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ARTICLE

THE INFLUENCE OF SCHOOL CONTEXTS ON BUILDING SCIENCE/BIOLOGY TEACHERS' EXPERIENTIAL KNOWLEDGE

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ABSTRACT:

This research aims to understand how school contexts influence on building Science/Biology teachers' experiential knowledge. Based on Wertsch's studies on mediated action, we consider that experiential knowledge is built in the tension between subjects and in the cultural tools they apply. We produced data through narratives from a focus group in which teachers discussed aspects related to planning, practice and assessment of teaching work. The results show that aspects such as planning time organization, resources availability and bureaucracy interfere in the possibility of producing interdisciplinary work and shared reflections; in the constant adaptation of what will be taught; and in the development of teaching autonomy. Finally, we suggest that mobilizing this knowledge in teacher training programs contributes to building teaching professionality.

Keywords:
Teacher Training;
Experiential Knowledge;
Mediated Action.

LA INFLUENCIA DE LOS CONTEXTOS ESCOLARES EN LA CONSTRUCCIÓN DE LOS SABERES EXPERIENCIALES DE LOS PROFESORES DE CIENCIAS/BIOLOGÍA

RESUMEN:

El objetivo de esta investigación es comprender cómo los contextos escolares influyen en la construcción de los saberes experienciales de enseñanza de los profesores de Ciencias/Biología. Teniendo como base los estudios de Wertsch sobre la acción mediada, consideramos que los saberes experienciales se construyen a partir de la tensión entre los sujetos y las herramientas culturales que emplean. Producimos los datos a través de narrativas de un grupo focal en el que los profesores discutieron aspectos relacionados con la planificación, la práctica y la evaluación del trabajo docente. Los resultados muestran que aspectos como la organización del tiempo de planificación, la disponibilidad de recursos y la burocracia interfieren en la posibilidad de producir trabajos interdisciplinarios y reflexiones compartidas; en la constante adaptación de lo que se enseñará; y en el desarrollo de la autonomía docente. Finalmente, señalamos que movilizar esos saberes en los programas de formación docente contribuye a la construcción de la profesionalidad de los profesores.

Palabras clave:
Formación docente;
Saberes experienciales;
Acción mediada.

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A INFLUÊNCIA DOS CONTEXTOS ESCOLARES NA CONSTRUÇÃO DOS SABERES EXPERIENCIAIS DE PROFESSORES DE CIÊNCIAS/BIOLOGIA

RESUMO:

Esta pesquisa tem como objetivo compreender como os contextos escolares influenciam a construção dos saberes experienciais docentes de professores de Ciências/Biologia. Baseando-nos nos estudos de Wertsch sobre a ação mediada, consideramos que os saberes experienciais são construídos na tensão entre os sujeitos e as ferramentas culturais por eles empregadas. Produzimos os dados por meio de narrativas de um grupo focal em que os professores discutiram aspectos relacionados ao planejamento, à prática e à avaliação do trabalho docente. Os resultados evidenciam que aspectos tais como organização do tempo de planejamento, disponibilidade de recursos e burocracia interferem na possibilidade de produção de trabalhos interdisciplinares e de reflexões compartilhadas; na adaptação constante do que será ensinado; e no desenvolvimento da autonomia docente. Por fim, sugerimos que mobilizar esses saberes em programas de formação de professores contribui para a construção de uma profissionalidade docente.

Palavras-chave:
Formação de professores;
Saberes experienciais;
Ação mediada.

INTRODUCTION

This study describes the results of research, conducted in the Graduate Program for a Professional Master's degree in Education from the Universidade Federal do Espírito Santo, which aimed to evaluate how school contexts influence the construction of science/biology teachers' experiential knowledge. For this, we sought to find the experiential knowledge emerging from the professional practice of teachers in public and private schools in municipalities in Espírito Santo, Brazil, based on James Wertsch's (1998) mediated action and notions of teacher education by authors such as Nóvoa (2017), Roldão (2005, 2007), Tardif (2014), and Tardif and Raymond (2000). We justify our choice of Sciences/Biology by the professional involvement of the authors of this research as teachers and teacher trainers in this area.

Of the studies on teacher education that contributed to professionalizing teaching (especially in the 1980s), we highlight those that recognizing the specific knowledge of the profession (Roldão, 2005). The growth of studies in this area brought to light a certain conceptual heterogeneity regarding the identification of teachers' specific knowledge and its sources due to several authors' proposed classifications or typologies (Gauthier *et al*., 2006; Tardif & Raymond, 2000).

This research agrees with Tardif (2014), who defines teaching knowledge as "heterogeneous knowledge" because they bring to light, in the very exercise of their work, quite diverse knowledge and manifestations of knowing-doing and knowing-being from varied sources" (Tardif, 2014, p. 61).

According to Ryder (2017), many aspects affect the teaching since teachers' practices suffer the influence of: (i) external contexts, such as national laws on education guiding school curricula; (ii) internal contexts, such as the social context of students, families, political pedagogical projects, and relationships between school agents; and (iii) personal contexts, such as teachers' own beliefs and training. Recent studies on Science/Biology teachers' training claim that the experience of teaching situations, the representations formed from that period of schooling, and reflections on teaching work are fundamental elements in building these professionals' knowledge. Thus, research must consider them in their initial and continuous training (Lima & Santos, 2017; Monteiro *et al*., 2019; Silva et al., 2018).

Tardif (2014) claims that work experiences seems to configure one of the main sources of teachers' knowing-teaching since the relationships they experience in their daily school routine with their peers highlight collective ways of being and a diverse knowledge of shared work on students, family members, pedagogical activities, teaching programs, educational policies, among others.

Thus, we highlight the importance of experiential knowledge, which Tardif (2014) considers as

> [...] the set of knowledge updated, acquired, and necessary in the practice of the teaching profession and which [...] is not systematized in doctrines and theories. These are practical knowledges (and not knowledge of practice: they do not superimpose themselves on practice to better know it but integrate to it, forming constituent parts of it as a teaching practice) composing a set of representations from which teachers interpret, understand, and guide their profession and daily practice in all its dimensions." They constitute, as it were, teaching culture in action (p. 48).

We may then understand practice as a learning process by which teachers rethink their training and adapt it to their profession. For Tardif (2014), experiential knowledge differs from other knowledge because it is "formed by all others, is retranslated, polished, and subjected to certainties built in practice and experience" (p. 54). Thus, we may say that the professional training knowledge— i.e., curricular, pedagogical, and disciplinary— undergo resignification in the practice of teaching and constitute elements of experiential knowledge.

For Tardif (2014), the confrontation between knowledge in teachers' collective experience also causes experiential knowledge to acquire a certain objectivity: "subjective certainties must then be systematized to become a discourse of experience capable of training other teachers and providing a path that helps them solve their problems" (Tardif, 2014, p. 52), configuring a shareable experience.

Thus, experiential knowledge can further develop teaching professionality, which we deem as "that set of socially constructed attributes that enable the distinction of a *profession* from many other types of equally relevant and valuable activities" (Roldão, 2005, p. 108). Pedagogical performance is not only based on the theoretical knowledge obtained during training but also on teachers' production of knowledge as they work in classrooms (Gauthier *et al*., 2006; Roldão, 2005; Tardif & Raymond, 2000; Tardif, 2014) which, if systematized, can contribute to teachers' initial and continuous training.

MEDIATED ACTION AS AN ANALYSIS UNIT FOR EDUCATIONAL RESEARCH

> Studying teaching knowledge is a complicated task as "knowledge is not something floating in space: teachers' knowledge is their knowledge and is related to the person and their identity, life experiences, and professional histories" (Tardif, 2014, p. 11). The author warns researchers studying teaching knowledge of the dangers of "mentalism" and "sociologism" as research establishes relations between knowledge and its constituting elements:
>
> Mentalism consists of exclusively or mainly reducing knowledge to mental processes (representations, beliefs, images, information processing, schemes, etc.) whose support is the cognitive activity of individuals. (Tardif, 2014, pp. 11-12).
>
> Sociologism tends to totally eliminate actors' contribution in the concrete construction of knowledge, treating it as a social production in itself and by itself, a production that is independent of teachers' work contexts and subordinated, first of all, to social mechanisms, to social forces almost always outside the school (...). (Tardif, 2014, pp. 14-15).

Thus, Tardif (2014) argues that teaching knowledge lies at the interface between the social and the individual since its construction depends both on the concrete conditions in which teachers' work takes place and on their personality and social experiences.

Wertsch (1998) approaches Tardif's ideas by highlighting that sociocultural research aims to evaluate the relation between human mental functioning and the social, historical, and institutional contexts permeating the investigated problems. For the author, research education and related disciplines often fall into two general categories: methodological individualism and social reductionism, thus limiting the analysis of research phenomena.

Methodological individualism is based on the logic that individuals' psychological and other processes define the starting point for assessing sociocultural phenomena. Social reductionism, on the other hand, assumes that only social facts should explain psychological processes. These opposing views characterize what Wertsch (1998) calls "individual-social antinomy." It tends to force researchers to adopt one position and entirely deny the other.

To avoid the pitfalls of this antinomy, Wertsch (1998) suggested that the terms "individual" and "social" or "mental functioning" and "sociocultural context" be thought of as interdependent related entities. Thus, he proposes that:

> Mental functioning and sociocultural context are understood as dialectically interactive moments or aspects of a more included unit of analysis—human action. As we understand it, action is neither conducted by the individual nor by society, although there are individuals and social moments for any action. For the same reason, a report of an action cannot originate from the study of mental functioning or sociocultural context in isolation. Instead, action provides a context within which the individual and society (as well as mental functioning and the sociocultural context) are understood as interrelated moments. (Wertsch, 1998, p. 60)

Wertsch focuses on the action itself and all its aspects. A form of human action of particular interest to him is mediated action, which he deems the most appropriate unit of analysis to evaluate human functioning.

For Wertsch (1998), all human actions employ mediational means (which he also calls cultural tools) that are inherently situated in cultural, institutional, and historical contexts. These mediational means, such as work tools and spoken language, constantly interact with agents, who configure their actions together. Wertsch (1998) claims that mediated actions consist of an "irreducible tension" between agents and their cultural tools, forcing us to surpass agents' individuality to explain the aspects configuring human action. To evaluate these aspects, Wertsch (1998) outlines a set of five elements in dynamic tension in mediated actions: *act, scenario, agent, agency,* and *purpose*.

Act represents what occurs in actions or in *agents*' thought, which in turn refers to who performed the action. *Scenario* is associated with the context in which the action takes place. *Agency* refers to agents' means and instruments in their actions. *Purpose* represents agents' intent or intentions when performing actions. For Wertsch (1998), these five elements configure a tool to analyze human actions and motives and reinforce the idea that actions are linked to motives or intentionality. The author adds that analyses of mediated actions should focus on agents and their mediational tools since they will better evaluate the other elements of these actions (act, scenario, and purpose).

Science Education researchers have used theoretical contributions from mediated action to investigate teaching and learning situations involving alternative spaces, procedures, resources, and tools. Based on Wertsch's ideas, Barcellos and Coelho (2019), Oliveira et al. (2019), and Pereira and Ostermann (2012) highlight that science learning and teaching implies various human actions, such as observation, analysis, questioning, arguing, planning, and evaluation, involving material cultural tools which show resources and restrictions. For Pereira and Ostermann (2012), research in science education may assess how new cultural tools can transform mediated actions conducted in classrooms. Oliveira et al. (2019) also point to the importance of investigating science teachers' use of educational resources since they "expand and enhance the qualities of mediational means in the act of teaching" (p.251) and can contribute to teacher training processes.

Thus, by dealing with mediated actions in teaching and their relations, we aim to show that teachers' production of experiential knowledge takes place in what Wertsch (1998) calls the "middle path," i.e., on the interaction between agents and cultural tools, betting on this methodological theoretical framework for our research.

METHODS

This is a qualitative study in which data were produced by narratives. According to Galvão (2005), narrative research should be deemed a way of understanding human experience and thus, optimal to analyze teachers' stories as it offers a means of hearing their voices and understanding their culture from their point of view. For Galvão (2005), "teachers not only bring to school a personal history which gives meaning to their actions but also live there a story which helps them give meaning to the world" (p.331). Thus, how teachers plan their lessons and the relationships they establish with students and other school agents can be seen as a way to reconstruct the history of their personal experience.

A focus group (Gatti, 2005) was chosen as it constitutes an appropriate means to give rise to our subjects' narratives. The following themes were proposed to correspond to specific actions making up teachers' schoolwork **1)** Pedagogical planning; **2)** Pedagogical practice in the classroom; and **3)** The evaluation of their work in school. Moreover, each of these themes refers to an *act* in Wertsch's perspective.

SUBJECTS

In total, 12 Science /Biology teachers in public and/or private schools in the state of Espírito Santo, Brazil, were invited to make up our focus group. However, our meeting was attended by only eight participants.

A meeting was held with participants on November 19, 2018, at the Universidade Federal do Espírito Santo campus in Goiabeiras, lasting about 1h50min. Participants' reports were recorded and then transcribed.

Out eight participants will be briefly introduced based on a questionnaire they filled out at the beginning of our focus group meeting. The names below are fictitious to preserve participants' identities. We should highlight that volunteers signed "informed consent forms," stressing our commitment to research ethics. Participants were allowed to make their decisions fairly and without constraints.

Chart 1. Characterization of participants

Research subjects	Age	Training	Professional experience	Institution(s) in which they work	Weekly workload
Ana	54 years old	Master of Education. Pedagogy and Licentiate Degree in Biological Sciences.	34 years	Public and private schools in Vitória/ES.	18h
Taís	24 years old	Graduate in Environmental Education and Methodologies in Science Teaching. Licentiate Degree in Biological Sciences.	4 years	Private schools. One at inner ES and two in the Greater Vitória/ES region	40h
Breno	27 years old	Graduate in Curricula and Education. Licentiate Degree in Biological Sciences.	6 years	Private school in the Greater Vitória/ES region	40h
Clarice	30 years old	Master of Animal Biology. Licentiate Degree in Biological Sciences.	3 years	State public school in Vitória/ES.	25h
Joice	28 years old	Graduate in Biological Sciences Teaching Methodologies. Licentiate Degree in Biological Sciences.	5 years	State public school in Vitória/ES.	40h

Research subjects	Age	Training	Professional experience	Institution(s) in which they work	Weekly workload
Denise	26 years old	Master of Education Graduate in Criminal Forensics. Licentiate Degree in Biological Sciences.	2 years	State public school in the Greater Vitória/ES region.	25h
Joana	25 years old	Graduate in Environmental Education. Licentiate Degree in Biological Sciences.	5 years	State public school in inner ES	25h
Guilherme	21 years old	Undergraduate student in Biological Sciences.	5 years	Private school in Vitória/ES.	20h

DATA ANALYSIS

By transcribing subjects' narratives, we found it difficult to dissociate them from their actions, i.e., as they discuss planning their classes, they also reported aspects of their practice in classrooms and how their work is evaluated.

Thus, in the light of Wertsch's mediated actions, we sought to find what cultural tools teachers used in their work—especially regarding planning, classroom practices, and the evaluation of their teaching actions—and the purposes for which they are used.

Then, the experiential knowledge teachers built by interacting with these tools during their actions in their institutional contexts was identified and characterized. Thus, the three main themes which were proposed and discussed in our focus group as structural categories of our analysis were used for evaluating teachers' reports and are shown below.

CULTURAL TOOLS AGENTS USE AND THE EXPERIENTIAL KNOWLEDGE EMERGING FROM THIS IRREDUCIBLE TENSION

First act – planning

Among the cultural tools subjects use to plan their classes, we highlight the following: oral discourse, WhatsApp groups, and electronic/manual agendas.

We found that teachers mainly use **discourse** in their interaction with other teachers and school agents at specific planning times. Joana states that

> *(...) I see planning as a moment of exchange, right? You talk to a chemistry teacher, with another sixth-grade teacher, right? I work with sixth grade 1 but the teacher of sixth 2 and sixth 3 is someone else. So, there is another rhythm... So, we exchange ideas, right? (...). I usually do a lot of practical chemistry classes, right? So, when we work on the chemistry of cells, a teacher will explain one part of the content and I will explain another (...) (Joana)*

As mentioned, Joana's narrative explains planning actions as it describes their performance. She finds that to be a common way to work. It includes exchanges between her peers which set appropriate opportunities for interdisciplinary experiences which she deems the purpose of planning. Dialogue, in this case, enables joint planning, an essential aspect to elaborate and execute interdisciplinary projects, as per Fazenda (2015). We should mention that Joana's school belongs to the state public system in which teachers from the same area—e.g., Natural Sciences—have common planning schedules to enable the exchange of knowledge

and practices of specific curricular components. As per Ryder (2017), internal contexts favor joint actions which the educational networks or schools that fail to either designate specific times for it or organize themselves for collective participation in them are often unable to observe.

Although the municipal public school in which she works has allotted time for planning, Ana's account evinces that teachers fail to engage in dialogue:

> *(...) we have five weekly hours of planning in municipal schools (...) in the afternoon period, we have a specific day of the week in which science teachers and those from another area suddenly hang out, right? And what I realize is that most of the time I sit there with other colleagues, and you even try to do something different "let's do something else with the class" [and they often respond] "I don't think so," I can't," or "I'm tired." And then we often might end up not planning as we should. This is a space the profession conquered for itself—I'm now talking about the public network—which actually ends up being used very little given what I'm talking about now. (Ana)*

Concrete working conditions—similar to Joana's report—overlap with teachers' personal contexts, i.e., their beliefs, values, and personal needs.

As per Wertsch (1998), the tension between agents and tools can change actions. We find that Ana and Joana intend to dialogue with their peers to innovate and plan interdisciplinary work with other teachers, but they face resistance from their co-workers, distancing them from the purpose or sense of collective planning.

Faced with this conflict of purposes, Ana believes that the space public teachers conquered finds itself scarcely used. She sees the act of planning and dialogue between teachers as a space in which they exchange experiences and strengthen their profession. Tardif (2014) states that the exchange of experiences and knowledge among teachers consolidates spaces of mutual training in which each plays the role of trainer and trainee. We found this aspect in another participant's narrative:

> *Planning in my school takes place every Wednesday (...) I was very lucky because, as soon as I came in, there was another biology teacher that welcomed me really well. At first, I had a lot of difficulty as I had gotten into Ufes in 2010 and left in 2017 with a master's degree with a vision like this. I took the Pibid, which helped me to have a notion of reality but [when] you have your classes, it's different. Then I would ask him "what do you think of me giving them [students] this assignment?" He helped me a lot. (Denise)*

Denise emphasizes the importance of the relationship she established with another science teacher at her school in the face of challenging moments right after beginning her teaching career. To overcome them, Denise shows the importance of listening to the other's experience to resignify her own experiences, such as those she developed during her initial training when she attended Pibid. According to Rodrigues et al. (2015), listening to peer practice is an indispensable resource for professionalization since the dialogue between teachers and their knowledge positively change their posture in the face of the challenges of daily school life. Although decisions remain subjective in particular contexts, Denise's narrative shows the importance of teachers sharing experiences to build the sociocultural space of schools.

The absence of time to plan and share experiences reinforces its relevance, as in the following reports:

> *As I work on the private and public networks, I say they are very different. So, in the private network, we do not have time at school to plan (...) our planning is all done outside class hours, although we receive for it in our wages, 15% of our salary is planning, right? So, I usually do my planning at home. (Ana)*

> *(..) teachers do not plan at school, especially because we have set class hours. So, most of the days I go, I give all my classes. I only have recess [for planning]. Naturally, I do my whole planning at home. (Taís)*

We found divergences regarding planning when we compared the organization of teaching across several professional contexts. For Wertsch (1998), "scenarios are a tool to interpret actions and their motives" (p.36). Thus, we found that the organization of planning in each school can interfere in this moment of interaction and dialogue between peers, instigating the production or use of new tools.

We found one way to try to fill teachers' lack of interactions at school during planning in some participants' narratives, such as:

> *I, as I have to leave early on Monday and Tuesday to attend Ufes, I can't be in all five planning classes with the other teachers. But we always meet in the corridors [of the school]. We formed a WhatsApp group because we (...) are very united in my school, so we always exchange ideas via the group. But there are teachers who have some difficulty with this technology stuff and WhatsApp, and they end up not participating much. (Joana).*

> *We have a working WhatsApp group. In addition to exchanging ideas, when a teacher misses work, they can share their [class] activity via the group. (Joice).*

WhatsApp groups enter the scene as a mediational mean that enables teachers to share ideas and support their work. However, Joana's narrative evinces that some teachers have limited use of this technology, thus failing to use this space as much as others. According to Wertsch (1998), agents, cultural tools, and the irreducible tension between them always have a peculiar past and always find themselves in a process of change, i.e., individuals have a particular history of experience with cultural tools which can offer an assessment of their development of this skill. For Wertsch (1998), the concept of mastery relates to subjects' ability to use cultural tools which research can evaluate by how aptly individuals use them, whereas the concept of appropriation refers to the process by which subjects choose and insert these tools in their actions. As the types of tools in subjects' actions depend on the sociocultural configurations of their environment, Oliveira and Mortimer (2020) argue that Transformations in the practice of teachers, especially those working with science, occur in the course of the historical evolution of both mediational resources and the development of their own skills in using them.

The situation Joana described also shows that the emergence of new cultural tools both enables and restricts action, as per Wertsch (1998). WhatsApp enabled the maintenance of dialogue among teachers who were unable to meet at their schools during planning. However, those who failed to appropriate this tool failed to interact in this new space of exchange. Thus, changes in work situations reshape teachers' knowing-doing, as per Tardif (2014), but if collective, institutional, teaching training plans fail to consider it, these changes may restrict themselves to individual domains or contexts.

Teachers must also deal with some institutional bureaucracies during planning, as the following narratives highlight:

> *(...) at my school, everything is very strict. So, we also have to be so and meet deadlines. There is no such thing as you not meeting a deadline. So, for example, lesson planning is done the year prior (...) I have to deliver the 2019 planning all ready and filled out for all classes by December 2018, class by class. So, we have to specify what will be done in each class (...) (Taís)*

> *In my school, it is like this, there are enabling teachers—which we are not—who prepare the course plan for the next year. I do my monthly planning at home based on this course plan, class by class (...) on the first business day of the month, it has to be posted in the system (...). Every day I fill something, manual agendas [...] we have manual agendas in the system, so why would I fill out manual agendas if I already fill electronic agendas? And it's a surreal deadline after another! (Breno)*

Breno and Taís work in private schools and show their intense bureaucratic demands. They enforce deadlines and their objectives and often fail to consider teachers' pace, time availability, and interests. Michel (2013) points out that the bureaucratic activities of private institutions fail to correspond to teachers' reality, occupying much of the time they would have for planning.

Other participants also found that the bureaucracy in private schools tends to be more rigid. Listening to Taís and Breno's narratives, Denise stressed that the requirements they described disagree with her school day-to-day and its conditions for planning classes:

> *I think it's kind of weird what you said about planning for the whole year in the previous year without knowing your classes. Because in state schools, guys, something happens every week. Paebes is tomorrow, so the class I planned for no longer exists. The other week I left early because it rained, this is how it goes. (Denise)*

Knowing the classes and dynamics of each institution is an essential condition for teaching. Internal contexts determine the specificities of the knowledge proper to the profession, which suffers interference from external contexts, i.e., the norms imposed on teachers' collective which are subordinate to private schools. Denise defends planning (and its materialization) as something flexible so it can adapt to the reality of each class and to the context of the public school in which she works. We observed, therefore, that agents grasp the meaning of contexts, which directly relates to how a mediational tool is used (Barcelos & Coelho, 2019; Wertsch, 1988;), in this case, their education plan.

Although private school teachers reported bureaucratic issues more often, some state public school teachers' narratives have shown that this issue negatively affects planning time at their schools. Joana points out that:

> *Bureaucracy takes up too much planning time. Is it important? Of course, it must exist (...) but there's got to be a moment reserved for that, not during planning. Having to keep filling out electronic agendas, weekly plans (...) some weeks I don't have time to look for something cool to do with my students. (Joana)*

We found that one of Joana's purposes when filling out plans, agendas, etc. includes responding to an external demand, as in the private school teachers' reports above. Although she highlighted the importance of bureaucratic procedures, her experience indicates that the essential thing would be to have a time reserved for such procedures since she is unable to achieve the main objective of her work—organizing and improving teaching and learning processes. On this aspect, Russo (2016) stresses that school planning in public institutions has configured a "bureaucratic procedure emptied of the meanings it could assume in schools" (p. 210), especially as a catalyst for collective reflections on themes permeating teachers' practice.

Second act - classroom practices

Among the cultural tools participants used in their classroom practices, we highlight multimedia resources (such as Datashow), materials for practical classes, and school curricula.

Multimedia resources clearly differ across public and private schools in view of the availability of financial resources of the latter, as in Breno's statement:

> *The school has a notebook for teachers who want to use in their classrooms, a Datashow, resources for us to use. Private schools always have them, right? So, if we want to do something unusual with Datashow, a different class, we can. (Breno)*

However, teachers' ownership, mastery, and appropriation of these resources fail to guarantee their adequate mediation, as Taís points out:

> *Parents will argue about it, just like in Linhares, parents do not like (...) they do not like that you are using Datashow in your class because, for them, teachers who use Datashow do not know their subjects (...) but there is school in which I work much more with Datashow ([a] much more visual [resource]), I find Cariacica much more visual than Linhares. Now, in Linhares, parents like the student there with the blackboard, blackboard, as do students. (Taís)*

Oliveira et al. (2019) state that "for teachers to succeed when using mediation, it is necessary that they offer real opportunities for the production of meanings and sharing of meanings" (p. 271). In the situation Taís described, we can claim that the relationship between the agents both in classes and also the school community (including family members) either enhances or restricts tool use. Teachers find that the use of a tool in their classrooms depends a lot on internal contexts, i.e., relationships between subjects and the social context of the those with whom they coexist in schools (which are based on their values, beliefs, and purposes).

Wertsch (1998) stresses that "the use of a particular mode of mediation generally depends on other factors related to history and cultural or institutional power and authority" (p.76). Hence the importance of always considering scenarios in the analysis of agents acting with cultural tools given the inseparable relations among these elements. Thus, despite the availability of a cultural tool (Datashow) in the private schools in which Taís works and her ability to use them, Taís uses it in a context (the school in the municipality of Cariacica) and refrains to do so in another (the school in the municipality of Linhares) mainly due to her students and their parents' opinions. This shows that dominating a cultural tool often fails to entail its appropriation (Wertsch, 1998) and that, when acting, teachers consider several conditions to structure and guide their professional practice (Tardif, 2014).

For Taís, using this cultural tool is associated with adapting to institutional contexts. This agrees with Gama (2015), who stresses that teachers often seek to maintain the teaching practices already inherent and characteristic of the institutional culture around them due to the opinion of the school agents involved in their actions, such as co-workers and students and their families.

Regarding **materials for practical classes**, we note that they feature more often in private schools due to their space and resource availability, as Breno points out:

> *At my school (...) there is a microscope, and it's easy to give practical classes. (...) There is glass equipment, behind it, reagents. There was a new laboratory with thousands of reagents (...) what I think is important in having all this is that we can instigate students' curiosity in addition to this issue of relating theory and practice. (Breno)*

As Wertsch (1998) points out, "the quality of the action is implicit in the quality of the scenario (context)" (p.36). So, according to contexts and objectives, actions acquire specific contours (Roldi et al., 2018). Breno thinks it is important to arouse students' curiosity, finding practical classes an effective way to do this. Andrade and Massabni (2011) highlight that practical school activities to promote students' scientific thinking is a pedagogical decision that depends not only on teachers but also on institutional conditions. However, these authors believe that if teachers value practical activities and believe they promote the effective learning of sciences, they will possibly seek ways to develop them in schools and overcome possible obstacles. Regarding this, we highlight Joana's narrative:

> *(...) I was a teacher before my master's degree. After I came [into the schools in which I work] I changed as you start to see other things, to talk to other people. So, that opens our mind, and we start thinking more about our practice. Today I try to promote more investigative practices with my students, even if the schools lack recourses as we do not have a laboratory, but I know that we do not need this for a practice to be investigative, it facilitates it, but it is not necessary. So, I try to innovate (...). (Joana)*

For Tardif (2014), when teachers develop their classes, they make personal judgments about how they should act, evaluating the beliefs, values, and knowledge they acquired in their initial or continuing training and in professional practice. Joana states that having entered a master's degree course made her rethink her daily practice and understand the importance of promoting investigative practices with her students, an aspect which made her overcome some difficulties, including the absence of a laboratory. Her attitude shows the influence of personal contexts, i.e., in their pedagogical practice, teachers resignify the several formative experiences they experience throughout their professional career (Roldão, 2005; Tardif & Raymond, 2000; Tardif, 2014). Thus, we agree with Nóvoa (2017) , who argues that teaching should be built within the profession.

The situation Joana described also shows that, as per Wertsch (1998), new mediational tools can transform mediated actions. The new cultural tools Joana introduced to her classrooms and agents' use (teacher and students) changed her teaching practice. However, this fails to mean that the only way to introduce change is via new cultural tools since these can also arise by "a variation in skill levels and other facts related to agents" (Wertsch, 1998, p. 77), i.e., the resignification of the use of mediating objects in science/biology teachers' actions can enhance the real capacity of resources to participate in the process of knowledge construction (Oliveira et al., 2019).

Teachers also use **school curricula** as a tool to guide their practice, as below:

> *I think the issue of pedagogical practice is also very motivated not only by what you care about, your students learning but also by what is objective, the mission of the school, what is in its curriculum. I see that a lot in the contrast between public/private schools. In public schools, if you (...) want to play a movie, that's fine, if you want to use a very cool practice for them to learn more, that's fine too, because you have more autonomy. Not so in private schools. In private schools, you are under great pressure (especially from families), and you have to find a way to account for all the content in the curriculum. (Guilherme)*

> *So, I find public schools differ from private ones because I work in both. In the public schools, it is like this: "I do not know botany, so I will not teach botany" (...) Now if I'm on the private network and management comes to you and says, "you're going to teach genetics," girl, you either handle it or you'll get fired. If a student asked you a question, you have to know the answer, if he realizes that you do not know it, a month from now (...) you will lose your job (...) But, at the same time, in the public school, I can work more often how I think best, adapt what I think I have to, private schools do not have as much flexibility. (Ana)*

The comparison between public and private schools evinces the internal aspects affecting teaching; in this case, curricula. Teachers' narrative contrast their autonomy to teach programmatic contents. While in private institutions teachers need to fully comply with the content provided for in curricula, especially because family members exert pressure toward it, in public schools, teachers report greater autonomy, enabling them to make the necessary curricular adaptations to contemplate the particularities of their classes. Similar to the results in Oliveira and Mortimer (2020), teachers' narratives shows that their concern with students' learning is one of the reasons transforming their pedagogical actions, although again under tension due to internal contexts, represented especially by families and what teachers understand as autonomy. Ana believes that teachers, by using this autonomy in public schools, can compromise the learning process to the extent that they choose on their own to avoid working certain contents in school curricula.

This indicates that, in teachers' opinion, autonomy is a "doing by yourself." However, as Monteiro et al. (2010) point out, "one cannot analyze autonomy from an individualistic or psychologist's perspective" (p. 119) since, as moral values, autonomy should not be considered an individual capacity but rather a collective construction. From this perspective, Nóvoa (2017) deems it important to recognize the collective dimension of the teaching profession to find that some knowledge and responsibilities avoid ending in an individualized understanding of teachers' work.

Third act - the evaluation of teaching actions

Among the cultural tools participants and other school agents use to evaluate teaching actions, we highlight self-assessment and students' discourse.

Regarding **self-assessment**, all volunteers reported reflecting on their own practices to find failures and improve their attitudes and methodologies in their classrooms, as per the following excerpts.

> *I reflect, I try to recognize my flaws. So, I reflect really deeply, including what I think worked. (Joana)*

> *(...) I always evaluate myself throughout the day and reflect on what was good or bad to try and always grow as a professional and improve my practices. (Taís)*

> *I also have this thing of evaluating myself, of also acknowledging what I have to change in my practices (...). I have to do my job as best as I can (...) because I know the responsibility and weight of my work. (Breno)*

> *I try to evaluate myself by the feedback my students give me. I shape myself as I reflect on that. (Clarisse)*

Cassettari (2014) claims self-assessments consist of a process in which teachers evaluate themselves and must offer value judgments about their own actions. Thus, as teachers critically analyze their pedagogical practices, they become aware of the required improvements in their work.

We should also stress that moments of reflection culminating in teachers' self-assessment often take place collaboratively, i.e., with their co-workers. We can see this in Guilherme's narrative.

> *Self-assessment is also a collaborative work, at least I find it so. (...) Among biology teachers, one can help another see things in practices that we alone can't. (Guilherme)*

Guilherme shows an openness and receptivity to criticism or suggestions from colleagues and vice versa, enriching this moment of shared reflection. For Lima and Santos (2017), spaces of collective reflection among science teachers is a way to highlight different possible solutions to problems common to the group, developing teaching knowledge (Tardif, 2014) and strengthening their profession (Nóvoa, 2017).

Teachers also use **students' discourse** to evaluate their work. When using it, teachers mainly seek to identify which aspects of their practice students deem good or bad, as per the narratives below. We also observed that some teachers seek to create a relationship of exchange and trust with their students and give them more autonomy:

> *In terms of evaluating my practice, I do this to the extent of the bonds that we create with students. We can see their reactions (...) (William)*

> *They take 10 students, and they evaluate the teachers. (...) Then, we see what they like or not and that dictates a lot of our work in the private network because, like, they talk about the good and bad things in our practice and coordination and direction know. (Breno)*

> *The students do polls and when a teacher poll pops up, the first thing they say is "teacher with a good blackboard, gives a lot of content on the blackboard, content within the schedule" and so on (...) "The teacher only teaches with Datashow." From there, I see what they consider good or not in practice and this interferes a lot because it is private school, right? (Taís)*

> *The movement I make is like this: I ask students to evaluate me (...) and I leave possibilities open (...) I think this is important because students start to see that we care about what they think and it's a way for us to establish a relationship of trust with them. (Joana)*

An interesting aspect in Breno and Taís' narrative is that they highlight the idea that students' assessments of teachers dictate their work. This agrees with Naiff et al. (2010), who claim that:

> What we see in private schools is students as the center of the process; satisfying it is the origin and result of all actions. Private schools are also attuned to market demands. In this type of school, the field of forces always tends in favor of the clientele (p. 59).

Thus, the situation teachers reported informs us of how power and authority forces surround mediated actions. For Wertsch (1998), the question of power and authority may relate to a certain authority agents enjoy to discuss a particular subject in the context surrounding them. Thus, the two teachers' narratives seem to describe this property of mediated action as they show that students use a discourse of power in the private schools in which they work.

Wertsch (1998) stresses that the cultural tools subjects use are material. Although the materiality of items such as computers, books, and objects for practical classes is quite evident—since they constitute physical objects we can manipulate —, this same property is less obvious when we consider cultural tools, such as discourse and language (Oliveira, et al., 2019). For Wertsch (1998), materiality characterizes all mediational means as their form of use changes the agents participating in the actions, as per teachers' narratives.

Given the above, we found that agents use cultural tools in our three proposed acts - planning, classroom practices, and evaluation of teaching actions - to achieve several goals. This agrees with Wertsch (1998), who stresses that the mediated actions and mediational means agents use follow an organization into multiple purposes, rather than a single one. The author states that finding a single purpose in an act indicates that researchers used a single point of view during their analysis and failed to consider the context (scenario) in

which acts took place since, for Wertsch (1998), "scenarios usually suggest or delimit the objectives which will be pursued in them" (p.60). Thus, as teaching actions are performed, they gain multiple goals (purposes) according to the forms of use of each cultural tool within institutions.

For Tardif (2014), experiential knowledge encompasses teachers' knowledge, competencies, skills or abilities, and attitudes from which they interpret, understand, and guide their profession and daily practices. The author also states that one of the main research strategies associated with this assessment of knowledge is to create possibilities for subjects to talk about "their reasons for actions or discussions, that is, ultimately of the knowledge on which they base themselves to act or discuss" (Tardif, 2014, p. 200). The author adds that studying the reasons for acting enables research to reach subjects' knowledge. We argue that teachers' goals reflect their experiential knowledge since they show why agents use certain mediational means in the tensions within their work contexts (Wertsch, 1998), constituting the knowing-doing and the teaching knowledge mobilized in these institutions (Tardif, 2014).

The following table summarizes and relates the experiential purposes/knowledge in the narratives of the teacher subjects in this research as they use mediational tools in the three analyzed acts.

Chart 2. Cultural tools used in teachers' professional practice and their experiential purposes/knowledge

	CULTURAL TOOLS	EXPERIENTIAL PURPOSES/KNOWLEDGE
1st ACT: Planning	Discourse	Planning interdisciplinary work. Exchanging ideas and experiences with peers and strengthen themselves professionally. Listening to others' experience to resignify their own.
	WhatsApp groups	Alleviating the lack of encounters between schoolteachers. Exchanging ideas and experiences with peers.
	Electronic/manual agendas	Meeting the institution deadlines. Organizing discipline contents.
2nd ACT: Classroom practices	Multimedia resources Datashow	Doing uncommon activities with their classes. Adapting to their institutions. Distinguishing planning and bureaucracy time.
	Materials for practical classes	Encouraging students to bring theory and practice closer to each other. Arousing students' curiosity. Promoting investigative practices.
	School curricula	Adapting program content according to the needs of their classes and institutional demands. Establishing connections among curriculum content and other disciplines. Surveying students' previous knowledge.
3rd ACT: Evaluation of teaching actions	Self-assessment	Recognizing failures in their own practice. Sharing criticisms and suggestions for methodologies and practices with peers.
	Students' discourse	Finding positive and negative aspects in their classroom practice. Creating a relationship of exchange and trust with their students. Stimulating students' autonomy.

As we argue that experiential knowledge stems from the irreducible tension between agents and their cultural tools within their institutions, we highlight the interactive character of this knowledge, as Tardif (2014) states:

> Rather than constituting intimate objects populated by mental representations, teachers' knowledge is always linked to a work situation with others (students, colleagues, parents, etc.), a knowledge anchored in a complex task (teaching) within a workspace (classrooms, schools) and rooted in an institution and in a society (p. 15).

Thus, from our analysis of the knowledge we found, we stress that teachers' educational acts encompass several ways of acting which they mobilized in their practice. Roldão (2007) deems the action of teaching an intelligent one, founded on a secure domain of knowledge, i.e., knowing how to teach. She defines knowing how to teach as "making someone learn something" (Roldão, 2005, p. 117). For her, recognizing that teachers have specific knowledge is an important element to develop their professionality. Roldão (2007) also points out that knowing how to teach, as a professional knowledge, is a composite knowledge, rather than a singular one.

> It emerges from several forms of formal and experiential knowledge, which a few professionals further develop and question. It only becomes a professional knowledge when and if teachers recreate it by mobilizing a transformative process in each pedagogical, contextual, practical, and singular act. In each single situation, professionals must know how to mobilize all the knowledge they had acquired, transforming it into the foundation of informed action, i.e., teaching as a process to build learning in others and by others, constituting an art and a technique based on science (p. 101).

For the author, experiential knowledge makes up teachers' knowing-doing. This agrees with Tardif (2014), who points out that "what we call the knowledge of teachers or knowing how to teach should be considered and analyzed according to the types of action present in practice (...) knowing how to teach refers, therefore, to a plurality of knowledge. (Tardif, 2014, p. 177), as evidenced in this synthesis. For our focus group, teaching seems under tension due to how public and private schools differ regarding norms defining time for planning and that for bureaucratic procedures; their resources to conduct their classes; relationships between teachers and their peers and with students and their families; and teachers' mastery and appropriation of new mediational tools.

FINAL CONSIDERATIONS

We sought to understand how school contexts influence the construction of science/biology teachers' experiential knowledge. We found that the institutionally organized time dedicated to teachers' work planning can influence the moment they share experiences with their peers, affecting how they plan their interdisciplinary work and how they may share their reflections. Another experiential knowledge we found includes the absence of such time in private schools (or in public ones with reported fragmented planning schedules), which can influence teachers' relationship with their co-workers, causing them to seek alternatives for such encounters.

School resources influence the development of teaching practices as they enable/limit science/biology teachers' mediated actions in these contexts. However, even if some schools had many available resources, the choice of their use may relate to discourses from other subjects who interact with teachers, such as students or their relatives. Some teachers find that appropriating a certain tool, despite its predominance, depends on such interpersonal relationships and certain school agents' power and authority discourses.

This may weaken teachers' autonomy, compromising teachers' decisions over their professional activity and negatively interfering its construction.

School bureaucracy also compromises teachers' autonomy. The prescriptive attitude that necessarily falls on teachers' tasks and educational content takes much of their planning time and may stiffen their class/education plans. This may influence their work as teachers must adapt program contents according to class needs in each institutional context.

Although we found that private schools had more abundant material resources and that their student families more often influenced school dynamics—whereas public schools showed poorer material resources and that their teachers enjoyed greater freedom to adapt curricula —, we neither can nor aim to categorize these institutions. Each context is unique as are school agents' relationships and teachers' backgrounds; the latter resignified by their professional actions.

Action mediated as a unit of analysis was fundamental to evaluate the several "paths of the middle," i.e., the interactive processes and the tensions between teachers and the cultural tools they use in different contexts in the three acts in this research. We believe that our analysis can support future investigations on how mediational means influence teaching relationships and the construction of its knowledge as these interconnected aspects remain scarcely explored in the literature.

Finally, we highlight that teachers share their experiential knowledge despite the unique contexts of their work and the several moments of their career. Thus, we suggest that training programs for science/biology teachers must mobilize and further discuss this knowledge (belonging to knowing how to teach) as it may contribute both to the teaching-learning process and to the construction of a teacher professionality.

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