital education in Cantabria (northern Spain). With the participation of 11 schools, we conducted 22 interviews and 2 focus groups to analyze the learning environments of the teaching staff, the personal collaboration networks in the professional field, and the factors perceived as relevant in the design of the digital action plan of each school. The results showed the existence of teachers in each school who were pioneers in the digitization process and who acted as intermediaries both with the public educational administration and with teachers from other schools. During the interviews with these pioneers, we evaluated their personal networks as well as the factors they deem significant for an effective digital transformation. The results were contrasted in a public forum in which 120 teachers participated. Based on these results, we discuss how the creation of a network of key actors could contribute in developing the digital capacity of schools in the region.

### Introduction

Digital technologies have been widely adopted in European schools, opening up new possibilities for education. They are usually seen as a catalyst for innovation and are expected to contribute to the enhancement of teaching and learning. However, digitalization is a complex process affecting all aspects of schools' operation which extend beyond pedagogical practice and infrastructure [1]. Along with the development of the digital competence of both teachers and students, it also entails rethinking the pedagogical models used and the related teaching and learning practices. That is why it is usually a long-term process in which it is essential to consider institutional, organizational, and personal factors that make educational change possible. In this study, we explore the potential of personal networks across the three levels mentioned above (institutional, organizational, personal) to enable digital transformation in schools. To this end, we monitored an initiative to launch a regional network of schools for the development of digital

competence in Education in the north of Spain.

Digital technologies can contribute to a transformation of the educational environment [2–4]. On the one hand, digital innovation has demonstrated its ability to complement, enrich and transform education, while also having the potential to accelerate progress towards Sustainable Development Goal 4 (SDG 4) for education, facilitating universal access to learning [5]. Digital technologies also help develop the skills that students' professional performance will require, such as problem solving, creating thought structures, and understanding processes [6].

This paper begins by providing a synthesis of the literature on collaborative networks between schools, paying special attention to the characteristics of those initiatives that were found to be particularly effective. We start from a metaphorical definition of the term "school network", widely extended in the educational context, to propose an operational definition based on social network analysis. Next, we present SELFIE, the tool which the schools participating in our research

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used to reflect on their digital capacity and design a digital strategy. Finally, we present the methodology and results of a pilot action-research experience to build a network of schools focused on the design and implementation of regional digital action plans in Cantabria, Northern Spain.

### Collaboration between schools

School networks consist of a set of educational organizations that collaborate for the same purpose over a defined period of time [7]. In some cases, they are formed by a group of schools that collaborate informally and work together around a topic of common interest. In other cases, they take the form of a federation or consortium, constituting a formal structure for the fulfillment of their goals. They can also be integrated into community coalitions with a greater diversity of actors. The networks may arise following bottom-up dynamics, initiated within the schools themselves, and/or may be driven by top-down forces, when promoted by governments or other external entities.

Collaboration between schools facilitates the sharing of expertise and exchange of experiences, contributes to the dissemination of best practices, promotes consistent action between different centers and, in general, enables efficient use of available resources [8]. School networks have been found to make better use of their organizational capabilities to improve teaching practices and student learning outcomes [9]. Furthermore, collaboration between colleagues from different schools benefits the professional development of teachers, while making more efficient use of available material and human resources [10–12]. Teachers also mention having developed a wide array of interpersonal skills, such as communication, cooperation and better time management, but also finding opportunities to be creative, to develop their own ideas and learn to learn through intercultural collaboration [13].

The effectiveness of networks largely depends on the quality of collaboration between the schools that constitute them. Leadership, sharing of resources, and the continued commitment of the participants are requirements for their proper functioning. More specifically, the interaction between teachers is a key factor in obtaining positive results. While it is typically teachers that tend to be the main component for such networks, the support of school leaders is imperative.<sup>1</sup> This can take the form of direct participation in the formal school improvement plans, as well as engagement and appointment of specific people to monitor progress, financial support and recognition in teacher appraisals [14]. School networks also have more impact when they are institutionalized or driven by local government, they last for at least two years, and connect the highest-performing schools with those facing the greatest educational difficulties [7].

### A networked approach to collaboration between schools

The term "school networks" is often used metaphorically, without an operational analysis of the structure and function of sustained collaboration between schools and/or teachers. However, social network analysis offers the possibility of systematically examining the structure of relationships between students, as well as the exchanges of advice and social support that occur between educators in schools [15]. It also allows the analysis of cooperation and knowledge sharing between schools: that is, at an interorganizational level [16]. With this approach, the degree of structural cohesion, the centrality of individual actors, the formation of groups and the role of the different stakeholders, which are the constituting elements of a given social system, can be empirically evaluated [17].

Second, network analysis can also be used to inform the design of interventions [18]. Network-based strategies are especially effective for

<sup>1</sup> The adoption of transformative forms of leadership favors the combination of bottom-up change processes together with the development of activities previously designed and adjusted to the teaching needs [57].

selecting and matching participants in preventive programs, using previous quantitative data [19]. Among other actions with a positive impact, relational indicators (i.e., how respondents relate to one another) have been used to identify opinion leaders, implement peer education programs, and interrupt negative relationships in risk groups.

A large part of the applications of network analysis have focused on interpersonal relationships, *between teachers*. Specifically, the analysis of whole networks has been used to show that the collaboration and exchange of educational materials between teachers depend on the existence of previous relationships and the individual characteristics of the teaching staff [20–23]. In turn, these exchanges influence teaching practices. For example, a greater density in collaborative networks facilitates the adoption of inclusive practices in schools with students who have special needs [24]. Exchanges can also focus on the interpretation of student performance data and subsequent follow-up [25], which can contribute to improving learning outcomes [26]. These types of exchanges are especially beneficial for novice teachers, who develop competencies when they participate in the negotiation of their educational ideas [27], and when they receive advice from expert teachers [28].

There is another category of social network applications which have been developed *at the individual level*. Personal networks have been used to describe the social support of novice teachers in their first year as teachers, as they struggle to position themselves in the school and develop contacts with more experienced colleagues [29–31]. Similar results have been observed throughout the professional life of teachers [32] but also with second career teachers, where professional networks have contributed on their socialization and development of social capital [33].

The analysis of relationships *between schools* is less common and still has enormous potential for development ahead.

### School networks for digital competence: a case study of the SELFIE project

The Human Capital and Employment unit of the Joint Research center (JRC.B.4) in collaboration with the Directorate General for Education and Culture (DG EAC) of the European Commission have developed the SELFIE tool (henceforth SELFIE). SELFIE is designed to support schools to reflect on their readiness to engage in digital education and to identify ways of improving it. Through a set of questions using Likert-type scales, based on the "European Framework for Digitally Competent Educational Organisations" [34], schools can identify the strong and weak points in the use of digital technologies. Since its official launch on October 25, 2018, more than 4 million users have used the SELFIE platform (until February 2023). This represents coverage of more than 29,000 schools in a total of 88 countries.

Previous research has shown the benefits of adopting the SELFIE tool, with an equalizing effect on the adoption of digital technologies [35]. In regions where SELFIE is not part of broader institutional interventions, schools with lower levels of digital readiness and ability were more likely to use the tool, suggesting that the motivation to improve digital skills outweighs other inhibitory factors from the organizational and institutional context.

In order to participate in SELFIE, schools are recommended to designate an Information and Communication Technologies (ICT) coordinator, who is responsible for setting up the SELFIE exercise (i. e. the completion of the questionnaire) and make it available to the school leaders, teachers and students. When all participants have provided their responses, SELFIE generates a response with aggregate results which then becomes the basis for collective reflection and discussion. The next step for the school is to design an action plan for the development of its digital capacity. In a recent impact assessment study of SELFIE, participating teachers and school leaders have frequently expressed the need for support in the interpretation of the SELFIE results captures in the report, but also for designing the action plan for the digital development of their school [36]. SELFIE is not a benchmarking

tool and, therefore, the rationale behind setting up a network would not be to focus on the SELFIE scores but on the development objectives of the schools based on their digital expertise (where they are already advanced with digital capacity and how they can improve).

The creation of a network of schools was put together aiming to support schools to make the most of their collective reflection and take action after the SELFIE report and after identifying their developmental goals. It is worth noting here that the mere involvement of teachers in professional networks is strongly correlated with the adoption of digital innovations [37]. A network of schools is explored in this study as a context to empower schools to take an active role not simply in the development of the digital capacity of their school but also in the implementation of national and EU policies on digital Education. Specifically, at a European level, the new Digital Education Action Plan (2021–2027), emphasizes the importance of a digital strategy for educational institutions in the context of the broader initiative “A Europe fit for the Digital Age”<sup>2</sup>. It was mentioned earlier that the schools participating in the study were all from the autonomous community of Cantabria in Spain. In this region, the digital transformation in schools is promoted through the initiative “DeCoDe Cantabria” which is the Plan for the Development of Digital Competence in Education promoted by the government of Cantabria in the schools of the Autonomous Community. The coverage of the plan extends to 280 educational centers and the proposed objective is for each school to develop its own Digital Action Plan, which will be included in the center’s educational project.

### *This study*

Collaboration among teachers from different schools, or more generally among staff members from different educational institutions, can be an enabler of digitalization processes. Information exchange, technical assistance, and social support can play a key role in the design and implementation of schools’ digital action plans. Indeed, teacher collaboration contributes to the development of digital capabilities. In this study, we developed a pilot action-research experience with a small selection of schools in the Autonomous Community of Cantabria with the aim of (a) determining which factors have a significant influence on the creation and maintenance of school networks, and (b) examining what characteristics of such networks can contribute positively to the development of the digital capacity of the participating schools.

## **Methods**

### *Participants*

Interviews were conducted with informants from 11 schools in the region of Cantabria (northern Spain). Two different interviews were conducted with each of them, with a total cumulative time of approximately 27 h. In the study participated six public elementary schools, three public high schools and two “colegios concertados” (privately-owned but state-funded primary and secondary schools) both from rural ( $n = 5$ ) and urban ( $n = 6$ ) areas. From the eleven schools four coordinators of the DeCoDe program,<sup>3</sup> four ICT coordinators and three members of the leadership team of the schools participated. Seven respondents were women and four were men.

The territory of Cantabria is eminently rural. There is a clear

<sup>2</sup> See: European Commission. ‘Digital Education Action Plan 2021-2027: Resetting Education and Training for the Digital Age’, 2020. [https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan\\_en](https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_en). See also: <https://education.ec.europa.eu/focus-topics/digital-education/about/digital-education-action-plan>

<sup>3</sup> A program of the Cantabrian region to promote the digitalization of educational centers.

predominance of agricultural activities and natural areas, while most of its municipalities have less than 2000 inhabitants [38]. Indeed, 60 percent of the municipalities are located in “mountain areas”, according to the classification of the European Commission [39]. More than half of the municipalities have a population density below 50 inhabitants per square kilometer. Hence, the provision of ICT infrastructures is deemed particularly important in these geographically remote areas, where it can also play a key role in helping prevent rural depopulation. Furthermore, the prevalence of small schools with highly cohesive staff predisposes them positively to embrace digital innovations and makes them perceive a direct benefit when they are provided with new ICT equipment and infrastructures.

The 11 schools had made use of the SELFIE tool with high levels of participation among both teachers and students. In general, the SELFIE exercise served as a kind of needs analysis that allowed schools to take informed decisions and identify their goals for their digital development. With few exceptions, the participants generally considered their schools well-equipped regarding technological infrastructures but emphasized the need to improve the training of teachers so as to make better use of the digital resources already available. Participants from several schools, staff identified the low level of digital competence among students’ families as a major barrier, while students’ responses to SELFIE sometimes suggested minimal pedagogical innovation around the adoption of digital tools (e. g. scarce interactive use of digital tools in class). Consequently, respondents mentioned the need to offer complementary support at home and to improve the pedagogical integration of ICTs in the classroom. As a rule, they consider that SELFIE allowed them to realize what are the needs that they must work on.

### *Procedure*

The schools selected to participate in the study belonged to the same regional government (i. e. that of Cantabria) which means that they operated under the same digital education policy, and were heterogeneous in terms of school development goals, digital expertise, type (i. e. privately-owned or public) and context (i. e. rural vs. urban, deprived vs affluent areas). Diversity in team composition seems to improve performance and learning capability [40]. A call for the participation in the development of an experimental network around SELFIE, was circulated by the Regional Ministry of Education and Vocational Training of the Government of Cantabria among the 65 schools participating in the piloting phase of the DeCoDe plan.<sup>4</sup> The call for expression of interest requested that the schools indicate the SELFIE areas in which they wanted to improve as well as the areas in which they had more experience and could support other schools. Based on that information, a selection was made to try to cover as many areas as possible. Schools participated voluntarily.

A reflective action-research process was followed in three successive steps. The first step focused on individuals from each of the 11 participating schools and involved the construction of the “personal innovation and learning environment” using a personal network analysis technique. In this step were also addressed the digital competences and the development plan of the school. After the individual phase, we organized working sessions with all participants both online and face-to-face. In these sessions, we focused on analyzing collaboration networks taking the point of view of schools as a whole. The discussion of these sessions involved also challenges in the implementation of the digital action plan and ways of overcoming them. During the first half of the online

<sup>4</sup> “DeCoDe Cantabria” is the Plan for the Development of Digital Competence in Education devised and promoted by the government of Cantabria in the schools of the Autonomous Community. The coverage of the plan extends to 280 educational centers and the proposed objective is for each school to develop its own Digital Action Plan, which will be included in the center’s educational project.

meeting, we carried out a participatory evaluation of innovation networks in digital practices. During the second half, we applied a structured feedback technique on the characteristics of personal networks. The third and final step involved a face-to-face public forum with representatives of the schools from Cantabria, in which we discussed the results of the two previous phases and the participants identified a list of recommendations for the creation of a school network around the development of schools' digital capacity.

In parallel, we prepared a "Guide for the design of school networks". According to the literature review, the creation of school networks is a medium- and long-term process, in which it is convenient to have the support of the administration (in this case of the regional ministry of education) and it is important to take into account the organizational aspects of the schools. Furthermore, for the creation of such a school networks other critical factors include the leadership model, the educational project (or "school plan"), the ICT coordinators in each school and the teacher training centers.<sup>5</sup> It is also recommendable to use a defined territorial framework and link school networks with pre-existing community coalitions. The design of the guide was based on best practices selected from a systematic review of the literature and an iterative process of revision with the teaching staff.

The iterative analysis of the information, with successive interviews with a small group of participants, improved the validity and reliability of the information obtained. On the one hand, the second interview served to confirm some of the interpretations made by the research team after the first contact with the participants. On the other hand, the visualization of the personal network introduced the possibility of reflecting with the interviewees on the information that they had provided in the first interview.

Therefore, in the development of the research, the principles proposed by Small and Calarco [41] were followed to collect quality information in qualitative studies, namely: empathy with the population under study, specification of the empirical evidence provided, search for heterogeneity in the participants, inductive follow-up of the information obtained and awareness of the relationship between the researcher and the researched. Triangulation strategies were also implemented in the data, the information collection methods, the participants and the researchers [42].

### Research instruments

The research instruments used in each of the three phases are summarized in Table 1, following a two-step sequence at the individual, and between school levels.

#### Personal networks

To describe the personal learning and innovation environments,<sup>6</sup> a technique was applied that combines (a) the generation of square matrices of relationships with (b) the analysis of the activities that the respondents carry out with their group of interpersonal contacts in the workplace [43]. First, each teacher was asked to provide a list of 30 people with whom she had an ongoing relationship in the course of her work at the school. Next, they completed a relationship matrix among

<sup>5</sup> In Spain, the territorial Teaching Centers are public centers dependent on the Department responsible for non-university education, in charge of promoting, planning, innovation and educational research, as well as promoting the development of teacher training in the region where they act (usually, Autonomous Communities).

<sup>6</sup> In this study we use the term "personal learning environment" applied to teachers: specifically, we evaluate the set of tools, people or resources that they use to incorporate technologies into their teaching practice. On the other hand, "organizational learning environments" refer to the strategies and means of organizational learning: that is, what are the resources organizations use to obtain new knowledge and adapt to a changing environment.

**Table 1**  
Instruments used in each research phase.

Phase	Instruments	Description
<i>Individual</i>	Personal network analysis	<i>First interview</i> - Name generator to get a list of 30 contacts. - Matrix of relations between actors. <i>Second interview</i> - Structured feedback on the personal network. - Analysis of digital practices associated with each contact.
<i>Between schools (online)</i>	Netmap Netmirror	- Use of network visualization as a group self-assessment exercise. - Identification of key factors in the construction of networks between schools.
<i>Between schools (face-to-face)</i>	Public forum	- Open discussion on strengths, weaknesses, and priority action strategies for the digitalization of schools.

the 30 actors, in which for each dyad they indicated the level of relationship they had with each other, from 0 ("they do not know each other") to 3 ("they are friends"). In a second interview, the research team presented to each participant the resulting visualization of their personal networks. Through a semi-structured interview, they were asked to describe their personal networks and to indicate which digital practices they enacted in interaction with each of the actors in their network (i. e. each alter). This makes it possible to place everyone involved in the adoption of digital practices (which are usually a small number of contacts) into the context of the (wider) personal network.

#### Group sessions

With five of the participants in the individual interviews, a three-hour meeting was organized to share and discuss the results of the previous phase. The debate in group was organized to facilitate comparison between personal learning environments (PLE) and organizational learning environments (OLE). The SELFIE tool identifies eight areas such as "Leadership" or "Collaboration and Networking" that can serve to prompt and structure the debate on the digital capacity of schools and as a basis for the development and implementation of a digital action plan as specified in the Spanish national strategy.<sup>7</sup> To guide the debate with respondents, two participatory strategies based on networks were applied. Netmap consists of a participatory group self-assessment process in which the participants identify which are the key actors in their community environment and how they are related to each other [44]. Netmirror consists of providing feedback on the results of the social network analysis to the respondents to find out their subjective reaction and/or promote behavioral changes [45]. Both are based on visualization as an intervention tool [18].

The group sessions allowed comparing the individual learning environments (assessed with the personal network analysis technique in the previous phase) with the learning environments of each school (assessed with the *Netmap* or *Netmirror* techniques). Each educator is used to employing a series of specific technologies and digital resources, following their own preferences. At the same time, schools provide their communities with a standard range of institutional resources and infrastructures,<sup>8</sup> which might only overlap partially with the PLEs of their members [46]. Hence, it may be decisive to generate a shared vision or have meeting spaces in the school to improve the digital competence of

<sup>7</sup> According to the Resolution of September 10, 2021, of the Secretary of State for Education, published in BOE no. 228, of September 23, 2021, in which measures are proposed to improve educational digital competence.

<sup>8</sup> The National Institute of Educational Technologies and Teacher Training refers, for example, to the library, the WIFI network, cloud storage, and institutional subscriptions to computer programs and services, among others [46].



the organization. To assess the degree of overlap between institutional digital platforms and places and personal uses of technology, we used the "Mapping Triangle" designed by Laurie Phipps and Donna Lanclos [47,48].

#### Public forum

To validate results, an open discussion session was organized with 120 representatives of the participating schools, focused on identifying problems and prioritizing solutions. Both best practices and strengths of the educational community of Cantabria in the digitalization of schools were described. During the session, participants also discussed what strategies could be effective for the construction of networks among schools in the region.

## Results

The study of the participant schools showed that there is a basic core of digital tools that largely corresponds to the ICT systems provided and supported by the regional government (in its capacity as the primary public administration responsible for education in Cantabria). In addition, research participants considered that the provision of infrastructure and equipment met the requirements for the adoption of digital education. Conversely, the digital competences of teachers, students and families still poses a challenge to the digitalization in education. According to the participants, there is a clear generational gap amongst the teaching staff, which influences their disposition towards the integration of digital technologies in their practice. In this context, the teachers who act as coordinators of the integration of digital technologies in schools have a key role in the construction of the inter-school network.

#### *Technology use in schools: from local innovations towards establishing a common institutional environment*

The integration of digital technologies in teaching and learning varies a lot across the different schools studied. In many cases, the record of accomplishment of educational digital innovation depends on the involvement of a small group of teachers, or individual experiences, manifesting as pockets of digital expertise. However, the COVID-19 pandemic was a turning point for the digital transformation of the schools in Cantabria. On the one hand, it raised awareness of the need to develop the digital skills of teachers, students and even their families. On the other hand, there was an extraordinary investment provided by European funds with the aim to enable access to digital technologies through the provision of appropriate infrastructure and technological devices. Virtually all schools indicated that now, in addition to a quality internet connection, they have a computer for each teacher and a device (often a tablet) for each student.

Currently the situation in each school depends largely on how they have acted in relation to the provision of the above-mentioned infrastructure. Schools previously lacking infrastructure now obtained the material conditions which would allow them to develop digital educational innovations and to adapt to the new situation with little difficulty. Schools with a pre-existing ecosystem of digital tools tailored to their own needs were forced to transition to a new top-down institutional learning environment. This sort of re-digitalization was at times challenging, as teachers and students had to re-learn again how to use the new learning environments. However, rather than being completely superseded, pre-existing tools and ways of organizing and sharing information were often merged, even if only partially, with the new systems and associated practices.

In Fig. 1 we have represented the digital tools used by teachers in the schools participating in our study. All the centers use Yedra, "the advanced services platform of the Cantabrian educational community

that allows academic management and educational monitoring tasks to be carried out using the Internet as a communication channel".<sup>9</sup> Together with this platform, the schools organize a large part of their activity with Microsoft tools, which are provided and supported by the Ministry of Education of the Government of Cantabria. In addition to Office and Outlook, the staff frequently uses Teams as an internal co-ordination tool, often being used to fulfill the functions typical of a Virtual Learning Environment (VLE) or Learning Management System (LMS). It is also a key communication channel with students, sometimes in use a way of reaching families too via students.

In those schools that started using Google Suite for Education several years ago, the teachers made an effort to adapt to the new ecosystem of the region, mainly adopting to Microsoft tools, following the guidance of the regional government about which tools can be used to handle personal data. Data privacy concerns operated as a key driver of change in that direction. Some of those schools are currently going through a process of reconfiguration, meaning that their educational communities somehow combine the officially supported tools with other digital resources that they had previously incorporated into their practice (for example, Google Drive as a cloud-based repository to organize documents). In other words, while the Yedra and Microsoft 365 tandem are officially positioned as the core of the EdTech ecosystem of this region, vestiges of previous technologies as well as long-established practices still remain alive in some schools.

"Although the schools have some autonomy, the regional Ministry of Education has made a very strong commitment to Microsoft. In fact, to write to the Ministry, to sign up for a course for example, it is mandatory to use the Microsoft account. In our case, it was quite a challenge since we had just used Samsung and Android, since we used the Google ecosystem before." [S3. Primary school, Rural]

While the core of the EdTech ecosystem was the same across all the schools in the study, there was a considerable level of heterogeneity regarding other elements beyond that common nucleus. For example, some schools use WhatsApp groups to coordinate the teaching staff, ClassDojo to communicate with families or some specific licenses, such as Aula Planeta Digital, to access educational content. Among the most mentioned for content creation, are also Genially, Kahoot and Snappet.<sup>10</sup>

#### *From the provision of equipment to the development of capacities*

From what was stated in the previous section, it can be deduced that teachers are aware that both the technological infrastructure and the specific software are necessary but not sufficient for digital educational innovation to happen. Thus, the digital skills of teachers, students and families are decisive in the transformation process. In that regard, respondents indicated that not all teachers have in-depth knowledge of the tools they use. Especially if we take into account the proliferation of platforms and the constant renewal of the wider digital ecosystem. As a result, sometimes there is a duplication of platforms with similar functionalities within the same school, or some teachers remain disengaged from the adoption of new digital practices.

There are important generational differences with regard to the digital skills of teachers. The elderly, especially those closer to retirement, generally show less eagerness and commitment to digital technology integration. Indeed, staff changes through generational renovation are an opportunity for educational change:

"One of the problems is the lack of time. We have so many educational and management responsibilities that there is no time left for

<sup>9</sup> <https://www.educantabria.es/tic/yedra>

<sup>10</sup> Although not mentioned during the interviews, it was noted in the public forum that some secondary schools used Moodle.

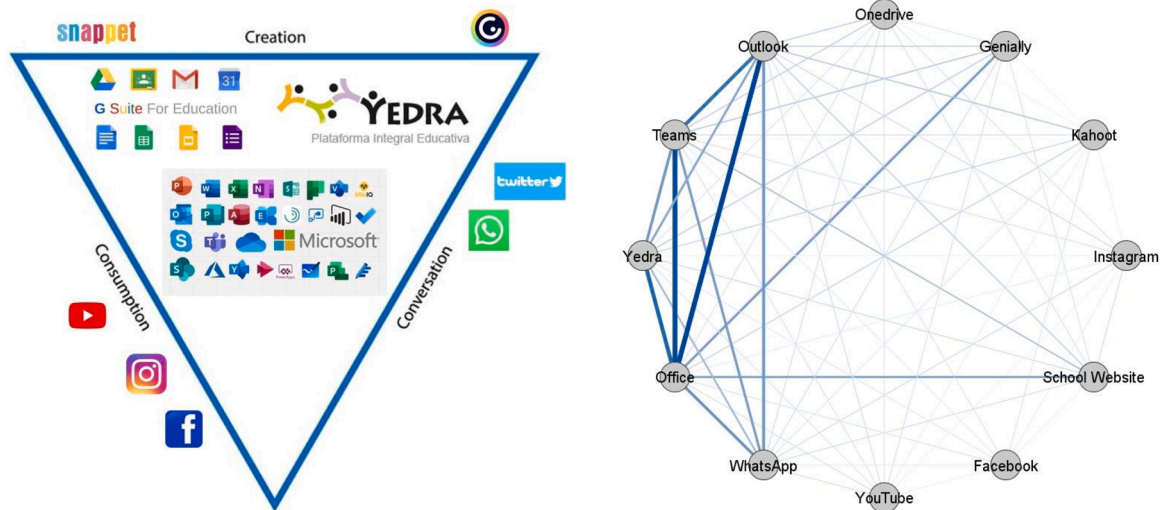


Fig. 1. Personal learning environment and organizational learning environment of Cantabrian schools. Left: The tools offered by the educational system or schools are located within the triangle. Outside the triangle are the digital resources that were promoted informally. Source: Own elaboration. The triangle is based on: Lanclous and Phipps [47]. Right: Tools most mentioned by respondents. Network made from a mode 2 matrix (that is, teachers x tools). The ties between pairs of tools indicate the number of alteri (i. e. members of the respondents' personal networks) that are connected by both tools. The thicker ties indicate that there is a greater number of users shared between both platforms (from among the members of the personal network of the respondents). In addition to the virtual teaching platform (Yedra) and Microsoft tools, teachers occasionally use WhatsApp and Genially, among many other applications. Source: Own elaboration.

training and getting familiar with these types of tools. In fact, the training is always done outside the school period. There is also a clear digital divide within the teaching staff. There are teachers with motivation and training and others who do not. There are many differences and a great diversity of levels in the digital competences of teachers.” [S2. Primary school, rural]

Other organizational factors that were repeatedly mentioned include an excessive workload, lack of time to reflect and a negative attitude on the part of some teachers towards the use of ICTs in education. Furthermore, if not properly backed by a solid pedagogical approach, electronic devices can be a factor of distraction for students.

“Distraction is the challenge. How to ensure that digital media does not distract students... When you incorporate digital tools, you can have discipline problems in the classroom: technology helps automate tasks, but it can be distracting, with students sitting for six hours... The attention window is getting smaller and smaller. Having students listen to you for an hour or two... that's now history. That is why the challenge for teachers is not just learning and using technology, but how to deal with the problem of attention afterwards.” [S4. High school, urban]

*The personal networks of the promoters of digital transformation*

In each school there is usually a small number of teachers who have an active role in the digitalization process. Sometimes they are the ICT coordinators or members of the school's leadership team. These are teachers who have personally carried out digital innovations and are regarded as pioneers with technology use for teaching and learning, who collaborate in the maintenance of computer equipment, who help and train their colleagues, and/or who are champions of the integration of digital technologies in their school. Normally, these professionals act as intermediaries between their school and the existing institutional resources for training and promotion of digital skills outside of school.

This specific role as technology pioneers is often reflected in the configuration of the personal network that promoters of digital change develop over time. The most common structure is a personal network made up of two cohesive subgroups: 1) a larger group made up of school colleagues (mostly other teachers) and 2) a smaller group of contacts

from the regional government and the teacher training center. This most frequent type of structure is represented in the central graph of Fig. 2. The example that we have selected to illustrate it corresponds to an ICT coordinator who has two thirds of his contacts at the school where he works, but who also maintains a regular relationship with seven members of the regional Ministry of Education, two members of the teacher training center and a university researcher.

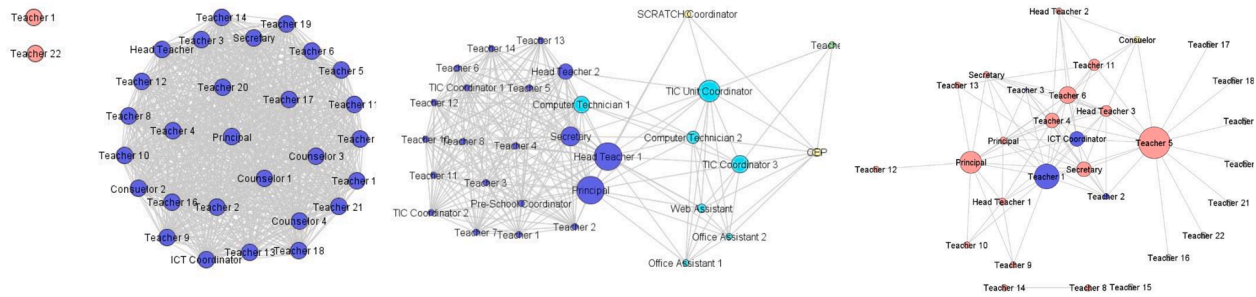
Another somewhat less frequent configuration includes mostly a third type of actors, namely teachers from other schools with whom both experiences and social support are exchanged (Fig. 2, right). Finally, in some cases, especially in smaller schools and in rural areas, the personal network is practically reduced to contacts with colleagues from the school where they work (Fig. 2, left).

Personal networks have a mean density of 0.46, an average degree of 15.40, and a diameter of 2.72. Approximately two thirds of the personal networks are made up of members of the respondent's school ( $M = 19.2$ ) and one third of contacts are outside their educational center ( $M = 10.7$ ). On average, they usually have four contacts with public education administration officials. Respondents are aware that the configuration of the network is related to accessibility to the information and support necessary in the process of digital transformation.

Logically, I relate to my co-workers at my school. But I also usually interact with teachers from other schools because they provide me with information about some specific tools and offer solutions to some of the problems that arise. Many times, they are personal relationships, personal contacts that I have. I also need to be in contact with some technicians from the regional Ministry of Education or the teacher training center because they have specific information. If I make a query about data protection, I always contact the Ministry. About software I get help from the teacher training center. Then I solve any query in Google. [S3. Primary school, rural]

**Discussion**

The coronavirus pandemic that started in 2019 had a disruptive effect on education systems at a global scale. First, it led to the temporary closure of school premises and strategies were put in place to guarantee the continuity of education. Structural reforms followed among which the digitalization of the educational system stands out [49]. In Spain,



**Fig. 2.** Three configurations of personal networks. Some informants concentrate their relationships in the school where they work (Left); others distribute their relationships between the school and a second subgroup made up of officials from the educational administration and the teacher training center (Middle); and a third group have more effective contacts outside their school than in the place where they work (Right). The colors represent the role of the members of the personal network: blue = teachers from the same school as the respondent; coral pink = teachers from other schools; light blue = officials of the Department of Education; yellow = teacher training center; green = university researchers and trainee students. The size of each node represents betweenness centrality. For example, in the center image, the school principal is on many of the shortest paths between the different members of the network. From left to right the networks vary in the sense of being less dense and more heterogeneous. Three respondents have networks with an average density of 0.819 and 24 contacts in the school they belong to on average (Left). Five respondents have intermediate networks in density (0.497), although they are homogeneous in composition (also 24 contacts on average in their own school) (Middle). Three respondents have comparatively less dense personal networks (density = 186) and a clearly heterogeneous composition, with only 7 contacts on average at their school (Right). Source: Own elaboration.

this meant the provision of infrastructure and equipment to schools, the provision of digital devices to students, and investment in teacher training. This process is clearly observed in the schools of Cantabria, in our case study. The decisive impulse of the regional public administration contributed to establishing a common digital environment, with which the schools not only share the virtual teaching platform but also the software used for the coordination of the teaching staff, and the basic tools for communication, storage, sharing, and educational monitoring.

As a consequence, teachers do not focus their demands on obtaining a greater provision of equipment, as was traditionally the case, but on the development of the necessary skills by teachers, students and their families. In the aftermath of the pandemic, awareness of the need to integrate ICT into teaching practice has also increased. However, when it comes to teachers, large individual differences in digital skills are perceived, especially between different generations. On the one hand, some teachers have little training in this area and are reluctant to explore the use of technologies in their practice (especially when they are close to retirement). On the other hand, those teachers who have already accumulated some experiences of digital innovation have to adapt to the new system promoted by the regional ministry of education. These observations coincide with relevant factors in the professional development of teachers identified in other contexts [50].

Added to this are the deficiencies in the technological skills of the students' families, in clear contrast to the aspiration of the students towards a greater interactive use of digital technologies in the classroom. Both the conditions at home and the aspirations of the learners have been documented as relevant factors in the process of educational digitalization [51], especially when there is a discrepancy with the expectations of teachers [52]. This has become more evident during the COVID-19 lockdown where children who had a supportive home environment (e. g. support from parents, a quiet space to work, the availability of devices, and exposure to different ways of learning, etc.) reported better learning experiences [53].

In this context, the creation of a network among the champions of educational digitalization in schools in Cantabria could strengthen the innovation process. Some of the key players in the technological transformation of the educational system in the region participated in this study. These are teachers and school administrators who are promoting digital action planning in schools and who have previously participated in a wide variety of digital innovation experiences. The creation of a space for exchange among this select group of key players contributes to reinforcing the process of digital innovation and potentially constitutes the seed of an effective network of collaboration among schools in the region. Interorganizational networks that obtain positive results tend to

adopt a center/periphery structure, organized around a dense core of particularly active and intertwined actors [54].

The analysis of the personal networks of the coordinators of the digital area in schools revealed that ICT coordinators usually act as intermediaries between the school and the resources available in the environment to support technical aspects of technology integration. The coordinators connect the teachers of the school in which they work with the technicians of the educational administration, the teacher training center, and a plethora of advisers in information technologies. They are a channel through which information, advice, guidance, material resources and technical help are transferred. Consequently, they act as an effective interface between the school and the administrative hierarchy of the educational system in the region, as well as between the professional resources of the school and those of other professionals located outside the school. This brokerage position usually play a catalytic role in science-practice transfer chains, facilitating the implementation of evidence-based practices in public schools [55].

These leaders are key actors for digital development in schools [56]. By adopting transactional or transformational leadership styles [57], they can contribute to the renewal of pedagogical resources or even to the transformation of teaching and learning processes [3]. To do this, they usually resort to clarifying objectives, curricular adaptation and the development of a digital culture in the center, as well as the empowerment of teachers, students and families [58].

The data also showed the existence of different types of personal networks, which position each coordinator differently in their relationship with the network of schools and in their functions as facilitators of technological change. There are coordinators who act as a link between the school and the educational administration, others are facilitators who connect teachers from many different schools, and finally there is a third group whose action is mainly concentrated in the school to which they belong. This typology bears a certain parallelism with that observed in the general population [59], although in this case it has other implications due to its repercussion on the digital transformation in education. For example, the coordinators connected with a great diversity of resources can make more contributions to the network of schools, while those who have dense and homogeneous personal networks (in their schools) could be the ones on the receiving end of the exchanges that take place. Thus, it is found that personal learning networks offer the opportunity to personalize the professional development of each teacher [60].

The diversity of personal networks also points to the different ways of exercising leadership to promote innovation in educational contexts. Both members of the management team and ICT coordinators can



organize their schools to facilitate participation in exchange and learning networks. This may require those forms of distributed leadership in which all available resources are deployed to improve the teaching and learning functions of schools [61]. In this context, the leaders promote empowerment in decision-making, facilitate interaction and foster the development of the capacities of the educational personnel of their schools. In our study we found that this can be done by mobilizing, to different degrees, the formal and informal resources of the education system.

Lastly, teachers conceive of digitalization as a process that goes well beyond the incorporation of new tools, as it encompasses institutional, political, and educational changes. The integration of technology in the classroom, the transformation of the teaching-learning process and organizational changes imply a far-reaching renovation of the educational system. Among other aspects, its relationship with the individualization and commercialization of teaching has been pointed out, for which a critical evaluation of the impact of digital technologies is necessary [62,63]. It is also needed to decide how to combine the personal and institutional uses of technology [64].

The channeling education only through technology [65] over prolonged periods as it happened during the Covid-19 pandemic, demonstrated clearly the importance of the school – and campus – as a key social equalizer. Poverty manifested as lack of access to ICTs infrastructure and equipment at home, so-called ‘digital poverty’, obviously affects the opportunities of disadvantaged students to engage in education, further eroding social justice in that situation. However, in addition to such an access-to-technology gap, educational policies and institutions aiming to tackle inequality need to acknowledge and address the role of capability and, most importantly, social structure [66–68].

#### *Practical implications and future research*

The creation of school networks is one of the strategies that can contribute to the professional development of teachers but also to the development of the digital capacity of schools. In addition to facilitating coordination among schools, it allows the exchange of best teaching practices. That is why it is particularly well suited to support the digital transformation process. On the one hand, teachers find a response to the perceived need for support and handholding as they integrate digital tools into their teaching practice. On the other hand, it accelerates the diffusion of innovations.

In this study we were able to verify that it is useful to create a network among schools before promoting the diffusion of innovation within each school. For this, it is convenient to select a small group of key players, especially motivated and competent in the area of information technologies and digital education, so that they establish a relationship with each other. It is a core group that constitutes the nucleus in the formation of the network. At a later stage, other teachers is expected to be added from each school. As the network becomes more heterogeneous, the diversity of resources that are shared increases and a more effective operation can be achieved.

The institutional context and time management play also an important role. On the one hand, the support of the regional ministry of education establishes the conditions and incentives to participate, while giving legitimacy to the entire process. Secondly, participation is a long-term process, in which time must be allowed for the formation of relationships, the progressive involvement of new actors and the creation of a shared history. The role of key participants has also been observed in online teacher communities [69].

Collaboration between schools is one of the ways to promote readiness to use digital technologies. The preparation of teachers for the use of digital technologies, in turn, depends on the preparation of the institutional context [70]. Thus, the infrastructure, the perceived quality of devices and programs, opportunities for personal development and formal and informal exchanges between teachers and institutions,

together with the capacity for technological integration in general, depend in part on the development of ties of collaboration between institutions and professionals.

Some notes for future research can also be derived from our study. In the group sessions, we compared two strategies for using network visualization to facilitate discussion, reflection, and awareness of the resources that the educational staff mobilizes during their educational practice. In one case, a participatory and consensual evaluation of the relationships was carried out (*Netmap*), while in the other the visualization was used to give feedback on the information previously obtained (*Netmirror*). While in both cases the visualization of networks is integrated with group dynamics, each one mobilizes a different psychosocial process. The feedback based on the visualization of the networks allows the respondents to become aware of the structure of their interpersonal environment, while the participatory diagnosis entails generating a shared vision, based on a process of consensus-evaluation among the participants. In both cases, the visualization of the networks is used as an intervention tool, but it is important to recognize that it generates different behavioral dynamics (and that these dynamics are determinants of the results obtained). In this regard, in relation to professional development, there are previous experiences in which network visualization has been used to improve teacher leadership [71].

We also had the opportunity to compare the feedback from the personal networks at the individual level with the presentation of results in a group. When respondents have the opportunity to compare their personal network with that of other participants, they become more aware of the peculiarities of their interpersonal environment. Social comparison makes more evident the structural properties that characterize each personal network. This is another interesting aspect amenable to further investigation in the future.

Finally, it would be interesting to combine in future research the creation and monitoring of school networks with the development of their digital capacity as it is supported by the SELFIE scores previously obtained.<sup>11</sup> After each school has reflected on their digital skills and what they need to improve on, they are in an excellent position to connect with other schools that can help them in the process of digital transformation. Thus, self-reflection with SELFIE could facilitate the design and implementation of effective school networks.

#### *Limitations*

The case study focused on the formation of collaborative networks in schools in a specific region of northern Spain. Although the research revealed generic patterns of interaction between teachers, it would be necessary to verify that the results obtained are generalizable to other geographical contexts. In addition, the development of typologies was based on a small number of interviewees, so it would be interesting to reproduce this same scheme with a larger number of cases. In the future, it would also be of interest to explore how these school networks affect the educational experience of students.

#### **Conclusion**

Policies to promote digital transformation in education in Europe have often consisted of investments in the provision of infrastructures, technological equipment, and software, together with initiatives for the professional development of teachers, especially through training actions to promote digital capacities [72,73]. Through an action-research experience with a selection of schools in Cantabria (northern Spain), we verified that the significant increase in investment in infrastructure and equipment after the pandemic has provided a technological endowment that is perceived as adequate. The focus has now shifted to the

<sup>11</sup> Especially if we consider that it is a tool with good validity and reliability indicators [74].



development of the capacities of the teaching staff and the integration of technologies in the school practice. The creation of school networks can facilitate this process, to the extent that it enables the exchange of support between teachers during the innovation process, while promoting the exchange and dissemination of best practices. The identification of a small group of key players, to form a driving group, is particularly useful in the initial phases of network creation to enable better development and/or improvement of the digital capacity of the schools.

In this study we detected the existence of two types of pioneers in educational digitization, namely: teachers who act as connectors with the public administration and teachers who act as intermediaries between a wide variety of schools. This shows that some educational innovators promote organizational change in schools through the mobilization of formal resources, while others resort mainly to informal resources. Consequently, when characterizing school intermediaries, we not only use the position they occupy in collaboration networks, but also the type of resources they mobilize. This combination of structural properties with the content of the interaction offers new opportunities, both for theoretical analysis and for the design of interventions in the educational context.

### Declaration of Competing Interest

There is no financial or personal interest or belief that could affect the objectivity of the research.

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