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Teachers' choice of teaching resources and the investigative approach: case studies in France and Morocco

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ABSTRACT

Learning science through 'rediscovery' is an old story that was thought up by Charles Brunold (Astolfi Jean-Pierre, 2014). In this approach, the aim was to get pupils who wanted to be active to rediscover the results of science, but 'it has to be said that even today, we hardly go beyond this issue when we talk about getting pupils to participate' (ibidem, 2014). This is because such teaching (the teaching of results) can only be described as scientific if the reasons that led to these results are made explicit (Bachelard, 1938, p. 234). In this context, Jaubert and Ribière specify that the construction of knowledge is inseparable from the appropriation of practices, including language practices.

1. Introduction

Institutional resources refer initially to official curricula and textbooks, although research has shown that a small percentage of teachers use science textbooks (Monseur & Demeuse, 2000). The official curricula remain an essential reference in the work of teachers, because they define not only the essential knowledge that must be acquired, but also the methods that must be assimilated. But because they have been published for the general public since 1985, and in particular for parents, the official curricula form a basis on which schools and parents can communicate and monitor the progress of their pupils and children. This is the framework within which teachers organise their teaching, taking into account the specific nature of their class.

Personal resources, as the name suggests, refer to everything that the teacher uses to make his or her teaching comprehensible. These are experiences transferred by colleagues, or resources produced by other teachers and accessible on websites.

The choice of these resources reflects what the teachers aim to achieve on the basis of their knowledge of the subject being taught. In what follows, we attempt to highlight these resources in an attempt to understand the choices made by teachers to conduct inquiry-based science teaching and their impact on the construction of knowledge.

2. Resources mobilized and teacher knowledge: teacher choice benchmark

Based on Grossman's study (1990, p.5), the teacher needs four main areas of knowledge: general pedagogical knowledge (PK), subject-matter knowledge (SMK), pedagogical knowledge related to subject-matter content (PCK), and contextual knowledge.

These four categories are interrelated:

- Subject content knowledge (SMK) is the knowledge that the teacher is responsible for teaching (concepts, facts, theories, approaches, etc.).
- General pedagogical knowledge (PK): refers to knowledge related to classroom management and pedagogical principles (everything that does not concern content).
- Contextual knowledge: refers to everything the teacher knows about the context in which he or she teaches (social, geographical, cultural, etc. situation of the environment and the learner).
- Pedagogical content knowledge (PCK): this is developed by the teacher to help the learner understand the content (transforming subject knowledge into more comprehensible knowledge for pupils).

In this research, starting from what teachers do when conducting science sessions, we seek to understand the logic that guides their actual practice. To do this, we first highlight

The actual experience of teachers in a didactic relationship, i.e. teaching based on investigation with a view to achieving a gain in knowledge. Secondly, the knowledge mobilised in the preparation phase in relation to their actual practices. In this context, researchers have noted that most studies on teachers' knowledge to be highlighted have been identified on the basis of what they say about their knowledge and practices (starting from

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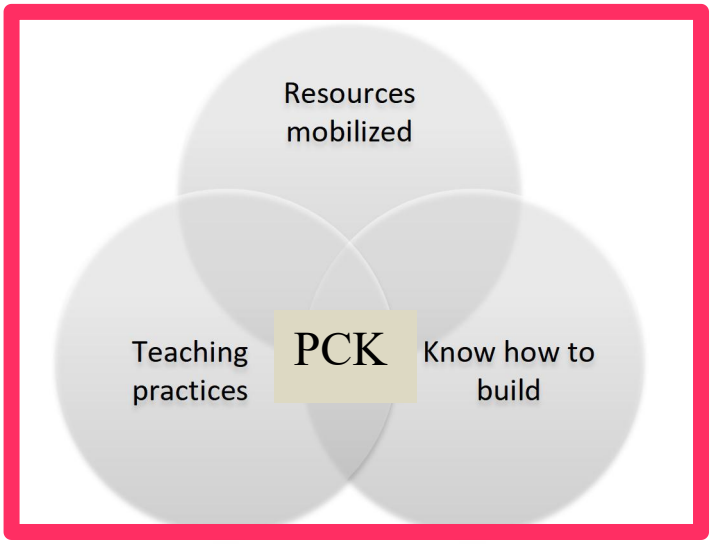
what is said by the teacher in order to identify the implementation of knowledge in the recorded data) (Cross, 2010, p.39). This approach, adds the author, only makes it possible to identify the knowledge about action that the teacher makes explicit in his statement. As a result, the knowledge actually used in the action can only be identified on the basis of face-to-face teaching practice.

The search for the manifestation of PCK through the trio of teaching practice-mobilised resources-constructed knowledge is a way of circumventing the question of the link between the knowledge and resources implemented and the conduct of investigation-based teaching in relation to the knowledge produced. It will therefore be studied on the basis of practice, thus reconstructing knowledge in action. Within this framework, the main researchers (Shulman, 1987 ; Grossman, 1990, Magnusson & al, 1999) recognise that PCK is of particular interest in the classroom. PCK involves teachers in mastering content, organising and managing their classes and pupils, and identifying and dealing with different learning needs1(Magidanga, 2017). For this reason, the analysis of practice focuses more on language practices in action and the explanations and written records of the teacher and pupils. These are three clearly distinct intervals, but they are interconnected in such a way that one leads to the other.



Intervals of didactic actions

The interval of teaching practices refers to the teaching-learning articulation in situation during a science session. The other two intervals refer to the possibility of reconstructing (on the basis of the practices identified) the knowledge mobilised by the teacher in order to understand the choice of resources, the way in which science teaching is conducted and the nature of the knowledge constructed.

This leads us to highlight the following points:

- Resources mobilised;
- Teaching practices in relation to the PCK;
- And the knowledge produced.

As for the resources mobilised, they refer to the experiences of colleagues and other resource persons whom they (the teachers) can call on for help. In this context, research on resources is treated differently depending on the approach taken by the didacticians. In this research, we are interested in science teaching resources. For this purpose, we distinguish between institutional (curricular) resources that comply with the curriculum imposed by the administration (official programme, school textbook, digital resources distributed by official institutions and teacher guides) and other resources called upon by teachers. The latter were classified in various ways by the researchers (material, human and cultural) (Reverdy,2014, p.2).

With regard to teaching practices, this research involves a process of transformation (Shulman, 1987) through which the teacher mobilises his or her pedagogical content-related knowledge (PCK) to move from disciplinary content to knowledge for teaching. This knowledge is of interest to us in this research because it is designed to help students understand and learn content. In this context, it should be noted that there is no consensus on the nature of the knowledge that constitutes PCK and the methodology for identifying it. Indeed, the different theoretical frameworks mobilised by researchers make it difficult to categorise them (Abell, 2007) and appear to some as 'elusive, described as tacit and is supposed to develop in practice' (Pitjeng-Mosabala & Rollnick, 2013). The search for the manifestation of PCK through the trio of teaching practice-mobilised resources-constructed knowledge is a way of circumventing the question of the link between the knowledge and resources implemented and the conduct of inquiry-based teaching in relation to the knowledge produced. It will therefore be studied on the basis of practice and knowledge reconstructed in action. This raised the question of scientific freedom in the two fields of research. Thus, by pedagogical freedom, we can understand that the teacher does not define the curricula or the tasks incumbent upon him or her. However, it is up to them to define their teaching practice and the mediations to be used to organise their class. This is what we can understand by the relationship partly determined by what the pupils know (the nature of the child as the starting point for Chobaux) and by what the objectives are (the end point) (Chobaux, 1967a).

As far as constructed knowledge is concerned, the shift from so-called traditional science teaching (based on texts and facts) to teaching based on 'inquiry-based teaching' has influenced the choice of school curricula, teacher training, the availability of teaching resources and, consequently, the vision of how knowledge is constructed in science. In 2007, in the Rocard Report, a link was established between student disaffection for science courses and the need to change the way science is taught. Teachers realised that their students' knowledge was very superficial and that most of the concepts taught had not really been understood (Reverdy, 2018, p.2). Within this framework, the knowledge taught at school is considered by some science didacticians, Astolfi (1992), as knowledge that is neither theoretical nor practical, but rather of a 'propositional' nature. It

1 Combination of pedagogy and teacher content.

is not theoretical in that it moves away from the problematisation from which it springs, and it is not really practical in that it deals with problems specific to schools. Rather, they are knowledge close to common sense (Astolfi 1992, 2005). This explains, according to Astolfi (1992), why little school knowledge can be reused outside school and why it does not acquire meaning among pupils. However, the criticisms levelled at school knowledge have not spared teaching practices. Indeed, although teachers are careful to implement official instructions that call for active participation and questioning (MEN, 2008), they 'remain prisoners of a traditional image of knowledge, as a text that states truths and is broken down into independent propositions, disconnected from their problematic context [...] knowledge then remains a ready-made product to be transmitted, a message to be passed on' (Astolfi, 2005a, p.74).

3.Research methodology

To try to answer the question posed in this research, we used a few data collection tools: observation, note-taking and interviewing and studying documents. This led us to observe two sequences in France. The first was on 'plant reproduction' with a class of 6 at collège Vauban. The second, in a CP class (age between 6 and 7), also consisted of 5 sessions and had as its theme 'the change of state of water'. The observations were madé after the teachers had confirmed their use of the investigative approach. As for Morocco, the collection was done in two primary schools with two different teachers with the same level - CE2- (the gradual implementation of the new programmes began with the primary schools). The first was a novice, with whom we were able to observe a sequence on dissolution (the solvent, the solute, mixtures, etc.). The second has been teaching in primary school for 7 years, and we were able to observe a sequence on light (types of light, shadows, etc.). The observation was supplemented by a study of the official texts and an analysis of the pupils' products and the teachers' preparation sheets.

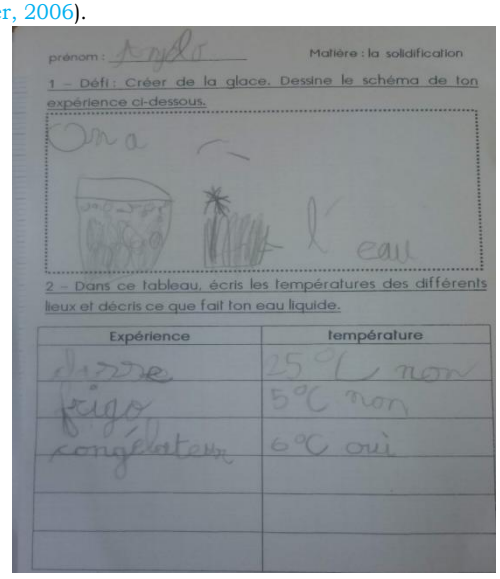
4.Results

If we go back to the stages followed by the class, the sequence of sessions follows the sequence envisaged in investigation-based teaching in its institutional form. However, an analysis of the sequences observed in France and Morocco showed that the conduct of this teaching was both simple and guided by basic documents. As a result, the possibility of unforeseen events occurring during the session is less and less likely. Analysis of the exercises proposed in the Moroccan textbook and the documents produced by the French teachers enables us to understand how the teacher managed the sequence in such a way that, in the cases observed in Morocco, he sees himself increasingly attached to the pupil's textbook.

The study of the recorded debate highlights key words during the different stages and shows how the pupils reacted to the predefined exercises. However, if the stages of this teaching were designed more or less jointly with the French pupils, the total reliance on the pupil's manual in Morocco tightened even more towards what is predefined. The role of the teacher and the pupil is increasingly confined to what is proposed in the official documents. As a result, certain moments of investigation and problem construction are being pushed aside (using the investigation notebook and proposing the research protocol).

4.1. Investigation Report

Designed to follow students through the investigative process, the use of the investigation notebook by French teachers is always an opportunity to let their students take the lead. These are moments when the learner is not content simply to be induced by observation, but also by questioning and elaboration (Laugier, 2006).


prénom : Matière : la solidification

1 – Défi : Créer de la glace. Dessine le schéma de ton expérience ci-dessous.

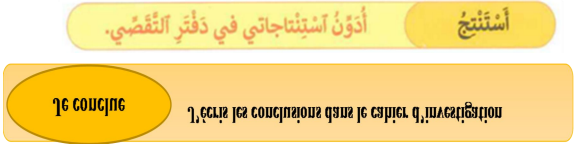
On a l'eau

2 – Dans ce tableau, écris les températures des différents lieux et décris ce que fait ton eau liquide.

Expérience	température
dans le	25°C non
frigo	5°C non
congélateur	6°C oui

Excerpt from the research book of a French student

In Morocco, although official documents explicitly call for the use of this document, teachers still leave it out. Although it is seen as a tool in which pupils 'write down their scientific adventures and help learners to master the scientific investigation approach, to spot their mistakes and the progress they have made' (Curriculum Directorate, 2019), the investigation notebook has not yet taken off. (Direction de programmes, 2019), the investigation notebook has not yet taken its place in the practices of Moroccan teachers. This is due to the central place occupied by the pupil's textbook in Moroccan teachers' practices

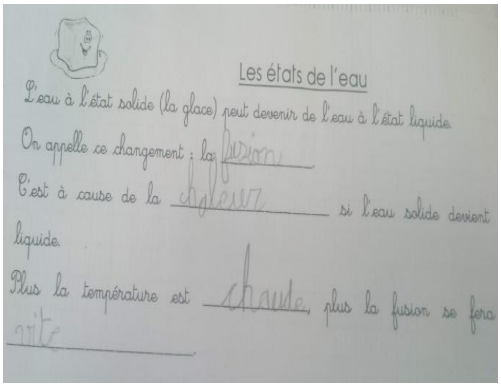


Excerpt from the student's manual calling for Using the Investigation Workbook

4.2. Text of knowledge constructed

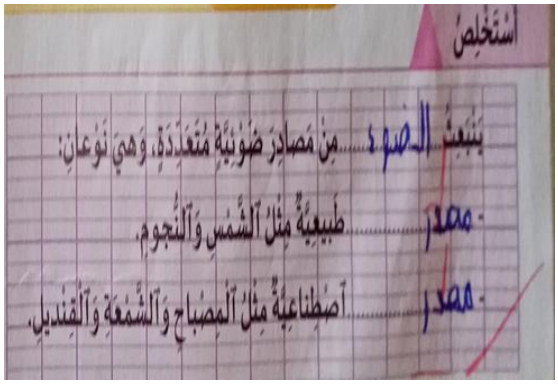
The implementation of a scientific debate based on the expression of the pupils' initial explanations and their ideas, followed by confrontation, suggests that the sequences were designed with the aim of enabling the pupils to access problematised (apodictic) knowledge. This can be explained by the fact that the class was run with a view to highlighting the relationships between different elements of the day's topics. Of course, the expression of this desire does not necessarily condition the involvement of the pupils in the construction of problematised knowledge. This is how we have identified passages that mark the specificity of each practice in the two countries.

For French teachers, the knowledge texts produced at the end of each session summarise passages where the pupils have been able to find the scientific names for the scientific concepts studied (fusion, solidification, germination, etc.) by playing a game of hangman's board before arriving at the gap-fill text to be completed with the words found.



Extract from the text of the knowledge built by the French students

So, for Moroccan teachers, the focus on the pupil's manual led the teacher to carry out typical sessions during which the pupils knew in advance what was expected. As a result, not using the investigation workbook and relying on the exercises in the student handbook led the class to find answers to the questions asked. In this way, the pupils were encouraged to fill in the blanks with words from the student handbook.



Text with holes to be completed by a student

On the basis of the above, we can see the way in which the resources have been invested by the teacher and the extent to which teaching practices adapt them (transforming the resources so that they respond to the pupils' proposals with the specifics of the class or adapt with it) and, as a result, the learning practices follow them in turn. In the cases studied, the game of adapting or transforming the resources used is a feature of the sequences observed in both countries.

5. Discussion

A teacher's professional experience depends on the teaching strategies adopted in which he or she selects, organises and mobilises resources in order to act [...] with relevance in a particular context (Le Boterf, 2002, p. 46). Within this framework, the general characteristics of the practices that emerged from four observations of sequences and data processing enabled us to understand these sides of the teachers' experience in the context of implementing the investigative approach and their choice of resources to mobilise. We use the term 'resources' in a very broad sense. A textbook, official texts, software, advice given by a colleague... all of these can provide resources for teachers' activities and practices (Gueudet & Trouche, 2009b).

Following the two observations made in France (the states of water and plant reproduction), we focused on the resources mobilised by the two teachers. In this respect, we found that, in both sequences, the types of resources used by the teachers could be summed up as follows:

- School curricula (the skills to be worked on are detailed on the school's ENT site),
- Exchanges with colleagues,
- Digital aids (videos, software to mimic fruit formation),
- Other resources linked to experiments carried out in the classroom (fusion, consolidation, dissection of the rapeseed flower).

On the basis of the skills to be developed (curriculum), teachers set out to find appropriate resources for what they are planning to implement. Exchanges with colleagues and digital resources remain the main sources on which teachers base their science teaching. In this respect, we have noted that, depending on the resources chosen, the way science is taught determines both the space for action by the pupil and the teacher. And as a result, the sequence of science moments is followed by the choice of when to introduce these resources and how the teacher uses them with the pupils.

From these two sequences studied, we were able to distinguish two cases (modelling and real experience) in which the resources mobilised were invested in two different situations. In the first, the teacher forced the introduction of these resources to guide her class (refusing some of the pupils' suggestions to impose the one linked to the resources available to her). In the second case, the teacher, while anticipating the students' proposals and their opinions, was able to guide her teaching towards what she wanted to achieve without any unforeseen circumstances. As a result, these resources are used to define the teachers' practices and the way the teaching is conducted.

In Morocco, the new 2021 curriculum explains; in the paragraph talking about the conditions for the implementation of an investigation-based education that The textbook, particularly the learner's book, is neither a starting point nor an end; whereby the lesson becomes a sequential completion of the various activities and exercises included in the book without modification or diligence. Nor should it be a substitute for real situations and more appropriate means and methods." (Program Directorate, 2021a). In our study of the sequences observed in Morocco, teachers rely on the textbook to teach science as all steps, experiments and conclusions are written down and explained to the teacher and student. We have seen that the textbook provides a number of services to both teacher and student, the most important being:

- Explains the steps to follow.
- Clarifies the objectives and what will be achieved at the end of each session, presenting images of experiments and manipulations that confirm or disprove assumptions made.
- The texts of knowledge with holes to be completed.

Another point to be taken into consideration is that the textbook remains in the classroom for correction (assign a note after each session) and is subject to inspection by the inspector to follow up on the teacher's work. But the majority of students have at home textbooks that are revised from the previous year, allowing them to prepare for the lesson with their families before arriving at school. As for the research book mentioned in the student's manual, teachers do not use it and simply write only on the textbook the knowledge they have achieved. We therefore find that the student's manual next to the teacher's guide is an essential resource for conducting science teaching. This makes the sequence of steps and teacher activities linear and without any change or diligence

In this respect, we were able to identify two teaching practices:

- The first is centered on what the teacher has as a resource to build a text of knowledge.
- The second anticipates student responses and proposals for conducting science education.

All the activities related to the resources mobilized by the teachers have given rise to moments of construction of texts of knowledge. In this title, we have focused on the trio studied: resources – practical – namely, from the analyses of the observed cases that make it impossible to conduct science education based on mobilized resources leading to scientific knowledge. We have identified that teaching science in primary or secondary schools in a formal, investigation-based setting is virtually centered on two essential elements:

- - Involve students and perform manipulations, observations and experiments in the classroom.
- Involve students or give more space to students

The above mentioned didactic intervals of the observed sequences are therefore related to the way in which the teacher mobilizes resources and conducts his teaching.

Thus, we have come to the point where support for resources to conduct a declared investigation-based teaching gives more space to teaching activities at the expense of the space given to students (first sequence). As a result, the knowledge to be built opened up on moments of exchange during which students are led to give answers to be validated or rejected by the teacher. In addition, the use of modelling (difficulty in conducting experiments in the classroom) did not allow the teacher, from her point of view, to leave too much hand to the students to propose and test their ideas on how fruits are formed. So, according to the teacher, the videos presented facilitated the abstraction work that helped students do what was necessary: bees, wind... play the role of the brush in nature...

In the second sequence, the teacher's anticipation of student responses left more room for discussion, suggestion and manipulation by working groups. The debates led by the teacher focused on moments of problem construction (diagram, explanatory model of the change in the state of matter...) during which the class produced arguments «for» and «against» related to the questions asked (how to melt ice faster- the idea of heat-, what is ice, how can we have ice...).

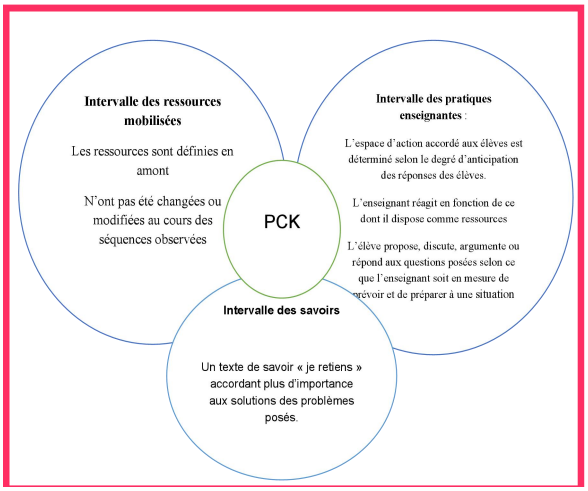
In both cases, the support of teachers on the resources they have available allows them to conduct science education differently:

- Guiding the class to what the teacher expects from the resources introduced. This engages students in a work of observation and abstraction made possible by the schematization made from videos. The teaching and learning activities are therefore guided by what the teacher presents as resources while focusing class work on checking assumptions (the floral parts responsible for transforming the flower into fruit).
- Leaving it to the class to propose and validate or not the assumptions made. In this case, anticipating student responses allowed the teacher to give students more room for action.

6. Conclusion

To conclude, we have almost reached the point where the resources defined upstream by the teacher in teaching science guide his teaching practices and determine the process of transmission or construction of knowledge (Orange, 2007). Certainly, teachers talk about the investigative approach and the scientificity of knowledge that would be realized, according to the statements of teachers, once students participate in the realization of experiments, manipulations... However, the idea of problematization is not present in teachers' practice. The text of knowledge answering questions, asked at the beginning of each session, refers to what the teacher was looking for at the beginning and that the resources mobilized were invested to reach the goal intended by the teacher.

The following diagram summarises the interaction of the didactic intervals of the sequences observed in France.



Didactic action intervals of the two sequences observed in France

In the French institutional context, the investigative approach is opposed to that of presentation and illustration and values an inductivist approach (Coquidé et al., 2009, p.52). Similarly, the new 2021 Moroccan curriculum adopts an investigative approach to create situations in which learners assume the role of scientists, observe phenomena, ask questions about them, Provide possible explanations, design and conduct tests and surveys to support or disprove their theories, analyse data, draw conclusions and design and construct models. The involvement of the learner in scientific learning that adopts an investigative approach will "allow him or her to gradually acquire concepts, knowledge and skills" (Direction des programmes, 2021, p. 356).

For the French teachers, the texts of knowledge built at the end of each session summarize passages where students were able to find the scientific name of the studied scientific concepts (fusion, solidification, germination...) by games of the hanged before arriving at the text with holes to be completed by the words found. So, for the Moroccan teachers, the focus on the student's manual led the teacher to carry out typical sessions during which students know beforehand what is expected. The non-use of the research book and the support given to the exercises in the student's manual led the class to find answers to the questions asked. Thus, the students were led to complete texts with holes by words proposed in the student's manual.

From what has been said, we can see how the resources have been invested by teachers and to what extent teaching practices adapt them (the transformation of resources so that they respond to students' proposals with class specificities or adapt with it) and, as a result, learning practices follow them in turn. In the cases studied, the game of adapting or transforming the resources mobilized is seen as a characteristic of the sequences observed in both countries.

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