

Benefits and challenges of collaborative work in the teaching of Mathematics in the Pedagogical Residency Program

Benefícios e desafios do trabalho colaborativo no ensino de Matemática no Programa Residência Pedagógica

Beneficios y desafíos del trabajo en colaboración en la enseñanza de Matemáticas en Proyecto Residencia Pedagógica

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Abstract

As is pointed out in the literature, collaboration between teachers and other members of the school community not only enhances the teacher's education, but also leads to better student learning. However, it is not always easy to work in partnership, because this requires constant evaluation and the ability to take account of different opinions. For this reason, this study involves an investigation of the benefits and challenges of collaborative work, carried out by the Faculty of Mathematics at the Federal University of Pará, within the scope of the Pedagogical Residency Program, and under the supervision of a preceptor and three residents. Our methodology entailed conducting semi-structured interviews and the results of our analysis showed that the Pedagogical Residency was a means of providing new ideas for the teaching activities of the field schools. It also revealed that the different players involved had difficulty in understanding their roles, when dealing with a new project that is carried out in Brazil.

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Keywords: Collaborative Work; Teaching of Mathematics; Pedagogical Residency Program

Resumo

Conforme aponta a literatura, o trabalho colaborativo entre professores e outros membros da comunidade escolar não só enriquecem a formação do professor, como contribuem para um melhor aprendizado por parte dos estudantes. Por outro lado, nem sempre é fácil realizar trabalhos em parceria, porque exigem constante avaliação e a habilidade de lidar com diferentes opiniões. Nesse sentido, no presente trabalho apresentamos uma investigação sobre as contribuições e desafios do trabalho em colaboração, desenvolvido pela faculdade de matemática da Universidade Federal do Pará, no âmbito do programa Residência Pedagógica, na percepção de um preceptor e três residentes. Para tanto, realizamos entrevistas semiestruturadas e nossas análises apontam que o Residência Pedagógica contribui com novas ideias para as atividades docentes da escola campo e revela a dificuldade dos atores em compreenderem seus papéis, tendo em vista tratar-se de um programa novo desenvolvido no Brasil.

Palavras-chave: Trabalho Colaborativo; Ensino de Matemática; Programa Residência Pedagógica.

Resumen

Como se señala en la literatura, la colaboración entre docentes y otros miembros de la comunidad escolar no solo mejora la educación del maestro, sino que también conduce a un mejor aprendizaje de los estudiantes. Sin embargo, no siempre es fácil trabajar colaborativamente, porque requiere una evaluación constante y la capacidad de tener en cuenta las diferentes opiniones. Por tal motivo, este estudio involucra una investigación de los beneficios y desafíos del trabajo colaborativo, realizado por la facultad de matemáticas de la

Universidad Federal de Pará, en el ámbito del programa de Residencia Pedagógica, y bajo la supervisión de un preceptor y tres residentes. Nuestra metodología implicó la realización de entrevistas semiestructuradas y los resultados de nuestro análisis mostraron que la residencia pedagógica fue un medio de aportar nuevas ideas para las actividades docentes de las escuelas de campo. También reveló que los diferentes actores involucrados tuvieron dificultad para entender sus roles, considerando que es un nuevo proyecto que se lleva a cabo en Brasil.

Palabras clave: Trabajo en colaboración, Enseñanza de matemáticas, Proyecto Residencia Pedagógica

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According to assessment schemes such as National Basic Education Assessment (SAEB)⁴, it is common for students in Brazil have difficulties in learning Mathematics. At the same time, research indicates that teacher education still needs to be more advanced, whether about mathematical content, pedagogical practices, or inclusion of people with disabilities, etc. (Giraldo, 2018).

The Brazilian educational policy approved the National Common Curricular Base (BNCC) for Elementary Education in 2017 and for Secondary Education in 2018. This is a Brazilian normative document that defines the essential learning at each level of Basic Education. Even though it has been approved without a wide discussion, especially with regard to secondary education, and finds criticism and difficulties in implementation, the BNCC is the document that guides the skills that students from all over Brazil must develop, as well as training initial and continuing education of teachers.

The BNCC in its 4th General Competence emphasizes the importance of students using different languages such as verbal, corporal, visual, sound and digital to express themselves and share information and experiences. These and other communication-related skills can be developed through collaborative work.

The implementation of BNCC in Brazilian schools poses challenges for teachers and researchers who must seek alternative methods of overcoming the difficulties encountered in teaching mathematics in our schools. Among a number of suggestions, collaborative work has attracted a good deal of attention, as it combines improvements in students' learning, with a means of enhancing teacher training (Gideon, 2002, Ronfeldt, Farmer, McQueen & Grissom, 2015).

⁴Basic Education Assessment System (*in portuguese*): <http://portal.inep.gov.br/educacao-basica/saeb>

At the same time that public policies are valued for valuing education in the country, there is an expectation that universities will bring solutions to the difficulties of teaching and learning mathematics, either through their research or through the need for better training in the future teacher in undergraduate courses. As pointed out by researchers such as Gatti (2008) and Fiorentini (2008), investing in initial and continuing teacher education is essential for improving the quality of teaching. Alonso-Sáez, Darretxe & Beloki (2019) note that although interest in collaborative work has grown, research on this topic involving the academic level is still scarce, demonstrating the need for further research that points out alternatives for its implementation and development.

The Pedagogical Residency Program (PRP) launched by Coordination for the Improvement of Higher Education Personnel (CAPES⁵) in 2018 is a national program that aims to improve the initial training of basic education teachers through immersion and experience in schools. Among the graduates' actions are classroom conduct and pedagogical intervention.

Within this context, we seek to answer in this article: What are the contributions and challenges of the collaborative work developed by the Faculty of Mathematics of the Federal University of Pará and three state public schools, within the scope of the Pedagogical Residency Program? With the aim of discussing the benefits and challenges of the collaborative work carried out by the Pedagogical Residency Program included in the Mathematics Degree course, at Federal University of Pará (UFPA), Belém-Pará-Brazil. For that, we report examples of some of the activities that were developed, and the improvement attained, as well as analyze the excerpts of the interviews with preceptors and residents, to evaluate the success of our attempts.

⁵ In portuguese: <https://www.gov.br/capes/pt-br>

The Pedagogical Residence Program in the Bachelor's degree course in Mathematics at UFPA

The collaboration project we are carrying out, is part of an institutional UFPA scheme that emerged from a declaration made by CAPES (06/2018). This is called Pedagogical Residency and is the first national project of its kind. The objective of the project is to optimize the training of future Mathematics teachers and, at the same time, to cooperate with the field schools in establishing the new common base that has been approved for Brazil. Our residential operations center is situated in three (3) schools of the public network, in the city of Belém, Pará State (Amazonia) Brazil.

Our project team members are:

- Three (3) supervising teachers (counselors), who are university lecturers in Mathematics. One of them is a project fellow. One of the teachers does research in the area of applied mathematics, another in the area of pure mathematics and another in the area of mathematics education. All three run teacher-training courses at UFPA;
- 3 preceptors (facilitators), each of whom is a teacher in one of the schools in the project. All three are scholarship holders;
- 30 students (residents) doing the Mathematics Degree course at UFPA, 24 of whom are scholarship holders and six volunteers.

How does the collaborative process take place?

The Role of the Teaching Staff:

- The counselors form a link between the university and school administrators. They must discuss with the managers the role played by the preceptor and the residents within the school. It is imperative for the project to be carried out in a way that benefits the school community.

- The supervisors are responsible for providing the preceptors with the necessary training to work with the interns. They must offer courses and seminars in which teaching theory is discussed and new theoretical, practical and technological resources for classroom work are introduced. (In fact, for the preceptors, the pedagogical residency program should be an opportunity to improve his/her practices.)
- They must have periodic meetings with the preceptor of each school, so that they can provide the residents with clear and objective guidance, and also to allow the preceptor to report on the progress of the project. The counselors and preceptors should work together to assess the results of the different activities carried out by the residents, and recommend new tasks.
- They should incorporate periods of “socialization” for the residents of the three schools, to enable them to learn about the activities that have been undertaken. This should include addressing areas that may have given rise to problems and discussing ways of tackling them.
- They must encourage the residents to conduct diagnostic tests and learn how to interpret the data obtained from the activities carried out in school.
- They should offer guidance to residents about how to produce academic papers for publication.

The Role of the preceptors:

- Helping resident’s adaptation to the life of the school community Assisting the residents during the first phase of the project, which involves observing the school activities.
- On the other hand, the preceptors, after using these resources in the school with the help of the residents, must inform the advisors which practices were the ones to get

the best results in the students' learning. Then, preceptors and advisors, will be able to discuss, think and write about it.

- The role of preceptors is also to point out deficiencies in the resident's formation, so that advisors can promote a discussion about professor's practices and the revision of the pedagogical political project.
- Helping the students to conduct diagnostic tests.
- Offering guidance to the residents when planning and taking interventionary measures within the school.
- Evaluating the residents performance and the results they obtained. Informing counselors of any unusual situations involving trainees.

The Role of the Residents:

- Finding out how the school operates and integrating its activities.
- Establishing the kind of difficulties that the students of the school face when learning mathematics.
- Drawing up an intervention plan to help the students overcome their difficulties.
- Carrying out strategic tasks and assessing the results.
- Writing about their experiences during the project.

Such tasks made up our activities, which brought benefits to the learning of Mathematics and to the academic training of those involved, as we will see. First, let's see what the literature says about the relevance and challenges of implementing collaborative work.

Conducting collaborative work according to the literature

Regarding teacher training, the researchers seem to agree about the need to improve teacher training in order to achieve better results in student performance. Fiorentini (2008)

notes that a solid scientific-cultural background is not enough, it is necessary for teachers to investigate and reflect on their practice. One of the ways to develop this type of activity is through collaborative work.

Although there is no formula or single way to carry out collaborative work, there seems to be no doubt that peer collaboration leads to improvements in: a) teaching institutions, b) the training of the professionals involved, c) the goals they share and d) in interpersonal relationships (Gideon, 2002, Boavida & Ponte, 2002, Cramer & Stivers, 2007, Ronfeldt et al., 2015, Alonso-Sáez, Darretxe & Beloki, 2019).

Alonso-Sáez, Darretxe & Beloki (2019) point out that collaborative work provides the necessary stimulus and assistance so that the teacher can develop academically, learning more in the moments of collaboration compared to the activities carried out individually. However, this way of working can bring new challenges to the teacher:

The most obvious difficulty is that we cannot change from day to night, the way that teachers have been working and understanding the teaching profession for decades: inertia is inevitable and comparing – sometimes arguing – what we may lose with this new way of doing, may arise as an obstacle (Alonso-Sáez, Darretxe & Beloki, 2019, p. 7).

This is particularly the case of teachers who usually talk about everyday subjects, but are not in the habit of exchanging experiences about the classroom, which means that isolated work is common, sometimes under the pretext of respecting their right to autonomy (Gideon, 2002). Another difficulty pointed out by Alonso-Sáez, Darretxe & Beloki (2019) and Fiorentini (2008) is the risk of wear and tear due to the excess of activities and meetings held during the collaborative work. In general, teachers have an exhaustive workday and few resources to pay for their studies, such as attending events or buying books. It is necessary to know how to manage time to plan tasks well, so that participants are not overwhelmed and do not compromise other professional or personal activities.

As Cramer & Stivers (2007) argue, collaboration in the context of schools has long ceased to be based on a simple "ingredient", such as an insignificant factor that depends on subjective desires. In relation to teacher training that takes place in collaborative activities, Heck, Bacharach & Dahlberg (2008) highlight the enrichment of their teaching strategies, the discovery of new teaching materials, the discovery of new methodological resources, as well as the development of a critical and reflective look at teaching practice. Such aspects have a consequence in the learning of their students, which corroborates Ronfeldt et al.'s (2015) statement "the more there is collaboration in the school, the greater the amount of student learning achieved".

From our tradition of working in a solitary way, it can be expected that we may feel not confident when working with someone else. As Cramer & Stivers (2007, p.7) point out, "Fortunately, the skills needed for successful collaboration can be learned" that is, learning how to collaborate can be acquired through dialogue, negotiation, and adjustment.

By bringing together a wide range of people who can interact, enter into a dialog and reflect together, synergies are created that allow for an increased capacity for reflection and an increase in the opportunities for mutual learning. This allows teachers to go much further and create better conditions for their students to successfully face any uncertainties and obstacles that might arise (Boavida & Ponte, 2002, p. 45).

It is thus the sharing of learning, exchange of experiences, communication, negotiation, and dialogue, which are the collaborative activities that are carried out within the scope of Pedagogical Residency. These can enable us to investigate the benefits of collaborative work in what concerns the training of the teacher (preceptor), future teachers (residents) and students learning.

Activities developed and improvement in student performance

Here we would like to present two examples of activities developed in collaboration within the Pedagogical Residency, in two different schools, pointing preliminary results regarding the students' performance and the relevance of the tasks performed.

In our first example, in school A, activities were proposed to retake the mathematical contents of Basic Education (addition, subtraction, multiplication, division, potentiation, rooting, numerical expressions, fractions, rule of three and fundamental geometric concepts). As is well known, it is common for high school students to have difficulties with basic mathematical concepts, which compromises their performance in the following school years. This activity was performed by the residents, under the guidance of the supervising school teachers.

In this sense, a diagnostic evaluation was initially performed through a test in order to investigate the main difficulties faced by these students. During the months of April and May of 2019, the 120 students of the first year of high school of this school received classes with diversified methodologies, involving lectures and dialogues, the use of games and mathematical objects, working the mathematical contents mentioned. There was a total of eight lessons, each 45 minutes long, taught at four different opportunities.

Then, a new test was applied, pointing the progress regarding students' performance, as follows: in the first test, 19.16% of the students obtained a minimum score (zero). In the following test, the minimum grade was 2.0. Regarding the maximum grade, there was an increase: from 8.75 to 9.5. Considering the simple arithmetic mean obtained in both applications, the values are 3.06 (first application) and 5.95 (second application), an increase of more than 94%.

As it turns out, the work of the residents brought a significant advance regarding student performance, which should not be limited to the performance on the applied test.

In our second example, at school B, activities were conducted with a mobile app to improve students' skills in solving equations in a 9th grade elementary class with 26 students. Again, residents under the supervision of the preceptor and the mentoring teachers performed the task. This development was due to the difficulties presented by the learners in the mentioned

content, as well as the observation that they used their smartphones in school, but not in school activities.

Initially a diagnostic evaluation with five questions was performed, pointing out the great difficulty of the students, despite the fact that they had already done several activities considered conventional, of exercise resolution. Then, through the MIT App Inventor 2 platform, an application for solving the 2nd degree equations was created, which was called the 2nd degree calculator, to assist students in their studies. This platform addresses the programming language through logic by assembling blocks that fit together, resulting in the commands that will determine the actions of the application.

The application was made available to students, who used it during the following fourteen classes, taught by their teacher. After this development, a new test with five questions was applied to the students in order to assess their progress, with an average growth of 58.8% in grades. Thus, this activity served as a positive experience, emphasizing how important it is to intervene in order to use technological means such as software and applications, and to define a good way to use the smartphone inside the classroom.

The results achieved in the two mentioned examples show the relevance of collaborative work in the Pedagogical Residency Program, in view of the exchange of experiences of the various actors. As Redmon, Brown & Sheelhy emphasize:

Learning about the teaching of mathematics occurs most productively when the professional audience is diverse and includes both local community members of teachers and others, such as university academics, whose taken for granted perspectives suggest novel ways of 'seeing' and interpreting the local practices. (Redmond, Brown, & Sheehy, 2011, p. 655).

As we will see below, in the statements of the interviewed residents and preceptor, both enrich their training with shared experiences: residents bring suggestions for new teaching methods and tools, while the preceptor collaborates with their teaching experience, culminating in improved school performance, regarding the learning of mathematics by their students.

Methodology and research tools

The research was qualitative (Gil, 2008) and included semi-structured interviews, which were conducted as follows: i) with one of the preceptors, called Jocimar - who was enthusiastic about making a contribution to the research project and appeared to be very much at ease when expressing his opinions - and ii) with three residents, called Renan, Silvano and Yuri, who assisted this preceptor. For our analysis we use Content Analysis (Bardin, 2015), organizing our reflections on the contributions and challenges that emerged during the performance of cooperative activities. The initial draft for the interviews contained the same questions, and was designed to reflect the attitudes to the Pedagogical Residency Program from different standpoints. The interviews were recorded on audio with the interviewees' authorization.

The significance of the pedagogical residency program from the standpoint of the preceptor and residents

Here are some excerpts from the interviews that we believe are of value in achieving our objective, together with a brief analysis conducted by the authors of the importance of collaborative work.

In the first question, on the significance of the Pedagogical Residency, the opinions of the residents are given in the following excerpts:

Interviewer: In your opinion, what is the importance of the Pedagogical Residency Program?

Yuri: The PRP is a different experience from all the others we have inside the University, because it gives us an experience of the school. In the other programs, even though there were practical subjects (like workshops), they did not prepare us as well as the PR. When we had to go to the classroom and do activities...we obtained useful experience there

Renan: PRP broadened the scope of the Internship, by giving us useful knowledge and experience.

Silvano: In PRP we were able to be active players, not just sit and watch. We trained to teach classes, having feedback from the students and the school teachers.

About this question, the residents highlight the importance of PRP as a way of experiencing teaching practice in a supervised and collaborative way, unlike having theoretical discussions in the classroom. It also upgraded the supervised internship, having the opportunity to actively participate. They improved their teacher-training through an exchange of experiences with school teachers. Such reports are not surprising if we observe the results of research on collaborative work, which generally indicate approval by the participants, for noticing their learning and professional advancement. (Boavida & Ponte, 2002, Redmond, Brown, & Sheehy, 2011, Keevers et al., 2014, Heinrich, 2015).

In the second question, about the collaborative process between the different actors, we have included some excerpts from the responses of the preceptor and one of the residents:

Interviewer: How do the different "actors" of this project (the preceptor, resident and guiding teacher) influence this collaboration?

Jocimar: The resident has this exchange of experiences with the school, as well as introducing the ideas of the university and we end up with an awareness of our reality [...]. This helps in improving the school and also his own view of education that sometimes ... as I always tell them, what we see in university in theoretical terms is one thing, it is different when we come to practice; we have to adjust our ideas [...]. This exchange is useful for the resident because he is getting ready for challenging situations.

Renan: At first, we had problems to understand the difference between the Internship and the PRP. Maybe we should have more meetings with the counselors, because sometimes the meetings with the preceptor included issues that nobody knew about, and we were in a state of uncertainty.

As the preceptor stated, the exchange of experiences was the main influence exerted by the various actors who took part. The emphasis was on the collaboration between the residents and the school teachers, and how this enhanced the views of each collaborator with regard to education and the teaching of Mathematics. As Cramer and Stivers (2007, p.10) explain, "Collaborative relationships can be a rich source of professional and personal growth, well worth the investment of time and effort that may be necessary to nurture them" by putting into practice the principles and methods that are taught in pedagogical theories. Tendo em vista a

troca de experiências, o trabalho colaborativo proporciona possibilidades de inovar e desenvolver a criatividade pelas diferentes ideias envolvidas (Alonso-Sáez, Darretxe & Beloki 2019).

However, the residents reported a problem regarding the lack of information, which they say could have been overcome by having more meetings with all the participants. Because of the innovative character of the PRP, some information requested by the residents, in fact, caused uncertainty among the whole group. This obstacle was also pointed out by the preceptor Jocimar and will be discussed here.

As Boavida and Ponte (2002) point out, the importance of dialogue and negotiation is becoming more prominent in collaborative activities. When entering into a dialogue that involves a clash of ideas, it is no longer a mere instrument for reaching a consensus and becomes a factor in increasing one's understanding of a particular theme or even opening up a new understanding. At the same time, negotiating meanings, objectives, priorities, or working methods, etc. is of crucial importance, given the expectations of each participant. For this reason, we asked the interviewed, the following questions:

Interviewer: What is the role of dialogue and negotiation for decision-making in collaborative work? How has this been happening in the Pedagogical Residency project?

Jocimar: We try to see what is most feasible for the school, and then adapt it to the needs of the residents [...], so we always talk to the students and try to match their needs with ours.

Renan: The preceptor was open to dialogue and negotiation; We were able to choose between activities that better adjusted to our schedule and timetable. At the beginning, we collaborated with several mathematics teachers, but after some time each of us chose one teacher to work with. Regarding the school activities, we discussed some ideas with the preceptor, (i.e. each person expressing his/her own ideas), until we decided which projects would be implemented. Then each resident chose the project he/she would take part in.

The preceptor and resident emphasized that the requirement that each part involved should be listened when taking decisions about the project. However, this meant aiming at an

overlapping goal, which was to meet the needs of the school, while improving the effective learning of Mathematics. Gideon (2002, p. 34) states that different points of view should be heard to ensure a successful collaboration: "successful collaboration requires all teachers to be heard and that administrators must be willing to accept differing viewpoints". This means that the participants must be open-minded when making decisions together.

When assessing how collaborative work influences classroom teacher practice, we asked them to comment on the following question:

Interviewer: Does this collaborative work mean that the learning you acquire influences your pedagogical practice? Please give a reply.

Jocimar: Yes. In what sense? When I'm advising the residents [...] I try to understand the approach they are adopting [by delivering some theoretical content or solving a problem] and I explain to them whether the approach they're adopting is proper [...]. When we are working, we cannot ask a question like "if I teach this way, is it valid?", Sometimes the resident teaches in an easier way, and this leads to an exchange of learning. Sometimes we realize of some mistakes we make, when we see someone else making the same mistake.

Jocimar says that collaboration with residents not only enhances their methods, but also makes him recognize his shortcomings. When he is in the classroom as the lecturer, he is not always able to see the weaknesses of his own methodology, which he noted as an observer, when correcting the residents' activities, developing a critical reflection about your teaching practice (Heck, Bacharach y Dahlberg, 2008). This assertion can be better understood by what Olson (1977, p. 25, apud Boavida & Ponte, 2002, p. 50) says:

Each one will come with their own goals, purposes, needs, understandings and through the sharing process, each one will depart having learned from the other. Each one will learn more about himself, more about the other, and more about the topic at hand.

Thus it is clear that Jocimar understands more about himself when collaborating with others and, in reflecting on his own practice, he is able to adjust it to suit the interests of his students' learning. Hence, it is not surprising to find it pointed out in the literature that

collaborative work, by enhancing teacher training, also improves student learning (Gideon, 2002, Cramer & Stivers, 2007, Ronfeldt et al, 2015).

While several good points emerge as a result of collaborative work, this does not mean that there are no further difficulties and challenges to overcome. At the beginning, collaborative work requires constant evaluation in order to make the adjustments that are needed. For this reason, we asked the interviewed:

Interviewer: Which obstacles did you have to overcome during this project?

Jocimar: The main obstacle that we had was finding out the meaning of Pedagogical Residency. Anything else? At the beginning, there was not enough information about how to decide what was right and what was wrong, which meant that each person had his own interpretation [...]. At school [...], we sometimes covered holes [...], because the school interpreted the Residency as a pinhole.

When embarking on a collaborative endeavor, it is natural that there will be uncertainty, doubts and different understandings about the objectives, the way of proceeding and the role of each participant involved. For this reason, Boavida and Ponte (2002) emphasize that collaboration is characterized by unpredictability, since not every detail can be decided in advance. Hence, different directions and roles must be adjusted, in light of the importance of the negotiations, in this case, specifically, with regard to the expectations of the school and the expectations of the residents and preceptor.

Conclusions

This article presented some contributions and challenges of the collaborative work between the Faculty of Mathematics of the Federal University of Pará and three state schools within the scope of the Pedagogical Residency Program. The analyzes were made through a qualitative research based on semi-structured interviews with a preceptor and residents.

The collaborative work within the Pedagogical Residency Program has increased the learning of the preceptors and residents, with regard to their activities and experiences. The preceptor/tutor has had experience of teaching Mathematics classes for many years, while the

students can collaborate by making suggestions for innovative activities, resulting from their learning in the degree course. This collaboration suggests that the learning of field school students can also benefit from enhanced learning.

At the same time, the analysis conducted shows that the innovation brought about by the RPP causes doubts, uncertainty and the need for adjustments and negotiation to enable the good work to progress. Different participants with different roles contribute to a plural and beneficial discussion between the parties. Since it is an innovative project, it is expected that these difficulties will appear, and hence everyone will be required to listen to each other, be flexible and learn how to deal with the unpredictable.

Despite the challenges and difficulties to be overcome, this research shows that it is possible to carry out collaborative work between the university and the schools of basic education, in order to bring benefits to all.

Finally, as a limitation of our investigation, which at that time was unable to deeply assess the learning of students at schools, we leave this aspect as a suggestion for future research. Another aspect to be researched is the contributions to the teacher training of the advisors, and, more broadly, of the school communities of the three field schools that benefit from the project.

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