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Problem-based assessment and its impact on pupils' learning: The case of science subjects

Abderrazzak MAZOUAK [1], Aziz MOUMEN [2], Maryam NADIR [3]

1. Regional Center for Education and Training Professions –Fez–Meknes Region, Fez, Morocco
2. Regional Center for Education and Training Professions –Fez–Meknes Region, Fez, Morocco, and Hassan II University of Casablanca, Morocco
3. Kenitra Institute of Sports Professions, Morocco

Abstract

Problem-based learning is one of the teaching tools used in the organisation of learning and assessment activities to implement the competence-based approach. New institutional recommendations within Morocco's formal education curricula, particularly at secondary level for science subjects and specifically for the natural sciences, emphasise the importance of problem-based learning and assessment activities in developing learners' problem-solving skills (one of the 21st-century skills). However, international reports assessing learners' ability to solve problem-based situations have highlighted the poor performance of Moroccan learners in solving scientific problems. This finding led us to examine the practice of problem-based assessment among science teachers and to conduct research aimed at elucidating their conceptions of problem-based assessment.

We opted for a questionnaire as an exploratory research tool, administered to science teachers as a means of gathering information, with the aim of identifying the degree of consistency and discrepancy between what teachers actually believe and what they should believe, from a didactic perspective, regarding the assessment of learning through problem-based situations.

This research has revealed a certain discrepancy in the transfer of this strategy from the theoretical stage (didactic research) to the practical stage (teaching practice).

Keywords: Design – Assessment – Problem-based situation – Problem-posing – Problem-solving.

Research question

Problem-solving is a complex, high-level intellectual activity; it is also a teaching and assessment strategy used to facilitate learning and to evaluate it. However, problem-solving only occurs if there is genuinely a 'problem' for the learner; in which case we no longer speak of 'problem-solving' but rather of a specific situation, the 'problem situation'. Sometimes a teaching and learning strategy, sometimes a strategy for assessing problem-solving skills, and sometimes the characteristics of a learning and assessment situation, the problem situation is very often all three simultaneously.

In Morocco, since 2002, problem-based teaching, learning and assessment has provided a methodological framework for implementing the competence-based approach, given the effectiveness of this teaching strategy in that it improves learners' outcomes, and in that it helps to prepare citizens who are able to draw on and apply their academic knowledge to solve real-life problems in their daily and professional lives.

However, current evidence suggests that young people, as products of the Moroccan school system, face difficulties in integrating into social and professional life. Consequently, international assessment reports, based on learners' ability to solve problem-based situations, have highlighted the poor performance of Moroccan learners in scientific subjects (Maghnouj, 2018) .[1]

In this study, we seek to explore an aspect that has recently become the focus of several studies in educational pedagogy: teachers' assessment practices. We therefore hypothesise that the gap between the effectiveness of problem-based teaching and assessment and the poor performance of Moroccan learners in science subjects is partly linked to teachers' conceptions of problem-based situations as an assessment tool.

Our overall objective is to analyse teachers' conceptions of assessment using problem-based situations. We will not limit ourselves to this analytical approach, but will integrate it into a broader research framework that takes into account the conceptions of the developers of the Moroccan science curriculum and textbooks on the same subject.

In this study, we will identify the conceptions held by science teachers regarding the use of problem-based situations as a tool for formative assessment.

Conceptual and theoretical framework

I. Problem-based situations in educational research

1 Meirieu's generalisation

Several definitions have been put forward for the problem-based situation; Meirieu summarises the definition of this teaching tool as 'a situation in which the learner is set a task that they cannot complete without acquiring specific knowledge. This learning, which constitutes the true objective of the problem-based situation, takes place by removing the obstacle to the completion of the task' (Philippe, 1990) .[2]

He thus defines the problem-based learning situation as the organisation, by the teacher, of a learning process with the following characteristics:

- It triggers a desire to learn in the learner;

- The learner carries out a task which presents a problem for them;

- The task compels them, through the constraints of the instructions, to undertake a learning process;

- This learning enables them to construct the mental operation corresponding to the targeted knowledge;

- The learning objective targets the obstacle to learning. This is referred to as the 'obstacle-objective';

- The constraints of the task ensure the construction of knowledge.

2 The problem-solving situation according to Astolfi

Science education highlights the crucial role that epistemological obstacles can play in learning. Astolfi (1993) defined several characteristics of the problem-based situation:[3]

- A situation aimed at overcoming an obstacle identified by the learner(s).

- A concrete situation, which enables learners to formulate hypotheses;

- A situation that enables the learner to break the problem down;

- A situation that motivates the learner and leads them to acquire the intellectual tools necessary to construct a solution;

- A situation that offers the learner the opportunity to express their ideas and to question them;

[1] Maghnouj, S., et al. (2018), OECD Reviews of the Education Assessment Framework: Morocco, OECD Publishing, Paris.

[2] Meirieu, Ph. (1990). Learning, yes, but how? Paris: ESF.

[3] Astolfi, J.-P. (1993). 'Three paradigms of research in didactics', Revue française de pédagogie, No. 103, pp. 5–18.

- Resolving the situation must not be beyond the learners' reach;

- A situation that encourages learners to debate and triggers socio-cognitive conflicts;

- A situation that allows for reflective feedback in order to consolidate problem-solving strategies.

3 Tensions relating to the design of the problem situation according to Fabre

Mr Fabre highlights four tensions relating to the problem situation (Fabre, 1999) : [4]

- **The tension between the situation and the problem-situation**: Depending on the importance attached to error and the learner's awareness of the problem, the problem-situation seems to oscillate between the 'success-understanding' model and the 'failure-correction' model. There are, in fact, two schools of thought: one that emphasises continuity, derived from an interpretation of Piaget, and one that emphasises rupture, derived from an interpretation of Bachelard. In the first case, it is a continuous approach that tends to reduce the problem situation to the mechanisms of situational pedagogy. In the second case, it is rather the emphasis on rupture that is brought to the fore. It is the learner's realisation of the problem that is most important.

- **The tension between the objective and the 'objective-obstacle**': There are two interpretations of the obstacle. Sometimes it is understood in a broader sense as a lack of knowledge or difficulties. At other times, it is conceived in its strictly Bachelardian sense. In the first case, the situation focuses on a 'possible objective'. In the second case, the obstacle requires an epistemological analysis of the learners' conceptions. For, according to Bachelard, the obstacle never evokes in the mind a lack of knowledge or culture, but always, on the contrary, the presence of a primary, unquestioned culture. We then speak of an 'objective-obstacle'.

- **The tension between resolution and problematisation:** What is the aim of a problem-based situation? Is it to resolve the problem or to construct it?

- **The tension between pedagogical management and didactic management:** Two ways of managing a problem situation. Either the epistemological issues at stake in the intended learning are identified. In this case, a didactic perspective is brought into play. Or the focus is on the teaching approach without addressing the problem itself. In this case, we speak of pedagogical management.

4 The key features of the problem-based situation.

Drawing on pedagogical and didactic research into problem-based learning, Musquer and Fabre have identified significant features of the problem-based learning situation (Musquer & Fabre, 2010) :[5]

- It stages knowledge in such a way that what is to be learnt emerges following an investigation or the formulation of a problem. The problem-based situation aims at the acquisition of new knowledge, preferably of a conceptual nature;

- The problem-based situation constitutes a challenge, or a critical situation. The problem must remain within the learner's zone of proximal development;

- The problem-based situation requires the learner to take ownership of the problem. Taking responsibility for the problem is a prerequisite for committing to its resolution;

- It enables the learner to assess their own performance without the teacher's intervention. The most important thing is not whether the task is successful or not. The key is to understand why one succeeded or failed.

II. Assessment as a learning opportunity through error

Assessment is a pedagogical tool tailored to pupils' needs, as it is integrated into the learning process. Indeed, it helps to highlight errors and gives learners the opportunity to take stock of what they have learnt; it can also serve as a means for

[4] Fabre, M. (1999). *Problem-based situations and academic knowledge*, Paris: PUF.

[5] Musquer, A. & Fabre, M. (2010). Between research and teacher training: working within the zone of proximal professional development. Recherche En Education. Special Issue No. 2, pp. 47–61. Onlinehttp://www.recherches-en-education.net/IMG/pdf/REE-HS-no2.pdf.

teachers to adjust and modify their methods and to suggest remedial strategies to learners.

1. Definition of assessment

Several definitions have been put forward for the assessment of learning; these can be classified into three main groups: those focused on the degree to which objectives have been achieved; those emphasising the notion of judgement; and those highlighting decision-making. In terms of choice, we may adopt De Ketele's (1988) definition, which we consider to be the most comprehensive: 'To assess means: to gather a set of sufficiently relevant, valid and reliable pieces of information, and to examine the degree to which this set of information corresponds to a set of criteria appropriate to the objectives set at the outset or added along the way, with a view to making a decision'[6] .

2. Types of assessment

There is a wide range of assessment types that can be grouped into three main categories; these correspond to three key stages of the teaching-learning process (beginning, middle and end), with three fundamental functions (anticipation, regulation and stocktaking).

- **Diagnostic assessment:** This takes place before the start of a teaching sequence; it helps to identify learners' prior knowledge and preconceptions regarding the subject matter to be taught. This type of assessment guides the strategy chosen by the teacher.

- **Formative assessment:** This takes place during the learning process and is useful for both the learner and the teacher. Indeed, it provides an opportunity for the learner to assess their progress in the learning process, recognise their level in relation to the set objectives, and identify and reflect on their mistakes. Formative assessment offers the teacher an opportunity, after addressing pupils' errors, to put in place remedial measures and adjust the course of the learning process.

- **Summative assessment:** This takes place at the end of a learning sequence; its role is to highlight the skills and knowledge acquired by the pupil at the end of the learning process. It enables the teacher to determine whether or not the objectives set at the outset have been achieved, and results in grading and certification. Furthermore, this type of assessment can guide the teacher's work by enabling them to refine their approach in light of learners' errors; this constitutes a form of remedial work, albeit less in-depth than that which follows formative assessment.

3. Error management according to pedagogical models

The status accorded to error is closely linked to the conception of learning; indeed, this conception has undergone a significant evolution over time.

- **The transmissive model:** this model regards learning as a linear process of transmitting knowledge to the learner. The pupil is seen as an 'empty vessel' with no prior understanding of the subject. According to this view, the pupil's error is regarded as a 'mistake'. *'Under such a conception, errors can have no other status than that of failures within a system that has not functioned correctly and which must be punished*.'[7]

- **The behaviourist model:** this model is based on the work of Thorndike, Skinner, Watson and Pavlov. Emerging in the early 20th century, behaviourists define the mind as a 'black box' to which we have no access, and therefore propose focusing on the learner's observable behaviours. This model advocates teaching by breaking learning down into sub-steps and providing positive reinforcement when learning has taken place. Thus, the typical teacher following this model is one who carefully plans their teaching progression by setting precise, targeted objectives focused on the skills pupils need to acquire, whilst the pupil's role is to follow the steps proposed by the teacher. In this model, mistakes are also viewed negatively. J.P. ASTOLFI uses the term 'bug' in reference to computer science. In effect, the teacher has designed a programme which they have passed on to the pupils. Errors arise because the pupil is unable to run this programme, as it has been 'installed' incorrectly. They are synonymous with the teacher's poor or inadequate breakdown of the learning process. They therefore necessitate a review of the established progression. Breaking the process down into sub-objectives helps to minimise learners' errors as much as possible.

[6] De Ketele (J-M) and Chastrette (M), et al., 1988, Guide for Trainers, DE BOECK-WESMAEL S.A., p. 183

[7] Astolfi (J-P), 2009, 'Errors: A Means of Teaching', ESF Issy-les-Moulineaux, p. 23

- **The constructivist model:** this model is based on the work of Jean Piaget; it focuses on the learner's cognitive and intellectual processes, thereby assigning a key role to pupils' spontane e conceptions. Starting from this initial state, the learner constructs their own knowledge, whilst the teacher acts as a guide and facilitator, implementing strategies suited to this approach. According to this view, error is an integral part of the learning process. Error becomes a teaching tool that helps to understand the obstacles to the transmission of knowledge and skills. Here, error takes on a positive role; for the pupil, it represents an obstacle on the path to constructing their knowledge.

Research methodology

1. Research question

To what extent do secondary school science teachers' conceptions of problem-based situations as a tool for assessing learning align with the key features of this teaching tool?

2. General research objectives

To address our research question, we opted for a questionnaire divided into two parts: The first part aims to collect socio-demographic information on the teachers surveyed. The second part has two general objectives:

- To identify teachers' attitudes towards the use of problem-based situations during the assessment process.
- To identify teachers' conceptions regarding the use of problem-based situations during formative assessment.

3. Specific research objectives

These general objectives are broken down into specific objectives derived from our research question and our theoretical and conceptual research framework. Table 1 summarises the objectives and the items corresponding to each of these objectives:

To determine the **frequency** with which this tool **is used** during assessment.
To identify the **stages at which it is used** during the assessment process.
To determine the **frequency** with which this assessment tool **is developed**.
To identify the **resources used to develop** this assessment tool.
To identify the **reasons for** using this tool during assessment.
Identify the **epistemological** issues surrounding the knowledge being assessed.
Identify the status of **problem-posing** in a problem-based situation
Identify the assessment **approach** used in the problem-based situation.
Identify the importance attached to **the objective-obstacle**.
Identify the status of **the error** when it occurs.

4. The questionnaire

4.1. The choice of questionnaire

We opted for the questionnaire because it was well suited to our research objectives. It enables us to gather a large amount of information and to reach a large number of individuals within the target population.

4.2. The choice of questions

We were keen to ensure that the questions varied in form. A few open-ended questions through which we hope to capture the conceptual structure underlying certain key concepts of problem-based assessment. Respondents are invited to answer using their own vocabulary and within their own frame of reference. However, the questionnaire has its limitations when it comes to these open-ended questions, as we are often left with responses that are difficult to interpret. This is why we have relied on multiple-choice questions (MCQs) to place respondents in situations that will encourage them to think carefully.

We are also aware that teachers' conceptions of their strategies for assessment through problem-based situations cannot be directly gleaned from answers to simple questions, but must be inferred from thoughtful responses in relation to real-life situations. We therefore deemed it necessary to identify appropriate and relevant questions and to contextualise them.

Our questionnaire, through the contexts it presents and the questions it poses, therefore serves as a means of eliciting respondents' conceptions by engaging them. However, the responses collected cannot be regarded as true conceptions. 'What a person expresses […] does not directly reflect the totality of their conceptions, but only their situational conceptions: those that are mobilised […] in that specific situation' (Clément, 1994) .[8]

4.3. The reference responses

The reference answers in our questionnaire are drawn from the theoretical framework for problem-based situations developed by the team at the Nantes Centre for Educational Research (CREN – France), which emphasises the construction of problematised knowledge and the mental processes involved in problem-solving during problem-based situations in assessment and learning.

5. Selection of the target population

The survey population consists of secondary school science teachers at lower and upper secondary levels, as the problem-based teaching and assessment strategy is officially required to be implemented in the classroom at both levels.

We limited our sample to 160 upper secondary school science teachers working in two provincial delegations in Morocco – Taza-Fès – given that the total number of science teachers in these two delegations is 384. Our sample therefore represents a significant proportion (41.66 per cent).

Presentation, analysis and discussion of the results

Question 1: Do you use problem-based situations when assessing learning?

This question aims to identify the frequency with which problem-based situations are used as an assessment tool. The results are presented in Table 3.

Table 1: Frequency of use of problem-based scenarios.

	Never	Sometimes	Rarely	Often	Always
Actual	1	62	19	62	16
Percentage	0.63%	38.75%	11.87%	38.75%	10%

Only 10 per cent of teachers state that they always use problem-based tasks in assessment; 38.75 per cent of respondents say they use them often, 38.75% use them sometimes, 11.87% state that they use them rarely, whilst only one teacher states that they have never used them when assessing learning; consequently, the responses from this latter case are not included in the results presented in the following items, which **explains the total sample size of 159 teachers.**

The use of this teaching tool in assessment practice remains limited in relation to the objectives set out in official documents. Indeed, there is a gap between what is prescribed (official documents) and what is experienced in practice (teachers' practices).

Question 2: When do you use problem-based situations in your assessment practice?

This question aims to identify the points at which problem-based situations are used during the assessment process. The results are presented in Figure 1.

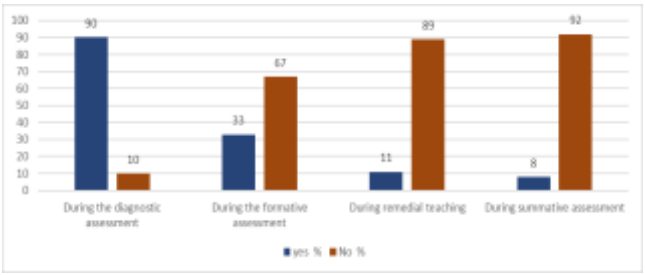


Figure 1: Stages at which problem-based situations are used during the assessment process.

The responses to this question show that 90 per cent of teachers believe that a problem-based scenario should be presented at the start of the assessment process as a didactic diagnostic assessment scenario. 33 per cent of our sample use the problem-based scenario during formative assessment, whilst 11 per cent regard it as a remedial tool.

[8] Clément, P. (1994). Representation, conception, knowledge. *In* A. Giordian, Y. Girault and P. Clément (eds.). *Conceptions and knowledge* (pp. 15–45). Bern: Peter Lang.

It can be seen th the use of problem-based scenarios decreases as the assessment process progresses from the early stages to the later stages.

Problem-based scenarios can be used during the teaching and learning process and throughout the assessment process. They enable learners to reflect on their problem-solving approaches. Most of the teachers surveyed regard the problem- situation merely as a tool for triggering learning, structuring it or assessing learners' prior knowledge, whilst failing to recognise that using the problem- situation during the assessment of learning would make it possible to verify learners' ability to apply what they have learnt to solve real-life problems.

In practical terms, and to ensure effective teaching, *Roegiers* proposes two ways of introducing problem-based situations (Roegiers, 2007) [9] : situations prior to learning and situations following the integration of learning. This author points out that incorporating such situations into the assessment process within a school system requires a high level of teacher training and motivation, adequate facilities and resources in schools, and smaller class sizes.

Question 3: Do you devise problem-based scenarios yourself when assessing learning?

This question aims to identify the frequency with which problem-based scenarios are devised during the assessment process. The results are presented in Table 4.

Table 2: Frequency with which teachers design problem-based assessment scenarios.

	Never	Sometimes	Rarely	Often	Always
Number of staff	4	62	25	51	17
Percentage	2.52%	38.99%	15.72%	32.08%	10.69%

The responses to this question show that only 10.69 per cent of our sample always develop assessment problem situations themselves, whilst the largest proportion, 38.99 per cent, do so only occasionally. A small number, namely 2.52 per cent, never develop them and use ready-made problem situations.

The reasons given by teachers for the difficulties in devising problem-based scenarios for assessment are explained by a lack of time and resources, an overloaded curriculum and, above all, a lack of continuing professional development on the subject.

Question 4: Please specify the resources used to design a problem-based assessment scenario ?

This question aims to identify the resources used by teachers to develop an assessment problem-based scenario. The results are presented in Figure 2.

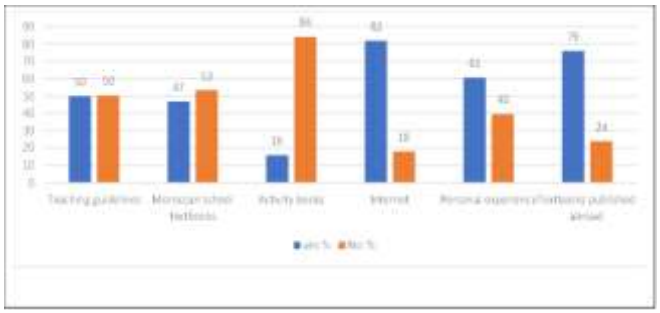


Figure 2: Results regarding the resources used to develop the problem-based assessment scenario.

The results show a variety of resources used by teachers when developing their assessment problem-based scenarios. Indeed, we find that the most frequently used resources are the internet, at 82 per cent, followed by textbooks published abroad (76 per cent). Moroccan teaching guidelines and textbooks are used in almost equal proportions (50 per cent and 47 per cent respectively).

The reliance on the internet stems from the fact that it provides websites featuring databases of assessment problem-based scenarios, discussion and sharing forums, exercises and documents, and, of course, ready-made problem-based learning scenarios that can be adapted for use in assessment.

Question 5: For what reason(s) do you use the problem-based learning scenario during assessment?

This question aims to identify the reasons why teachers use problem-based scenarios during assessment. The results are presented in Figure 3.

[9] Roegiers, X. 2007. Situations for integrating what has been learnt at school. De Boeck

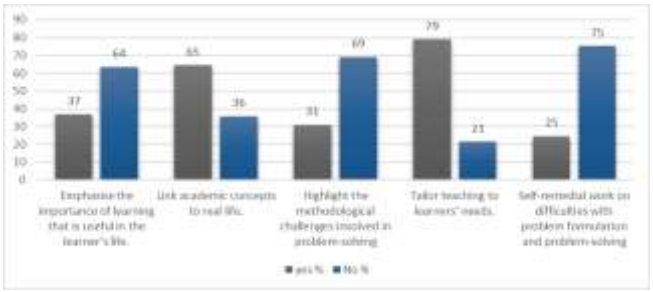


Figure 3: Reasons why teachers use the problem-based scenario during assessment.

The responses to this question show that the overwhelming majority of teachers surveyed (79 per cent) use problem-based learning during assessment to 'tailor teaching to learners' needs, and 65 per cent admit that they use problem-based learning to link academic concepts to real life. However, only 37 per cent recognise the importance of this teaching tool in terms of the practical application of learning in the learner's daily life. Thirty-one per cent justify the use of problem-based scenarios during assessment to highlight methodological difficulties in problem-solving. And a small number (25 per cent) of teachers use problem-based scenarios as an assessment tool to enable self-remedial work on difficulties in formulating and solving problems.

The majority of teachers fail to recognise that the use of problem-based learning as a teaching tool is aimed at developing problem-solving skills, and thus their use as an assessment tool helps to highlight methodological difficulties in formulating and solving problems, particularly as it enables learners to reflect on their learning processes and their ability to use this reflection to overcome their difficulties independently.

Question 6: How do teachers approach the didactic treatment of the problem when planning a problem-based situation for formative assessment?

This question is posed to ascertain whether teachers attempt to identify the epistemological issues underlying the concepts targeted by the formative assessment problem-based scenario. In our case, the aim is to understand how teachers conceived the problematisation of knowledge (epistemological conception). The results are presented in Table 5.

The majority of teachers, namely 66.7 per cent, stated that when planning a formative assessment problem-based scenario, they sought to contextualise the problem in relation to the concept within a framework familiar to the learner. 11.3 per cent stated that they looked for a ready-made resource from school textbooks. Only 15.09 per cent and 6.9 per cent of teachers – a total of 22.01 per cent – demonstrated an epistemological approach to the didactic treatment of the problem when planning a problem-based formative assessment scenario. These teachers express a preference for exploring, from a historical perspective, the problems that led to the development of a concept (historical approach) or for identifying the current challenges posed by the concept in Life and Earth Sciences and other disciplines (interdisciplinary approach).

Question 7: What are teachers' intentions when carrying out formative assessment of learning through problem-based situations?

This question is asked to ascertain the recommended approach when carrying out formative assessment of learning through problem-based scenarios. Is it focused on the construction of the problem or on its resolution? The answers to this question are presented in Table 6.

Table 3: Results of the problem-construction versus problem-solving dichotomy in formative assessment using problem-based learning.

My intention during formative assessment using problem-based learning is:	Sample size	Percentage
The learner's resolution of a problem.	72	45.28%
The learner identifying a problem.	43	27.04
The learner's success in the task set for them.	31	19.5
Helping the learner understand why they failed.	13	8.18%
Other:	0	0%

A large number of teachers – 45.28 per cent – state that their aim when using problem-based formative assessment is for the learner to solve a problem. 19.6 per cent of teachers indicate that their aim is for the learner to succeed in the task set. Therefore, the majority of teachers – 64.88 per cent (= 45.28 per cent + 19.6 per cent) – favour a problem-solving approach. 37 per cent of teachers take into account the importance of the learner identifying the problem and engaging in cognitive activity.

It would therefore appear that the problem-solving approach is the most commonly practised. However, it is undoubtedly in the process of problem-formulation that the learner's highest level of cognitive activity lies. The emphasis is placed on the solution itself, to the detriment of genuine problem-formulation.

This observation highlights the need for teachers, in their practice of problem-based assessment, to develop a multidimensional problematisation involving the identification, construction and resolution of the problem.

Question 8: What are teachers' views on the formative assessment approach based on problem-based situations?

This question is asked to ascertain the approach recommended by teachers when carrying out problem-based assessment. The responses to this question are presented in Table 7.

Table 4: Teachers' views on the formative assessment approach using problem-based scenarios?

During a problem-based formative assessment situation:	Number of respondents	Percentage
I present a general piece of information and ask the learner to verify it.	9	5.66%
I start with several facts or observations, clarify the problem to be solved, and guide the learner to formulate a hypothesis to confirm it and arrive at a piece of knowledge.	87	54.7%
I start with the learners' preconceptions; I challenge them within a context familiar to the learner; I give them the freedom to ask questions and experiment, then to verify or refute their ideas, leading to new knowledge.	49	30.82%
I start with the components of a reality to construct that reality (from the simple to the complex)	14	8.81%
Other:	0	0%

During their formative assessment using problem-based scenarios, several teachers – representing 54.7 per cent – stated that they begin with a number of facts or observations, specify the problem to be solved, and then guide the learner to formulate a hypothesis in order to confirm it and thereby arrive at a conclusion. 8.8 per cent of our sample stated that they start with the components of a reality to construct that reality (from the simple to the complex). Therefore, 63.5 per cent of teachers – the sum of the two preceding percentages – predominantly use the inductive approach in their practice of formative assessment through problem-based learning. This empiricist and positivist approach, which takes observation as its starting point, remains very prevalent amongst science teachers. And this traditional approach to problem-based assessment explains the difficulties encountered by Moroccan learners in international assessment contexts.

We can therefore conclude by highlighting the inductive and empirical tradition that characterises the approaches of a large number of science teachers when implementing problem-based assessment.

Question 9: How do life and earth sciences teachers interpret the obstacles to learners' learning during formative problem-based assessment situations?

This question is asked to determine how teachers interpret obstacles during formative assessment using problem-based scenarios. The results are presented in Table 8.

Table 5: Results of the consideration of obstacles during formative assessment using problem-based scenarios.

The difficulties encountered by learners during the problem-based formative assessment scenario are interpreted as:	Number	Percentage
A lack of background knowledge or understanding of the subject on the part of the learner.	60	37.74%
A shortcoming in my planning of the assessment problem situation.	22	13.84%
The presence of an obstacle that I must not reveal to the learner.	23	14.47%
The presence of an obstacle that I need to make visible to the learner.	54	33.96%
Other:	0	0%

Several teachers, representing 37.7 per cent, state that learners' obstacles to learning are interpreted as a lack of cultural understanding or knowledge on the part of the learner regarding the subject. Others, representing 13.8 per cent, state that the obstacle is interpreted as a flaw in their planning of the problem-based assessment situation. Therefore, more than half of the teachers surveyed – 51.5 per cent – are unaware

that one of the essential characteristics of a problem-based scenario is the presence of obstacles, and that learners' conceptions and thinking habits constitute such obstacles. These teachers are unaware that obstacles must be taken into account when designing a problem-solving situation.

These findings are consistent with the above, as we found that 63.5 per cent of teachers primarily use the inductive approach when carrying out formative assessment through problem-based scenarios.

Summary

The analysis and discussion of the questionnaire results enabled us to identify science teachers' conceptions regarding several criteria of problem-based assessment.

- The first section, concerning teachers' attitudes towards the use of problem-based assessment, enabled us to draw the following conclusions:

- The use of this teaching tool in assessment practice remains limited in relation to the objectives set out in official documents.

- The use of this tool decreases as the assessment process progresses from its early stages to its later stages. Most of the teachers surveyed consider problem-based learning to be merely a tool for assessing prerequisites (diagnostic dimension) in order to tailor teaching to learners' needs, whilst overlooking the fact that the use of problem-based learning in assessment makes it possible to verify learners' ability to apply what they have learnt to solve real-world problems (pragmatic dimension), just as they overlook the fact that using problem-based scenarios in formative assessment would enable learners to reflect on their problem-solving approaches and highlight methodological difficulties in problem formulation and resolution, thereby promoting self-remediation (formative and regulatory dimension).

- The majority of teachers are far from devising bespoke problem-based assessment scenarios, and most rely on off-the-shelf scenarios. The reasons given by teachers for the difficulties in devising problem-based scenarios for assessment are explained by a lack of time and resources, the overloaded school curriculum and, above all, a lack of continuing professional development on the subject.

- Teachers' reliance on the internet stems from the fact that it provides websites featuring databases of assessment problem-based scenarios, discussion and sharing forums, exercises and documents, and, of course, ready-made problem-based learning scenarios that can be adapted and modified to tailor them to specific learning difficulties, such as in formative assessment situations.

General conclusion

We are therefore justified in concluding that there is an inconsistency or discrepancy between what educational research says about problem-based learning as a teaching tool and the views held by science teachers.

Faced with the ambiguity of official texts, inadequate initial training and a lack of continuing professional development, teachers may feel they are fulfilling what is required of them without, however, actually employing a genuine problem-based assessment scenario. They apply this strategy during assessments based on their own initiative and their personal interpretation of this learning and assessment tool. Problem-based assessment is, in itself, complex and challenging, and if teachers are led to believe that what they design corresponds to what they are supposed to design, there is no reason for them to question their methods. It is therefore hardly surprising that teachers find it difficult to implement problem-based assessment in their practice.

The aim of this study is to examine the conceptions of secondary school life and earth sciences teachers regarding problem-based assessment. Our approach draws on research in didactics and pedagogy that emphasises problematisation and the mental processes involved in problem-solving during problem-based assessment situations.

Through this study, we have sought to address the question of the consistency between secondary school science teachers' conceptions of problem-based assessment as an evaluation tool and, on the one hand, the theoretical framework of didactic studies, and, on the other hand, the discourse of official curriculum guidelines.

What are the specific contributions of this study? What are its limitations? And what further research might this work inspire? In this general conclusion, we shall attempt to answer these questions in a concise manner.

Contributions of our research

The questionnaire we developed – through the variety of question formats it contains and the range of practical contexts

it presents – enabled us to identify a considerable gap between what educational research suggests and the objectives set out in official documents, on the one hand, and teachers' understanding of problem-based assessment, on the other. Research places greater emphasis on assessing learners' problem-formulation skills; official documents highlight the need to develop the citizens of tomorrow who are capable of resolving real-life problem-based situations in both daily and professional contexts; whilst teachers hold an empirical view of scientific knowledge and advocate traditional, knowledge-transmission-based teaching methods.

Limitations of our research

Like any research study, ours has the following limitations:

- Our research involved 160 science teachers from the (secondary schools). It is exploratory in nature, which means the findings cannot be generalised. However, given the diversity of our sample in academic, professional and socio-demographic terms, we are justified in suggesting that the views of the teachers surveyed regarding this strategy and the difficulties encountered reflect a picture that is fairly close to the reality experienced by a large proportion of science teachers in Morocco in general.

- A second limitation relates to the respondents' answers, not all of which were substantiated; consequently, we were unable to interpret them.

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