

Teachers' reflections on mathematics teaching practices in a vulnerable context

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ABSTRACT. The objective of this research is to show the difficulties and the challenges identified by teachers in their mathematics teaching practices. The research is based on the concept of reflection-action, thus a workshop-course centered on collaborative work and on reflections about teaching practices was designed in order to achieve the objective. Ten mathematics teachers the Telebachillerato (Higher Secondary Education Subsystem, Mexico) participated in this research. The results show that teachers have a variety of challenges, but also difficulties, particularly involving getting students to construct knowledge autonomously, as well as teachers selecting and using resources in accordance to the subject matter to be taught. In addition, there is also lack of mathematical and pedagogical knowledge in the participants. Collaborative work is required, leading teachers towards building the necessary knowledge for Higher Secondary Education in order to avoid student obstacles.

Keywords: Teaching practices; Mathematics; Reflection; Vulnerable context; Higher Secondary Education

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INTRODUCTION

Teachers' formative education is a factor that affects the quality of education and the academic performance of students (Jawarski & Wood, 2008, Leikin & Zazkis, 2010). In this respect, education in Mexico has entered into a process of crisis within the past two decades, and this is due to the lack of skills in teachers or lack of improvement thereof, among other aspects. In Higher Secondary Education, most of the teaching staff in the subject of mathematics is made up of professionals with extensive disciplinary knowledge, but without an initial pedagogical training. For some researchers (i.e., Escalante, 2008), such a lack causes the teaching of mathematics to be unfavorable to the acquisition of the expected learning, which in turn leads to the memorization of formulas, procedures and concepts without the comprehension of what is being learned. It also leads to a lack of interest in students to continue learning, as they perceive mathematics as meaningless and unnecessary

knowledge for their daily lives or towards their studies.

For Kieran, Tanguay and Solares (2011), it is essential for teachers at any educational level, to develop and implement skills related to the teaching of mathematics in order to contribute to the quality of education in students. Likewise, the National Council of Teachers of Mathematics (2014), NCTM, states that the teaching of mathematics requires teachers who possess a deep understanding of the disciplinary knowledge and of the didactic skills, through which they will make teaching become effective in the development of students' learning. This is a great challenge for teachers who work in Mexican institutions within a vulnerable context (i.e., those that tend to students of low socioeconomic status), as is the case of Telebachillerato (Higher Secondary Education Subsystem, Mexico), since most of them have a different profile to teaching and mathematics (INEE, 2015). The resulting deficiency is reflected upon the scores acquired on national evaluations on vocational performance, since this type of population usually obtains the lowest results (INEE, 2015).

In Telebachillerato, mathematics teachers require didactic knowledge to meet the demands raised by the Subsecretaría de Educación Media Superior (2015, SEMS for its acronym in Spanish), as it demands skills that allow them to "reorganize learning

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environments from which students can structure new knowledge and develop skills" (p. 14). As part of these skills, teachers are expected to select and possess adequate materials to teach mathematics, such as the textbook, educational videos and teaching guides (INEE, 2015), since these are essential resources that deliver learning activities and mathematical argumentation, guiding them on what they must teach and how to teach it (Weiss, 2017). Additionally, they must be able to adapt the learning activities to their working conditions, the children's needs and the resources at their disposal.

In this regard, greater attention to the teaching practices of mathematics teachers is required in this type of vulnerable context. In other words; what the teacher must know and be able to do in this type of context, as well as how they can be given opportunities to provide high-quality teaching in mathematics (Ball, Thames & Phelps, 2008). Higher Secondary Education institutions promote teacher training courses and teacher refresher courses constantly. However, several researchers (Guzmán, 2001) state that although teachers participate in these types of courses, there is little evidence in the classroom to indicate any significant change in their teaching practices. Perhaps this is due to the courses being brief, sporadic and, often times, far away from the reality of the classroom, thereby lacking a link between the curriculum and their real teaching practices (Jaworski, 2006). In relation to this, Hill, Sleep, Lewis and Ball (2006) consider that proposals in which the teachers are involved to discuss their own teaching practices is required; likewise, for Sfard (2005, p. 401) researchers must do joint work with teachers in which the former "listen [...] and think with [them], rather than tell [them] what to do".

According to the literature review, Mexico lacks research studies concerning mathematics teachers in a vulnerable context, such as the Telebachillerato, which address the comprehension of the teaching practices within the classroom; particularly, to establish intervention proposals that contribute to the pedagogical training in Higher Secondary Education teachers (Páez, Ramírez, Cañedo, Eudave-Muñoz, Carvajal-Ciprés & Macías-Esparza, 2019). The objective of this research is to show the difficulties and the challenges that teachers identify after reflecting, along with their colleagues, about their own teaching practices in the subject of mathematics.

CONCEPTUAL FRAMEWORK

The concept of reflection-in-action given by Schön (1983, 1987) is taken as a frame of reference, which is seen as a means for teachers to analyze their teaching practices, or that of their colleagues, and to learn from it and to transform it. The idea of reflection, or reflection-in-action, stems from the assumption that

teachers' knowledge is immersed in the actions that form part of their teaching practices, so that when they observe and reflect on their actions, it is possible to identify the knowledge immersed in it. In this regard, Schön (1983) states that "our knowledge is ordinarily tacit, implicit in our patterns of action [...], the workaday life of the professional depends on tacit knowing-in-action" (pp. 55-56). In this sense, teachers have the ability to reflect upon their actions and the knowledge related to their teaching practices. Reflection is carried out over the actions performed by the teachers themselves and they arise when the teachers are presented with situations that are unfamiliar to them, even when these are routinely. For Schön (1983), "Stimulated by surprise, they turn thought back on action [performed] and on the knowing which is implicit in action" (p. 56).

An unfamiliar situation becomes conflictive or confusing when teachers resort to their knowledge, mathematical or didactic, available at that time, but its implementation is problematic. This type of situation is "characterized [...] by uncertainty, disorder and indeterminacy" (Schön, 1983, p. 26), in such a way that teachers question and, additionally, modify their knowledge of the action (Schön, 1987, p. 44). The reflection involves teachers becoming aware of and analyzing the reason behind the knowledge leading to such an outcome and is also focused on three aspects: the results of the action, the action itself, and the implicit knowledge in said action. Faced with the unexpected situation, the reflection can manifest at two different moments: during or after the action. These moments are not exclusive to each other; teachers can reflect on the action and, at a later time, reflect on it again. Reflecting, be it during or after the teaching practices, involves focusing attention on the action taken, which generates a new understanding over the unexpected situation.

Reflection gives rise to experimentation in situ, in which the teacher becomes a "researcher into his [...] practice" (Schön, 1983, p. 262), as they build and test new actions with which they explore their unexpected situation, they verify their comprehension or affirm the steps they took to address this situation. In this regard, Gilbert (1994) and García et al. (2006) consider reflection as a means for teachers to explore, evaluate and improve upon their teaching practices. On the other hand, for Conway (2001), this type of reflection refers to recognizing the past within the present:

[...] looking back is turning inward, examining one's own remembered experiences and/or anticipated experiences, not exclusively looking back in time. Looking back in the reflective sense is about gaining some reflective distance to understand better the meaning of lived experience, one's relationship within and to the world. (p. 90)

In the teacher training and teacher refresher, reflection is an essential component to build learning related to the teaching of mathematics. Teachers cannot simply emerge and “criticize” their knowledge, but they can also give sense to unique situations or those of uncertainty for them. Reflective practices are a process in which teachers seek knowledge when faced with a problematic situation (Gilbert, 1994, Schön, 1983). Therefore, reflection contributes to teachers improving their teaching practices. In this regard, Gilbert (1994) states that:

Reflection-in-action occurs when new situations arise in which a practitioner’s existing stock of knowledge [...] is not appropriate for the situation. It involves reflecting on ‘knowing-in-action’. ‘Reflection-in-action’ is a process through which hitherto taken for granted ‘knowing-in-action’ is critically examined, reformulated and tested through further action. It is a process of research through which the development of professional knowledge and the improvement of practice occur together. (p. 516)

MATERIAL AND METHODS

This research is exploratory in nature and is focused on collaborative work with mathematics teachers at Telebachillerato and their teaching practices, which is understood as the social activity that this educational actor performs in the classroom to promote learning in the students (Rogalski, 2003). From this perspective, teaching practices are a social phenomenon that occurs

in a certain moment in the reality of the classroom (Cohen, Manion & Morrison, 2007, Schoenfeld, 2007, 2008). A semi-presential workshop-course was designed for collaborative work and to generate a reflection on teaching practices (see Páez et al., 2019).

For the purpose of contributing to the teacher training of teachers in a vulnerable context, a workshop-course “Reflection on and for teaching practices in mathematics” was designed, which has two objectives: (a) To promote in teachers a reflection and discussion on their teaching practices in the subject of mathematics, in order to identify problems or situations that are conflictive for them and to propose resolution strategies; (b) Develop or contribute to the competencies that Higher Secondary Education teachers in a vulnerable context must possess, through reflection and collaborative work.

The workshop-course methodology is based on the Guzmán Marín and Inciarte (2004) proposal in which, through collaborative work, participants have the possibility to analyse their real mathematics teaching practices (by locating their competences performed within the classroom), to specify the characteristics of teaching through competences, and to address the need for accompaniment in their training; in particular, the discussion of problems arising from real teaching practices in terms of Schön (1983, 1987) was taken as a basis, that is, on situations that generate uncertainty in teachers faced with lack of mathematical or didactic knowledge. To achieve the objectives, the workshop-course includes four learning modules which, in turn, are determined by several Topics of study and a set of Activities (Table 1).

Table 1. Reflection on and for teaching practices in mathematics workshop-course content

Modules	Topics of study
1. Telebachillerato mathematics teacher.	1.1. Mathematics teaching practices’ needs and difficulties. 1.2. Expectations as teachers and on their teaching practices. 1.3. Strengths in teaching mathematics.
2. Mathematics teaching practices.	2.1. Mathematics teaching practices’ scope. 2.2. Mathematics teaching practices’ impact and efficiency. 2.3. Strategies to demonstrate mathematical knowledge. 2.4. Strategies to validate the learning of mathematics.
3. Implications of the curriculum in teaching practices.	3.1. Why teach math, and for what purpose? 3.2. Teaching practices scope to achieve the curricular objectives. 3.3. Characteristics of teaching practices to achieve the curricular objectives.
4. Teacher resources.	4.1. Use and aid of resources available to teach mathematics. 4.2. Implications of the resources in teaching and learning mathematics.

Additionally, the workshop-course seeks for participants to achieve three teaching competences: (a) Develop ongoing training from teaching practices, (b) Perform didactic transposition processes, and (c) Collaborative work (Guzmán et al., 2014). The first competence focuses on the management of the process

of joint analysis, improvement and reflection of teaching for teachers to explain their daily teaching practices, to visualize the existing gap between those they possess and those they wish to possess. The second competence refers to transforming a teaching knowledge into a teaching object. The third one refers to sharing and building, among colleagues, new

common knowledge which can be used within the classroom.

As part of the workshop-course methodology, each Topic of study is worked on through a set of Activities, which involve situated tasks that trigger a reflection in teacher-participants, on the strategies and solutions of their teaching practices.

These tasks are performed individually, in trios, and in the group by the participants. It is important to mention that the product obtained by some of the Activities was the basis for the design of other Activities, which means that many of the activities were developed during the implementation of the workshop-course. These were designed to be worked in trios, where each member had a specific role, which was exchanged in each Topic of study: presenter, facilitator and observer. The presenter oversees sharing the products generated by the trio in the workshop-course group spaces, the facilitator coordinates and organizes the trio's internal work, and the observer registers the experience (Guzmán et al., 2004).

PARTICIPANTS

Telebachillerato teachers who taught mathematics in either the first or second semester were invited for this

research. Ten teachers participated in the workshop-course, most of which have a master's degree in education; two have master's degrees in mathematics. In addition, half of the participants have at least eight years of teaching experience in Telebachillerato. All ten teachers have didactic knowledge that has acquired through experience by teaching mathematics and other subjects in Higher Secondary Education.

DATA COLLECTION

Data collection was carried out in two intertwined stages: (a) class observation and (b) the implementation of the workshop-course.

Classroom observation. An essential aspect of the workshop-course is the teaching practices employed within the classroom; this is in order to identify relevant aspects that could become the subject of discussion (reflection) by the teachers through the Activities that were designed in the Topics of study. Therefore, as part of the workshop-course methodology, it was decided to perform two classroom observations for each teacher participant: the first one during the development of the course in order to gather input for the Activities and the second one afterwards with the purpose of observing changes (impact) in the teaching practices (Table 2).

Table 2. Classes observed by teacher participants

Teacher	Mathematical contents	
	First class	Second class
Daniel	Second grade equations	–
Paco	Ellipse	Functions (concept)
Alfonso	First grade equations	Pythagoras Theorem
Juan	Notable products	–
Martha	Factoring	–
Aldo	Second grade equations	–
Francisco	Determinants for 2x2 system	Pythagoras Theorem
Ana	Addition and subtraction of polynomials	Complementary angles
María	Characteristics of a circle	–
Felipe	Notable products	Complementary angles
Carlos	Notable products	Complementary angles
Sofía	–	Complementary angles

The observation that was implemented for this research was non-participant to explore the reality of the classroom, since it allows for "the opportunity to collect live data on situations that occur naturally", such as "events that arise in the classroom... In addition, it can focus on behavior or qualities... from the professor" (Cohen et al., 2007, p. 396).

As can be seen in Table 2, not all teachers were observed in two classes, thus some mathematical contents differ. The observations were carried out through video recordings. At first, eleven classes were videotaped, and then seven, for a total of 18 observed classes. Classroom observations were carried out in November 2017 and in February 2018, respectively. To this end, the observation date was determined with the

corresponding authorities and with the teachers, and their consent to be observed was obtained.

For the observation, each one of the teacher participants' schools was visited, respecting their work plan: content to be taught and time allocated to it. Although video cameras were used for this task, efforts were made for the observation not to affect the scene and the natural context of the process of teaching and learning that was taking place at that moment (Cohen et al., 2007, Schoenfeld, 2007, 2008). To avoid bias in the collected data, teachers were only told the purpose of the first observation.

Implementation of the course-workshop. The workshop-course lasted for three months (from November 2017 to January 2018) and it was semi-presential. The first module was carried out through

the educational platform GADEE (www.gadee.mx/moodle/course), the first session and the rest of the modules were presential. The first session was presential due to two specific purposes: (a) to present the program to the teacher participants, explaining the semi-presential modality to them, clarifying doubts associated to the course and starting the Activities related to the Topic of study 1 from the first module (Status of the Telebachillerato teacher in the mathematics subject); (b) to assess the results obtained as a group and finish the formative process. As for the last three modules, they were carried out in five presential sessions, each one lasting five hours.

DATA PROCESSING

The analysis performed on the collected data was done through the categorization and codification in terms of Miles and Huberman (1994). To do this, the video recordings were segmented in units of analysis to identify characteristics of the teaching practices for

each teacher given in the classroom. In addition, in the workshop-course sessions, fragments of teachers' discourse were identified that were relevant to the difficulties they faced when teaching mathematics and the challenges they faced regarding this discipline. The analysis allowed for the identification of different cases that show the reality that occurs when teaching mathematics in a vulnerable context, as it is in Telebachillerato.

RESULTS

In the course-workshop teachers reflected on the characteristics of teaching mathematics in Telebachillerato. Through reflection they considered that their teaching practice should be related to planning the class, having a direct work with the students, explicitly mentioning the objective in the class, questioning the student to make thought about what he does (Figure 1).

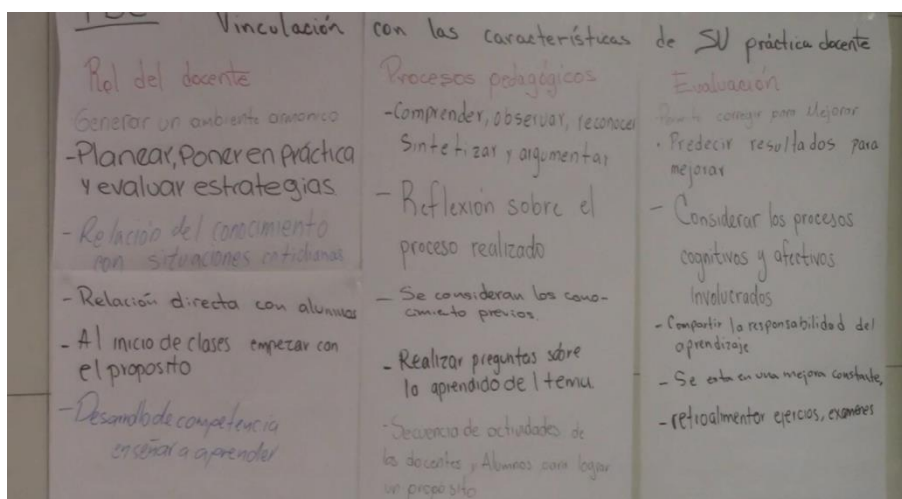


Figure 1. Reflection's teachers: characteristics of teaching mathematics in Telebachillerato.

The teachers consider that one of the challenges they have in their profession is to get students to build mathematical knowledge, which involves leading them to discover and infer mathematics from a necessity that they must meet; for example, Carlos states the following: "When you are going to give an assignment to the students, the only thing you can tell them is to rely on what they can... They will have to resort to the guide to get a procedure. But a need must be provoked. Many times, they are taught the procedure and they are told to do this... but they must be taught to do it by themselves." The foregoing states that students are the ones who must build their own knowledge with the teacher's guidance. In this sense, the student is seen as the main actor in the process of teaching mathematics (Martínez-Rizo, 2003).

Even when teachers consider carrying out this challenging task in the classroom, they sustain that the autonomous construction of knowledge depends on the mathematical content that was previously taught. In this regard, for Carlos "there are topics that are taught; there are topics they have never heard before". This leads to the realization that if content is already known to students, then autonomous learning can be achieved; in this respect, students are simply either reviewing or expanding their knowledge. In addition, they consider this challenge difficult to be put into practice, as Daniel states:

There are topics that are very difficult to give [the students] that freedom to build or to land it on situations of their daily lives. It really is complicated on topics related to calculus, from my point of view, it is complicated for me. I have searched, and we

have talked about this, for sample classes. I tell them that I want them to give me a sample class where you land it into your daily life... There are topics that are very complicated as to how you land them into your daily life.

For teachers, this challenge is a difficult one as the construction of autonomous knowledge is attributed to the mathematical content, rather than to the didactic strategies and to the learning activities that they employ in the classroom. Additionally, this attribution is given to students, as if they were solely responsible for such construction; for his part, Juan considers that students do not find any sense in the mathematics that he teaches them, thus making it difficult for students to become autonomous: "it is one of the greatest barriers that students say: 'what is this for?'".

Teachers believe that part of their teaching practices is to motivate students through the recognition of the work that they do in mathematics; likewise, they state that it is necessary to recognize the conceptual or procedural mistakes that the teacher makes during class; for example, in the feedback given by the participants in the workshop-course, Daniel mentions the following in regard to a mistake that he made in one of his classes:

For me, it is important to be told that I imparted [the class] well in spite of the mistake I made in the problem or that the exercise I employed in my class was not adequate because the answer was undetermined... In that moment I thought "Now, how do I tell the students that the one who made a mistake was me and that the procedure that they followed was correct, without making them feel confused". If it is satisfactory for us to have another teacher give you feedback on your class, for students it is even more so.

In the teaching of mathematics, teachers believe that the resources used were occasionally not the most appropriate, for example, projecting a set of exercises and asking students to copy them to their notebook, thus generating a waste of time (Figure 2). For teachers, meaningful learning must be achieved by students in the classroom. To this end, they believe that teaching mathematics must be done using more constructivism, so that students can apply what they learn in their daily lives. In this regard, Juan states that "situations that students are familiar with must be used for learning to be meaningful".

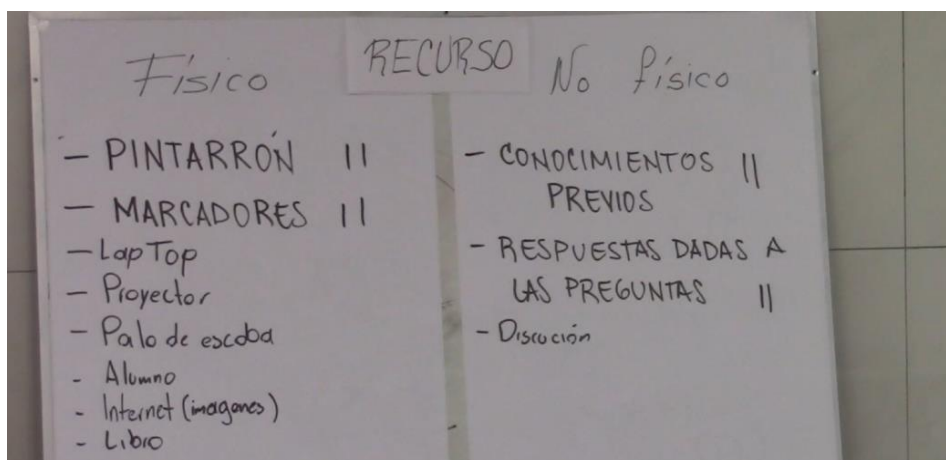


Figure 2. Resources that teachers consider necessary to teach mathematics.

An important aspect that teachers become aware of, through the reflection and feedback given by the participants to one of their members, is to motivate students to learn mathematics for their daily lives and to hold responsibility over that learning. Carlos states: "we must seek to raise awareness about their role as students". It is also necessary to recognize the work that students do, as this is an incentive to be motivated and to get involved in the class. Having the proper resources (Gueudet, Pepin & Trouche, 2012) to teach mathematics is necessary as part of the teaching practices, since they consider that these allow them to generate better learning.

In this respect, teachers must possess a mastery over these resources, for example, when using educational videos. To illustrate this, Maria used a video in her class focused on explaining the process of adding polynomials, but in the workshop-course she realized that she herself as a teacher lacks depth and reflection about this procedure. She assumed that students understood the explanation that the resource provided: "at the beginning of the topic I play a video and I trust it and leave aside a step-by-step explanation of the procedure". In this regard, teachers also consider the relevance of the didactic resources that they use to teach mathematics (Figure 2). Carlos

states that the table he used to teach Cartesian graphics was not the most appropriate, and he contemplates student participation as an important resource to teach mathematics.

CONCLUSION

The results show that Telebachillerato teachers show great interest for education, particularly to educate students who can integrate themselves into their daily lives with the mathematical knowledge that they build in the classroom, but they are aware that this is a great challenge for them. For teachers, the main challenge is to lead students to build their own knowledge in accordance to the requirements set by the Mexican Public Education System (Páez et al., 2019). In addition, teachers face challenges such as the use of materials and resources that are appropriate for the subject matter. Teacher lack of knowledge leads to the generation of difficulties in the teaching of mathematics which, in turn, generate conceptual, didactic or procedural obstacles in their students.

The feedback given by the members of each trio during the workshop-course, allows them to discuss, justify and argue about their teaching practices, but mainly, it leads them to become aware of the difficulties that arise while teaching mathematics. For example, disregarding the mistakes they make in class so that the students are left with an erroneous idea, or the belief that what the teacher did was correct. Likewise, teachers highlight the importance of getting students involved in the construction of knowledge, in which they are the active participants.

The results show that collaborative work between researchers, teachers and the corresponding authorities is needed to achieve better teaching practices in vulnerable contexts; particularly, to contribute to their mathematical and didactic knowledge.

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