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Preventive support scheme for mathematics learning: possible ways to provide aid before and after the class session

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Since 2013, we have studied a support scheme for students who have difficulties solving mathematical problems. We call this a "preventive support scheme" and are interested in modelling its functions. These interventions take place before and after a specific classroom session, in order to facilitate the students' introduction to the planned learning situation, their involvement in the work required and their appropriation of the target knowledge. The work proposed in this scheme can take various forms and the aim of this communication is to illustrate this point by presenting, for a given situation, different tasks which can be proposed either before or after the classroom session. This study will allow us to highlight the precautions to be taken to design such devices.

Keywords: Didactic system, preventive support scheme, students in difficulty, fractions.

Introduction

Our research focuses on students who have difficulties solving mathematical problems (they fail to engage the situation, hesitate, do not know how to start, wait for their peers to find the solution...). Since 2013, we have studied the effects of a support scheme for them which we call "preventive support schemes" (Millon-Fauré et al., 2021). Unlike other support initiatives implemented after classroom sessions as part of remedial strategies, the proposed preventive strategy is implemented both before and after mathematical problem-solving sessions involving all students: a supervisor (teacher, remedial education specialist, etc.) works, before and after the classroom session, with a small group of students deemed (by the teacher) to have difficulties in problem solving. The "preventive" aspect of this scheme is linked, not to the learning difficulties that these students may encounter in a problem-solving context, but rather to the difficulties they demonstrate in taking their place as learners in such a context (Assude & Millon-Fauré, 2021; Tambone, 2014).

The choice of tasks which can be proposed within the framework of this scheme is sometimes not a clear one since it is necessary to facilitate the students' participation in class while not overly advancing in the actual problem-solving. It is for this reason that we want to present in this paper, for a specific classroom session on fractions, different options which could be proposed in the

preventive support scheme, either before or after the classroom session. To do this, we will first quickly describe the different functions of the preventive support scheme.

Theoretical framework: the preventive support scheme

To model this preventive support scheme, we draw on the notion of the didactic system and the (structure; functions) coupling. The didactic system comprises three elements (knowledge, student and teacher/supervisor) and all interrelationships between these. Chevallard (1999) distinguishes between two types of didactical systems: the principal didactical system (PDS), essentially the classroom, and the auxiliary didactical systems (ADS), which include some, but not all students of the PDS and are peripheral to the class. The ADS follows the same objectives as the class but does not have its own program. Thus, the class, which guides the study of the target knowledge, consists of the PDS, for which two ADS are provided: one before (pre-ADS) and one after (post-ADS) the classroom session. Supervising a small group of students, the pre-ADS aims to create favorable conditions so that students who are deemed to be "in difficulty" can better integrate the study during the PDS (therefore this device is part of an inclusive perspective). The post-ADS, held after the classroom session, is a further work session with the same group of students, with the purpose of revisiting the knowledge presented in the PDS. The aim of this scheme is to enable students in difficulty to catch up with their classmates and it is therefore not relevant for all the students in the class. These two ADSs depend on the PDS, which determines what the student is supposed to know and do. In summary, we have the following structure:

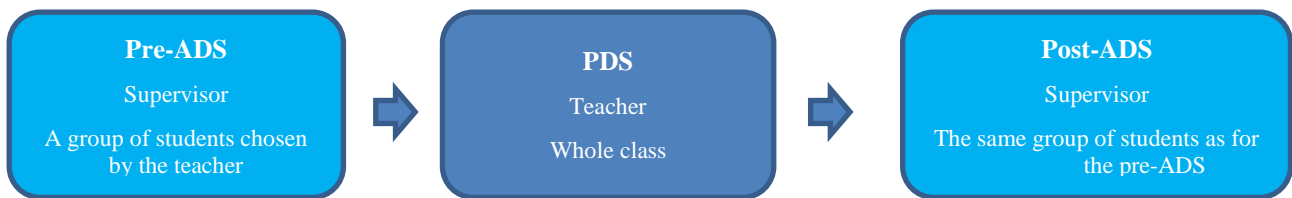


Figure 1: Structure of the preventive support scheme

The pre-ADS

Through our analyses of different potential iterations of preventive support schemes we were able to identify several functions associated with the pre-ADS (Assude, Koudogbo et al., 2016; Assude & Millon-Fauré, 2021; Theis et al., 2014).

The *mesogenetic function* relates to the introduction, during the pre-ADS, of different objects which will make up the PDS milieu. These objects may vary, as they depend on the nature of the situation studied in the PDS. Certain pre-ADSs present the instructions for the problem which will be worked on later in the PDS. In others, objects of formerly acquired knowledge, useful for the work to be done in the PDS, are introduced. Generally speaking, this mesogenetic function enables struggling students participating in the ADS to become familiar with certain objects of the PDS milieu before the other students in the class.

The *chronogenetic function* plays out on two levels: not only do the students involved in the pre-ADS have more time to become familiar with certain objects of the milieu but above all this additional work is set up before the session so that they have a little bit of advance on their classmates. It is nevertheless important to note that, the didactic time (Chevallard & Mercier, 1987)

does not progress. In practice, the aim of the pre-ADS is to prepare students to fully engage in solving the problem set out in the PDS, but not to solve it before the other students.

The *topogenetic function* has been demonstrated through numerous observations made during the various experiments conducted within the preventive support scheme, since the students in difficulty have been shown to be capable of fully assuming their role as students in the PDS. We were able to observe that they are very often able to engage as fully as the other students in the PDS situation, and even to contribute to the progress of didactic time, despite having been deemed to have difficulties. Moreover, the teachers were able to confirm that this level of involvement of these students in difficulty was unusual.

The post-ADS

This auxiliary didactic system presents three functions (Assude & Millon-Fauré, 2021; Morin et al., 2019; Theis et al., 2016).

First of all, it presents a *memory function*, since the aim is to have the students recall the session and revisit the essential steps of the lesson. This work seems particularly formative insofar as the description of the various events and their chronology make it possible for students to better understand the articulations between the various concepts approached and the path which led to the construction of the new knowledge. Assude and Paquelier (2005) similarly emphasize the benefits of this recollection and highlight three of its effects: the expression of a personal time in the classroom, the reconfiguration of the student's lived experience and a time recalled as a shared time. The researchers nevertheless specify that this exercise can prove delicate for most of the students to perform and requires specific guidance by the supervisor, which underlines the value of this memory function in the post-ADS.

This ADS also presents a *renewal of the institutionalization*, wherein the supervisor asks the students what should be remembered following the PDS session. This question will lead students to explain the knowledge involved in different ways. These successive reformulations are intended to help students in difficulties to better understand the processes of decontextualization and depersonalization involved in the taught knowledge, which can enable them to make up for the delay they often experience at this point. Indeed, we observed that some students needed more time than their peers to access the targeted knowledge: implementing these post-ADSs sometimes enables certain students to complete a process of learning that had only begun in the classroom (Assude & Millon-Fauré, 2021). This time of recalling the lesson can also lead the students present to ask questions about certain aspects they had not dared to raise in class. These reformulations can furthermore facilitate knowledge.

We also observe a *reinvestment function*, as the post-ADS helps the students to transfer the knowledge discovered in a given situation, to use it in another context. Indeed, it is not only a matter of the student having understood and memorized the problem taught during the PDS: they must also be able to contextualize this knowledge and use it in a new situation, which may sometimes require the support of the supervisor. In order to facilitate the implementation of this articulation between taught knowledge and operational knowledge in different contexts, the supervisor will propose, during the post-ADS, to solve similar tasks or a reflection on the types of tasks in which the targeted techniques could prove useful. However, care should be taken to ensure

that the tasks proposed are not too different from those worked on during the PDS, otherwise the student may not be able to build on the knowledge acquired in the PDS.

With these theoretical underpinnings, the purpose of this paper is to consider different pre- and post-ADS actions which can be implemented for a given class session.

Methodological aspects

Our work contributes to the recent current of collaborative research (Bednarz, 2013). The data collected during this project consisted of all ADSs and PDS plans, video recordings of pre- and post-ADS sessions, PDS sessions, student productions, and recordings of interviews with teachers and supervisors before and after each preventive support scheme session. We conducted an *a priori* analysis of the sessions and then viewed the sessions, annotating the verbatim with respect to the potential functions of pre- and post-ADS of the scheme and their effects. We were particularly interested in the students who had participated in the two ADS sessions: we observed the manifestations of the functions, the way that these students engage the situation, and analyzed the proposed techniques and their possible difficulties in order to study their evolution during the sessions. Examples of analyses are presented in our previous articles (Assude, Koudogbo et al., 2016; Assude & Millon-Fauré, 2021; Theis et al., 2014).

To present the potential actions to be implemented before (pre-ADS) and after (post-ADS) the classroom session, which emerged during the implementation of this scheme and the reflections of the team, the focus of this communication is on a specific class session targeting the concept of fractions. The main task of the PDS was to find the whole from one or several parts (Van de Walle & Lovin, 2005).

***A priori* analysis**

The first targeted task is to reconstitute the whole from its quarter, represented by a small cardboard square. The main technique here is to draw the outline of the square four times on the paper to form a whole. The main potential erroneous techniques are the following: performing the reverse of the task or drawing the original square and reproduce it four more times to have a total of five parts instead of four. In the second task, students can reconstitute the whole from its third, represented by a small Cuisenaire© rod. The techniques required for this task are similar to the first, but here are aided by the use of rods. The final targeted task is to reconstruct the whole from its three-fifths, represented by a cardboard rectangle. Examples of incorrect techniques associated with understanding the role of the denominator or numerator of the fraction would be to reproduce the cardboard five times since it is one-fifth, or to reproduce it three times since there are three.

To illustrate the nature of the work proposed in the preventive support scheme, we will now describe different pre- and post-ADS which could be implemented for this particular session. These proposals are based on analyses of the experiments we have conducted, several of which have been effectively implemented.

Propositions for potential pre- and post-ADS

From these three tasks proposed in the PDS, several pre- and post- ADS can be outlined. These are presented hereafter by analyzing them in terms of their potential functions, always with the aim of making problem solving accessible to these students and enhancing their participation in class.

Potential pre-ADS

A first action could be to **reactivate certain objects of formerly acquired knowledge** which are required during the PDS session to ensure that the students will be able to use them (*mesogenetic function*). In the particular case of the classroom session observed here, the supervisor could for instance decide to ask the students questions about the concept of fractions: what do they remember about fractions? Could they give examples of fractions? How can a given fraction be represented? It is also possible here to return to the lexicon linked to this mathematical concept, such as the terms 'numerator' or 'denominator'. It should be noted that this vocabulary is not really essential for understanding the PDS instructions or for solving the proposed problem, but it can facilitate the description of the techniques that will be used in the class.

A second possibility consists of **presenting to the students the instructions of the problem subsequently worked on** and to **focus the questioning on the understanding of the task**, while taking care not to make the students actually perform the task (*mesogenetic* and *chronogenetic* functions). The instructions of the problem chosen being quite limited, this choice can prove difficult or even irrelevant for the supervisor to implement.

Along the same lines, it could also be useful to **have the students work on a similar type of task** to that of the PDS but with different numbers, for example, more simple fractions such as a half or third (*mesogenetic* and *chronogenetic* functions). However, the supervisor must be mindful not to advance on the didactic time by working on techniques which are too similar to those required in the PDS.

Another option is to **work on techniques which are relevant to the PDS tasks** by asking students to identify a part of a whole using a material support (*mesogenetic* function): for example, find the quarter from a whole represented by a rectangular piece of paper. The corresponding technique consists of sharing the whole into four equal parts (by folding, cutting or marking), then identifying the unit fraction one quarter of the whole (by hatching, coloring or superimposing). By isolating the quarter of the whole, it is possible to observe that the parts are all the same size and that what remains (three quarters) is the complement to constitute the whole (four quarters). This technique helps to convey the "part of a whole" meaning of a fraction as well as the relationships between the parts and the whole. This will be useful in solving the PDS tasks (reconstructing the whole from a part of the whole).

Regarding techniques involving the Cuisenaire© rods, it could also be useful to take a moment to **discuss the material** with regards to fractions (*mesogenetic* function). Indeed, it is very likely that the students had already used this material in the context of counting and the first operations on integers. They therefore know that each colored rod has, in the context of natural numbers, a specific length and represents that number (for example, the red rod has a length of 2 cm and represents the number 2). However, when used in the context of fractions, the measurement of the rods differs depending on the unit chosen. Thus, it is necessary for students to choose the rod that represents the whole (or the unit) and this rod can be different to the situations illustrated. These differences can then be pointed out during the pre-ADS, either in the context of a more open discussion based on a simple task of representing a fraction from a whole, or in a more direct way by the supervisor.

Potential post-ADS

The supervisor can first of all ask the class to **recount what happened in the PDS session** (*memory* function). The supervisor's questions will encourage the students to enrich certain passages of their narration by expanding on points that were perhaps covered too quickly. It is also possible to use elements from the PDS to facilitate this recollection: for example, the supervisor can present photos of the board taken during the classroom session or certain student productions. It is also possible to make a video recording of the session and then to extract some key segments which the students must then comment on. It should be noted that, for this type of preventive support scheme, the fact that the post-ADS supervisor is not the class teacher can be an advantage. Indeed, in the students' eyes, questions about the session will seem much more justified than if they are asked by someone who attended the session.

A second type of post-ADS consists of **questioning the students on what they should retain from the session**. It is then a question of activating the didactic memory of the class in order to make the pupils reiterate the knowledge stated in class, possibly after certain reformulations guided by the teacher (*memory* and *recollection of the lesson* functions).

The supervisor can **propose a similar type of task** to that proposed in the PDS and which can be solved in the same way, while being mindful not to propose a more complex task (at the risk of losing the benefit of the confidence acquired by the students during the pre-ADS/PDS). This enables the student to apply the technique acquired during the PDS (*reinvestment* function). One variant consists of **asking students to propose a similar type of task** to that given during the PDS, being nevertheless mindful that the task should not be too different to the original task (the supervisor no longer controls the didactic variables in this case).

A fourth type of post-ADS could take the form of **revisiting a difficulty observed during the PDS** (*memory* and *recollection of the lesson* functions). For example, the final task related to reconstituting the whole from its three fifths represents an obstacle for students who struggle. It might therefore be interesting to return specifically to this task and ask students to comment on the strategies, correct or otherwise, which may have been employed by their peers.

Conclusion

The purpose of this communication is to consider what preventive measures can be put in place to support students identified as having learning difficulties before and after a class session on mathematical problem solving. It is true that the students are taken apart before and after the class session, but this measure allows them to become more involved in the mathematical task and to contribute to it like all the other students. This is a device that gives them back their power to learn in synchrony with the other students in the class.

Thus, after having specified the functions of the scheme, we have, from an experimentation based on the concept of fractions, presented the tasks proposed in the PDS and suggested other possible interventions. Below is a schematic summary of the pre- and post-ADS associated with the chosen classroom session (PDS) (Table 1). Such analyses can be made for other mathematical topics as measure of length (Theis et al., 2014), notion of area (Assude, Millon-Fauré et al., 2016), volume (Marchand et al., 2021) or construction programs (Millon-Fauré et al., 2021).

Possible actions – pre-ADS	PDS	Possible actions – post-ADS
- Reactivate certain objects of formerly acquired knowledge required to solve the PDS tasks	T ₁ : Reconstitute the whole from its quarter (cardboard)	- Recount what happened in the classroom sessions
- Question the students on their understanding of the PDS instructions	T ₂ : Reconstitute the whole from its third (rod)	- Question the students about what they should retain from the session
- Work on formerly acquired techniques relevant to the PDS	T ₃ : Reconstitute the whole from its three-fifths (cardboard)	- Propose a similar task to the students
- Discuss the material of the PDS		- Revisit a difficulty observed in the PDS

Table 1: Overview of potential actions for the pre- and post-ADS

The result is a range of possible tasks available to supervisors involved in the system. The choice of one of these tasks depends on the students, their difficulties, the PDS teacher, the ADS supervisor and the situation itself.

This study thus illustrates the richness of the preventive support scheme, which can be adapted by the teachers/supervisors in various ways. However, these choices directly influence the effects of the pre-ADS on the PDS and in turn the PDS on the post-ADS and can sometimes call into question the possible gains in terms of student engagement. This is particularly true when tasks that are too similar to those of the PDS are dealt with in the pre-ADS, or when tasks that are too complex are introduced in the post-ADS, which shifts away from the aims of the classroom session and generates certain effects related to the topogenetic function. For this reason, we believe it is essential to inform teachers/supervisors of the different options available, so that they can then choose the one which will prove most beneficial for their students.

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