A biographical experience concerning the role of ICT in Mathematics education

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RESUMEN

The article starts with the theoretical and empirical introduction, mentioning the role of ICT in teacher training, and proceeds with the methodological presentation of the general research and its design. The next section presents the results obtained, divided in two subsections - the biographical synopsis and the status and use of ICT in Teresa's teaching and training practice. The conclusion, as allowed by Teresa's narrative, closes the text.

Objectives: The article belongs to a qualitative biographical-narrative research, which involves obtaining biographical testimonials from teachers/ researchers who train teachers with the help of Information and Communication Technologies (ICT), to promote skills such as critical thinking, creativity, collaboration, cooperation, and communication, un-

ABSTRACT

Una experiencia biográfica sobre el papel de las TIC en la enseñanza de las Matemáticas

El artículo comienza con la introducción teórica y empírica, mencionando el papel de las TIC en la formación del profesorado. Prosigue con el diseño metodológico de la investigación y la presentación de los resultados obtenidos divididos en dos subsecciones: la sinopsis biográfica y el estatuto y uso de las TIC en la práctica docente/ formativa de Teresa, para terminar con la conclusión posibilitada por la narrativa recogida.

Objetivos: El artículo es parte de una investigación cualitativa biográfico-narrativa, visando la obtención de testimonios biográficos de docentes/ investigadores que forman a docentes con las Tecnologías de la

derstood as essential for the development of comprehensive education, curricular sustainability, and participatory citizenship.

Methodology: The research problem involves the determination of the importance and status associated to the use of ICT in the professional understanding and practice of the participants, according to biographical narratives: What importance and status do the participants associate to the use of ICT, in their understanding and practice of the teaching profession? The teachers' professional biographies were reconstructed from the collected opinions and perceptions, providing answers to the research question.

Results: Here, we report the biographical narrative of a university teacher/ researcher, under the pseudonym "Teresa", who is dedicated to Mathematics education in teacher training. From her reconstructed biographical experience, we will highlight a close relationship to the theoretical and empirical contributions presented in the introduction, and to results previously obtained through our research.

Keywords: Information & Communication Technology, Life Histories, Mathematics Education, Personal Narratives, Qualitative research, Teacher Education.

Información y Comunicación (TIC), para promover competencias como pensamiento crítico, creatividad, colaboración, cooperación y comunicación, entendidas como esenciales para el desarrollo de la educación integral, sostenibilidad curricular y ciudadanía participativa.

Metodología: El problema de investigación visa determinar la importancia y el estatuto asociado al uso de las TIC en la comprensión y práctica profesional de los participantes, segundo sus narrativas: ¿Qué importancia y estatuto atribuyen los participantes a las TIC, en su comprensión y ejercicio de la profesión docente? Las biografías profesionales de los profesores se reconstruyeron a partir de las opiniones y percepciones recopiladas, proporcionando respuestas a la pregunta de investigación.

Resultados: Aquí, reportamos la narrativa biográfica de una docente/ investigadora universitaria, bajo el pseudónimo de "Teresa", quien se dedica a la educación matemática en la formación del profesorado. De su experiencia biográfica reconstruida, destacaremos una estrecha relación con los aportes teóricos y empíricos presentados en la introducción, y con los resultados obtenidos previamente en nuestra investigación.

Palabras Clave: Educación matemática, Formación del profesorado, Historias de vida, Investigación cualitativa, Historias de vida, Tecnologías de la información y la comunicación.

ARTICLE STRUCTURE

We begin the article with an explanation of fundamental theoretical and empirical elements related to the role of ICT in the teaching and training of teachers, particularly in the field of Mathematics education. The second section will address methodology, followed by results and conclusion.

1. INTRODUCTION

Information and Communication Technologies (ICT, hereinafter) have nowadays become even more essential tools for teachers. With the global health crisis caused by COVID-19, the teaching / learning process of students from different educational stages cannot continue without them. The digitization of education prompted by the pandemic, and regardless of the social gap it can imply (Almazán-Gómez, 2020; Jiménez, 2020; Rogero-García, 2020), may put an end to current ways and tools of schooling, in favour of the online system (Feito, 2020). However, do teachers and students have sufficient digital skills to deal with the implications of this escalating importance of ICT? In this sense, the European Higher Education Area has issued clear statements regarding the competences of teachers and those that the students must develop. "Knowing how to do" and "Learning to learn" become realities for the agents involved in the teaching / learning process, for which ICT will provide new support mechanisms (Lopes & Gomes, 2018), which will need to be controlled by teachers (Roldán, 2016). This will involve discussion on digital competence levels of both teacher (Casal *et al.*, 2018) and student (Colás-Bravo *et al.*, 2019). It would also imply a change in the educational paradigm (Rodríguez *et al.*, 2007), with ICT becoming a transversal training axis at different educational levels (Marqués 2004), and a mark of identity for the new generations (Cózar *et al.*, 2015).

The importance of training future teachers in ICT, from the early stage, has been widely documented by different research projects, carried out from the end of the last century to the present day (Garrido-Miranda, 2018; Rodríguez *et al.*, 2007; Padilla-Hernández *et al.*, 2020). The COVID-19 virus has just brought to light the technological problems experienced by teachers, who have realized how ICT became the only way to continue their teaching work (Gómez-Gerdel, 2020), often requiring (in many cases) considerable adjustments in terms of their practice (Colás-Bravo & Hernández-Portero, 2017; Sánchez *et al.*, 2020). These adjustments would need to go even further, since they would require the empowerment of different forms of appropriating disciplinary contents (Caramés, 2019).

So, what happens to the pre-service training of Mathematics teachers? Are they trained to serve students with and from ICT? Do they consider themselves digitally competent? And has using ICT in one's classes meant many changes for one's way of understanding the teaching / learning process? All these questions governed the research which originated this article, based on the data obtained through qualitative research of a biographical narrative nature, which collected the formative experience of university teaching staff who use ICT

for their teaching practice. But first, let us briefly contextualize what happens in Didactics of Mathematics, with respect to the previously posed questions.

Mathematics teachers from the different compulsory educational stages have voiced their concern about the incorporation of ICT in their classrooms, as shown by the research work of several authors (Maz, 2012; Suárez, 2017; Lopes & Gomes, 2018; Palmas-Pérez, 2018). Specialized literature has collected experiences related to the applications of ICT in Pre-School, Primary or Secondary classrooms (Hernández *et al.*, 2016; Ovalles *et al.*, 2018; Lugo *et al.*, 2019; Conde-Carmona & Fontalvo-Meléndez, 2019), as well as University classrooms (Ryokiti & Oliveira, 2016; De Oliveira & Carvalho, 2017; Ruiz, 2017; Ferrando *et al.*, 2018; Hernández & Juárez, 2018). This evidences the considerable reflection on the use of ICT by teachers in Mathematics classrooms (Palmas-Pérez, 2018), and how it has even created a need for the methodological recycling of specialist teachers, as shown by the experiences of different researchers (Ryokiti & Oliveira, 2016; Olivier *et al.*, 2016). Applying changes to the standard approach, they have reached the conclusion that mathematical knowledge can be built using digital tablets, for instance. This is where the teachers' greater or lesser awareness and self-perception of their competences and basic skills (Morales-López, 2015) may or may not lead them to apply ICT in the classroom. Meaning, it would be a question of not perceiving ICT as a negative, complex challenge (Palmas-Pérez, 2018), and beginning to see them as facilitators for understanding mathematical concepts. Since their use is currently unavoidable, due to the lockdowns caused by the pandemic (Gómez-Gerdel, 2020), online work is now massively widespread.

Mathematics teachers are required more than just knowledge of the mathematical content. Within their pedagogical knowledge, they must change the way they face the teaching / learning process, thereby adjusting the teaching practice to the students' new demands (Suárez, 2017). Thus, according to the educational paradigm shift, the use of ICT would supposedly have a relevant contribution: some experiences with specific software, such as GeoGebra (Ryokiti & Oliveira, 2016; Salas, 2018), GEUP (Conde-Carmona & Fontalvo-Meléndez, 2019) or SAMD (De Oliveira & Carvalho, 2017) can be highlighted. In other words, ICT should be understood as bridges towards other forms of representation and access to mathematical ideas (Palmas-Pérez, 2018), facilitating the understanding of their concepts by students and mitigating the teachers' fears regarding their own usage.

2. METHOD AND INSTRUMENT

This article is part of a broader research project, of a qualitative, biographical narrative nature. In accordance with the foundations of the qualitative approach, we undertook research

with a descriptive and interpretative objective, resulting in the consequent paradigmatic conclusions, which are impossible to generalize or universalize. The operating methodological procedures are semi-structured, in-depth interviews, which allow for a reconstruction of the participants' professional biographies (Goodson, 2017; Hühn *et al.*, s/d; Landín-Miranda & Sánchez-Trejo, 2019; Edwards & Holland, 2013; Amado, 2014; Ramos, 2018).

The research problem involved the determination of the importance and status assumed by the use of ICT, according to the professional understanding and practice of the participants in the study, as may be captured from their biographical narratives. This can be phrased as a question: What importance and status do the participants associate to the use of ICT, in their understanding and practice of the teaching profession? The teachers' professional biographies were reconstructed from the collected opinions and perceptions, providing answers to the question.

The research aims at collecting and analyzing training experiences shared by university teachers who use ICT as an important training tool, to develop critical thinking, creativity, collaboration, cooperation, and communication skills in their students, understood as essential for a comprehensive education, reaching towards curricular sustainability, as well as responsible and participatory citizenship. According with the descriptive and interpretative nature of the qualitative research, it does not aim at developing teaching perspectives and procedures susceptible of being generalized or universalized. Rather, it highlights the personal and individual status of the interviewed teachers / researchers, seen as exemplary cases. Therefore, the main value of the participants' contributions resides on their paradigmatic status and ability to shed light on biographical experiences.

As a broader theoretical background, the research is based on a personalistic perspective of the human being and teacher, understood as a practical, dialogical, and historical being, as well as on a relational and dialogical vision of education, developed in previous writings such as Ramos (2018). This personalistic conception of the human being, as well as its practical nature, are at the core of qualitative methodology usage, as it allows for searching and capturing the meaning that social actors give to their actions (Ramos, 2018).

The object of study is the corpus which compiles the discourses collected and reconstructed from the interviews. This article contains the analysis results for the in-depth interview conducted with a university teacher, Teresa, who tells us about her teaching and training experience.

Teresa —along with other research participants— was recruited via personal appointment by a pool of university teachers and researchers known to us, using the Snowball sampling procedure (Vinuto, 2014).

The interview was conducted using Skype software on last June, the 10th. The recorded interview was transcribed, and the text was subsequently validated by Teresa.

The protocol for the data collecting instrument begins with the ethical issue of information anonymity and confidentiality, moving on to the collection of the interviewees' biographical and curricular data. Our interviewee expressed the desire to maintain anonymity and confidentiality, which we guaranteed by using the pseudonym "Teresa". The recording was destroyed once its transcription was validated. The transcribed text itself was kept confidential. The information necessary for the reconstruction of Teresa's biographical experience was extracted from it. In this article, Teresa's words, when quoted, were translated into English. The signing of the declaration of informed consent closed the chapter on the research's ethical concerns. Questions were presented in a thematic and open approach, covering the relevant areas for the treatment of biographical aspects related to the general theme of the research.

Treatment of the discourse involved inductive analysis of the text from the validated interview, highlighting Teresa's perceptions and opinions to identify, collect, structure, and synthesize her views on the issues exposed and treated in the document.

3. RESULTS

Teresa's biographical narrative may be reconstructed highlighting two main sections: her biographical synopsis and the status and usage of ICT in her teaching and training practice.

3.1. Biographical synopsis

Teresa is 44 years old and is a professor and researcher at the University of X (Spain), in the Faculty of Education. She has a degree in Mathematics from the same University, where she also obtained a Doctorate in Computer Science (2009). She has been working for «20 years now, 13 of which as a teacher».

Her professional life, until 2016, involved a vast and demanding set of tasks: teaching at the University of X (Degrees in Mathematics and Engineering), while serving as Director of European Projects at the Institute of Robotics and ICT of the same University, in charge of European Projects and their financing. These projects were focused on enterprise knowledge transfer, rather than research. Along with all that work on transfer projects, she also wrote her Doctoral Thesis.

In the 2016-2017 school year, «the opportunity to completely change my role» arose, and Teresa took on the position she currently occupies at the University of X, «as Professor of Didactics of Mathematics» in several Degrees (Primary Education Teacher, Preschool Teacher, and a Master's in Secondary Teacher Training).

Throughout her diverse university experience, she has had the opportunity to work on a considerable variety of projects, from which she highlights service-projects with Computer Engineering students and Algebra master classes. At present, her work is «something totally different, since the training of future primary school teachers is focused on their future roles as primary school teachers», who must have «a mathematical foundation» and solid didactic training, into which she puts «a lot of effort». This formative work focused on the didactic dimension is carried out with both pre-service teacher students and in-service teachers. Her students do their internships in schools, which allows her to maintain close contact with primary schools. Simultaneously, the training of in-service teachers is also carried out in their schools, which enhances that knowledge of the educational reality in which they work, as well as the transfer of knowledge, by «offering them our advances in the latest research from our faculty».

These references lead Teresa to underline the «eminently practical» nature of her teaching, immediately pointing out «the most important area in which I'm working, and of which I feel most proud (…) is that of bringing Mathematics to the real world». With clear satisfaction, she states: «Mathematics, most noticeably in primary school, is seen as a horrible monster, a set of procedures, a set of techniques for which students are unable to see purpose». To avoid this situation, «together with other colleagues from the faculty, we are dedicated to applying elementary Mathematics, which is basic and doesn't pose any difficulty, to problems» which «students face (…) in their daily life». She provides an example, referring to a citizenship problem: «one of the examples I feel most proud of is when statistical charts are shown in class and students are able to analyze what they are seeing. Now, unfortunately, we see many charts on television, and during election periods they bombard us even more (…) … They give you charts of voting intentions, trends …». To achieve this goal, she explains: «I have a battery of charts —well-intentioned or malicious—, all of which are false and continuously shown on television, with either the wrong scale, or… —intentionally or not, I think it is intentional— but they are poorly done and opening the students' eyes to that fact is basic training. We must use that in Mathematics from an early age, to be critical citizens, not distrustful, but critical». Another application field related to everyday experience concerns going «to the supermarket. I always joke around with them, that you go to the supermarket and have two offers: one is that you buy 2 products and the third one is free, and the other

one tells you that the second unit you buy has a 70% discount. Which offer is better? None of my students know how to solve it, and they are 22 years old!!! It is a matter of percentages and basic maths».

Concluding this reference to the critical and civic application of Mathematics, she underlines her belief that «the training of future teachers and, consequently and by "inheritance", of their future primary school students, must include training in basic Mathematics, because they're essential to a critical citizen - at least so they will not be fooled. This is the field in which we are now having the most influence and of which I feel most proud».

Another essential dimension of her university work is research.

She begins by referring to her «initial research work», the Doctoral Thesis, which «was focused on the treatment of computer graphics, based on chaos theory». She considers that «as a matter of fact, the work I did had quite an impact in its day, but due to life circumstances I abandoned it, it «took a backseat», but there were other people who continued that work, and I changed my own work radically».

At present, she mentions that her work has «two open fronts»: (a) The research on Didactics, «research on how students deal with problems of realistic Mathematics and not procedural problems like "Pepito had two marbles and bought two more, how many does he have by the end?", not this, but, as I said before, bringing Mathematics closer to something more interesting and realistic»; (b) The work on a financed transnational project aimed at high school teachers, in collaboration with researchers at the Real Colegio Complutense, of Harvard. «Two years ago, » she stayed at Harvard, with a scholarship. Her work involved «characterizing how secondary school Mathematics classes are given nowadays, in Spain. We apply observation instruments, and then observe practicing teachers in real classes, where the teacher is teaching Mathematics, and they are analyzed by their usage of textbooks, their control of disruptions in class, and anything else». She mentions that this «is just beginning, we have not yet been able to advance and publish anything on it».

3.2. Use of ICT by Teresa

The next section of Teresa's biographical account deals with her use of ICT, in general, and with her work as a teacher.

ICT have always had a very important place in her research work, as it involved «computer simulation». Currently, they remain essential for the «statistical treatment of the results

obtained, and for analysis, using spreadsheets or data processing programs, where the responses are analyzed».

Regarding research on teaching, task recording is tantamount. «One of the things I use the most, and which is giving me the best results, is recording conversations between students, their discussions (group work, not individual work) on video —if possible— or at least on audio». She further elaborates on this work (which has already been published): «recording their discussion while solving a modelling problem, (...) we have a way of representing how much time the students spend in each phase of solving the problem, while they're trying to understand it, while they're trying to find out which data they need and which they don't, the time they spend doing mathematical operations, the time they spend trying to see if the solution makes sense or not...». For this purpose, she considers that «ICT help us a lot —on the one hand— to record and be aware of the real process students follow to solve their problems, and, on the other hand, to later analyze —qualitatively or quantitatively— the results we've obtained in this case».

In teaching, «recording elements to both audio and video» is still important. But to obtain data from these recordings, she uses «a computer program —developed by me— to draw the graphs with the time students spend in each of the phases of the resolution process», data which is later processed in «spreadsheets or the SPSS program, to help us with quantitative analyses». Called «Task Time Tracker», this program originated from «an international research project, working with Professor Jonas Ärleback, from Sweden».

For qualitative analysis, she uses the MAXQDA program. Still, she considers that the use of her «Task Time Tracker» program is much «easier: because of the workload, because of the volume we handle, it's much easier for me to put on the audio or video of what we're doing with the students and take handwritten notes with keywords». She finds it essential to be familiar with this program: «Yes, I've automated it, so the time chart is generated with a few keystrokes, but there's nothing more to it, it makes work easier...»

The programs and tools used are provided by the students, the University and Teresa —her «Task Time Tracker» tool. «In fact, I ask students to record themselves with their mobiles (yes, their mobiles). The institution provides me with the software required for my work, and as for the tool I use, I've programmed it, so it's mine».

Analyzing the students' attitude towards the use of ICT, Teresa begins by stating that «Students are very surprised», since «apart from the tape recorder or mobile they use to record themselves, they don't use ICT». She then expands on her pedagogical thinking, refe-

rring to her didactic modus operandi, aimed at the development of autonomy and intellectual mastery of technology by the students: «one of the things that characterize the problems I give students is that I introduce a problem, but don't give them any kind of data. For example, a typical problem that we work in class at the beginning of every school year, on the first day of class, is: how many people can fit in the faculty hall? Then, they will say: well, we must go down and measure. Well, go down, measure and find out how many people can fit per square meter, and see if all of us occupy the same space, or … Then they start working from there, but they do not need much, maybe they need to look for some data on the Internet, if there is something they need to know, but they usually use pencil and paper and their own perplexity towards the problem, because these are not usually complicated problems, but they are disconcerting to them, since I do not give them data of any kind».

This practice of throwing them into a situation where they need to produce the solutions themselves forces them to develop their creativity, by having to «measure it, or look for it, or imagine it». When they manage to overcome the difficulties posed by the pedagogical situation, they begin by manifesting a combination of «a lot of laughter and a lot of protesting». She vehemently mentions that «Yes, they protest a lot», and justifies this by presenting another practical problem with which she challenges the students: «One of my favorite problems is giving them the plan of a house, the floor plan, like when you go and buy one, and then ask them how much paint is required to paint the walls of that house». Based on this question, she poses several others, concerning the standard sizes of house components —such as beds— and the opening of doorways, so that «from there [you can] work with scale in mind and know how many meters you have on your wall». At that moment, she states, «they begin to protest and ask: "and how high are the windows, how do we know how tall the walls are...?"» But this behavior is finally outweighed by the satisfaction of discovering that the absence of data does not imply they cannot solve a problem: «the moment they discover that not all problems need to have all the data to perform an operation, they become very happy». Using an everyday example related to civic order —political demonstrations where estimates of the number of participants will vary according to the entity which provides them— she shows another practical problem usually posed to her students: «The government always says that a million people have attended, and the police say ten thousand, (...) and I always tell them: how many people could fit there?» The initial protest —«How do I know?»— is followed by an indication of where to look for the solution —«Well, it's easy, if there are so many square meters and you have five people per square meter, you already have it (...) It's that easy». Then, amazement surfaces— «They're very confused» —and, finally, gives way to the aforementioned contentment— «but then they're very happy» —and to an increase in the

corresponding critical citizenship implications— «Well, I can already know if what they are telling me is true or not, just with a multiplication».

Teresa continues the presentation of her pedagogical thought and practice, showing how she gives ICT a status subordinate to the domain of critical and autonomous thinking by the student, who uses them as an instrument to enhance those capabilities for action. In this sense, they provide an added value for teaching, which Teresa highlights by referring that the first thing she wishes to do with her teaching «is to put the brain into operation», a statement followed by the idea that «later, when we do a multiplication, or the necessary operation, that is what ICT are for —either a calculator or a much more powerful tool like SPSS, which tests hypotheses— but there's a problem if they do not know which hypothesis test they have to run».

Thus, she considers that «for me, ICT are fundamental in this regard, because they take away an automatic part of your problem, so you do not have to use your brain, you use an automatic procedure, you know how to do it and that is it». This instrumental role implies that with the removal of the automatic «problem (a division, a square root or whatever), you can dedicate your whole brain to improving the resolution of the problem». In conclusion, she says that «I always tell them the same thing: the calculator knows how to multiply, what I want you to know is what you must multiply, and from there we can extrapolate it to basic operations or to much more complex operations».

Teresa's effort to foster in her students an autonomous and critical attitude towards the use of Mathematics, when teaching their own students, places heavy demands on the use of ICT, concerning the possibility of generating products in which they may have a prominent role. Teresa begins by referring that students in her Faculty of Education «do not know how to program», which is why «the statistical treatments carried out are very basic, such as — for example— hypothesis testing, for which SPSS is used. But beyond using spreadsheets to make a chart, or things like that, students do not have sufficient knowledge of Mathematics or higher programming», admitting that «they do not need it, either». Thus, she acknowledges not having «any student specializing in ICT, my students are specializing in Mathematics and Science». The only chance for that to happen is if «either you find someone who knows how to program for something or who decides to focus the final projects of the master's degree or a Degree Project on programming something...». Nevertheless, often the use of ICT by her students does not go beyond spreadsheets or SPSS. Only in exceptional cases can one go further, such as a case which she recalls regarding «a Master's student who took a problem and programmed it as a video game, but it was a very exceptional case, a person who knew how to program».

However, the in-service teachers Teresa and her colleagues follow up in their school practice reveal some notable experiences while teaching Mathematics in the spirit she referred to: «There was even a girl who was featured in a work we published in an international conference, regarding her interaction with her 6-year-old students, which then received many positive reviews – both from me and my colleagues». It is not the only case in which Teresa and her colleagues are able to verify good practices when they go «to schools, to see practicing teachers who were used to teaching Mathematics in a certain way, and then they tell us about some very positive experience they've put into practice». But she points out that those experiences are not fundamentally related to ICT: «Related to ICT, no; related to ICT, no, because people who are practicing in primary schools do not use them to analyze their results, they analyze them with pencil and paper, and that is it, right? They do not give this a higher treatment».

4. DISCUSSION AND CONCLUSION

The interview allows Teresa to discuss the final topics related to her pedagogical viewpoints regarding ICT and their value for the nurturing of a critical and autonomous attitude in her students. The leitmotif for these reflections is the situation generated by the pandemic. They begin with a questioning stance regarding teacher training. It seems to her that this situation requires a change of perspective in teacher training, regarding the prospects for the use of ICT in teaching. In her understanding, available tools should be critically re-evaluated in their limitations and possibilities. She admits that she was «not already a fan of using an app, GeoGebra, for example, or any program that helps with geometry or anything, (…) not very much a fan, because it seems more important for me to "use my hands"». Still, the «situation that has been created now, with the pandemic, and the need to teach from a distance», has led her to reconsider the value and possibilities of ICT.

She starts by mentioning that ICT, by themselves, have no absolute value for teaching, in her opinion. This naive belief in their absolute value was noticeable during the pandemic. So, she states that «I have found things that instead of teaching, "unteach", or confuse students». She mentions that «some proposed activity or app you find out there for free, with all the good will in the world, which people make available to the educational community —and I include myself among them—» is not always beneficial unless framed in pedagogical perspectives which, according to her, should be emphasized. In her opinion, based on the previous arguments, «we have failed to teach our students how to use those tools we find every day on the

Internet to "digitally train"». Teresa goes on to say that «teaching the same concept digitally, not with pencil and paper», she has come across the fact that her «students aren't able to tell if that tool they've just found, that app or computer program, actually works, or if it can or cannot be used to explain the concept they want to teach». In this sense, she proposes a line of work for the didactic research of Mathematics, opening up «that field», which would require, in her opinion, «a very great effort». She formulates her position by stating, self-critically, that «I had totally closed off that field, because (…) I only use ICT a posteriori», that is, «I didn't use ICT as tools to teach concepts». She now clearly believes «that this is extremely important, since a totally different teaching paradigm is opening up for us, and we must know how to use the digital tools we have at our disposal», concluding that «at least until now, we haven't devoted them the effort we should have».

Teresa's final set of reflections focus on the distance teaching / learning experience during the pandemic lockdown period. She considers that she has «been very lucky, as when they "closed" Spain in mid-March, I had already given all my classes, save for a few ones in the master's degree in Secondary Teacher Training». Those students were a more adequate group for overcoming the difficulties that had arisen, since «they're students who've already finished a degree, who are doing postgraduate studies, are learning independently» and have been able to fully respond to the tasks and demands they were faced with: «you give them a research article and they're able to read and even discuss it». This circumstance was beneficial, since she did not have to teach distance classes, like some of her colleagues who were « "caught off-guard" by the situation while teaching 1st and 2nd year classes to students who are still very fresh in the field of Higher Education (…)».

These references motivate her to further expand, in a vibrant and assertive tone, her critical views on the way a misconception of e-learning became widespread, when everyone was faced with an untimely and unheard-of situation. She states that «recording a class, spending two hours (…) in front of a screen explaining how fractions are added, it's not e-learning for me, it's "we get out of trouble" because I cannot be with you in class. That is to say: it is not possible to do the same thing in my house that I would do if I had a blackboard behind me, so that's not e-learning». Merely getting out of trouble is out of the question; instead, we must assume firmly that «if I want to explain the difference between a square and a rectangle» there is a need to «look at what technological tool —there are lots of them— will allow me to create an activity and a context where I am able to convey the difference between a square and a rectangle, because if I tell you "draw a square", and you draw it, "draw a rectangle", and you draw it, that's not e-learning either, that's the same as taking the textbook and telling the

student to look for exercises 3, 4, and 5, and let me know when he has finished, and I'll correct it». In Mathematics, distance education implies «proposing activities that make sense», and not just placing a screen between the student and the teacher.

Her critical judgment does not condemn the teachers' practical response to the demands of the pandemic situation. For Teresa, the pandemic «has caught us teachers on the wrong foot. That is, we did not know how to do this, and, frankly enough, I believe we've finished the course "in fits and starts"». Still, we must look towards «next year», since «blended education» and «mirror classes» are being considered in Spain, a situation that would require «us, trainers, to "charge our batteries"», since blended-learning (…), for me, is the greatest deception they've ever invented». This opinion is supported by her belief, manifest from the start, that «If I record myself showing you the difference between a square and a rectangle, that is not e-learning, it is the same as reading a book. Well, you have the Notes for my subject, read them and if you don't understand something, ask me; it's the same, but with a camera involved». She then concludes, underlining that «This is not teaching at a distance, and I believe we're not trained for it, we're not prepared», while admitting that «I don't know if we have the strength to do it». She expands on her doubts and concerns, as well as her work situation, stating that «I am worried about September (…), because here they are, talking about blended classes, but I am going to give twice as many classes, because I have to teach half of the students at a time, as only half of them can be in class. This means I will give twice as many classes but will be paid exactly the same. And then, I will have to prepare the video classes … of course, it's a perversion of the system…».

The interview gives evidence of a significant consistency between Teresa's perception and pedagogical foundations and the elements provided in the theoretical and empirical foundation of the article. This is noteworthy, supporting the conclusions exposed beyond the exemplary nature of Teresa's biographical experience. In a final synthesis, we can highlight the following points, which we find particularly relevant.

Teresa recognizes the potential formative value of ICT for helping teachers in training acquire skills in Mathematics and its didactics, but never relying on it absolutely, at any time. Instead, she highlights the relevance of a holistic sense in the teacher's practice, to which they must be subordinated. Teresa's proactivity is evident through her involvement in the rational and instrumental use of ICT, aimed at supporting and consolidating the teaching practice and its critical understanding. Also worthy of mention are her interest and the capabilities she revealed when programming her own auxiliary software tool for teaching practice, «Task Time Tracker». Among those interviewed during this research project, Teresa stands out for

insisting upon the subordination of ICTs to the ultimate aims of education, embodied in the figure of the teacher.

This project could be enhanced, in the form of a broader case study, by analyzing Teresa's work and conceptions while resorting to other data collection instruments and participants, thus further consolidating her substantial testimonies and biographical example. It is, however, a tribute we pay to the pandemic, which does not allow for the necessary travelling and in-person contact.

Finally, one can point out how little generalizable —and even less universalizable— the conclusions are, due to the casuistic nature implied by qualitative research. In this case, we highlighted Teresa's contribution, for its exemplary value. The development of the research project presents other results, with the testimonies of more collaborators on our research, whose stories and biographical experiences will be presented in future publications. For the moment, we only highlight their consistency with the biographical experience we have reported in this article and in previous ones (Sadio-Ramos *et al.*, 2021a, 2021b, 2020).

However, we do not wish to close the article without failing to point out a panoply of studies that provide broad perspectives to this research project and help consolidate it, in its view of the meaning of teaching practice. The value of biographical experience in teacher training, and its study according to the qualitative approach, using biographical, narrative, and semi-structured or in-depth interviews as a privileged means of access to social and personal reality, is highlighted in other research works, converging in this project's fundamental idea (Sotos-Serrano *et al.*, 2016; Vargas-Hernández & Caycedo Lozano, 2011; Salazar-Amaya, 2019). The notion of education as an act that involves the person is also expressly supported, even to the point of vehement emphasis on ideological and spiritual perspectives (Rodríguez, 2020). We are, in this sense, facing a vein we consider fundamental for the exploration of the meaning of education, emphasizing people and their stories as fundamental agents in the production of sociohistorical reality.

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