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Teaching mathematics in Middle school in Algeria

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Abstract

We show that the middle school second-generation textbook of mathematics, for the first middle school year, is not committed to the new curriculum, at least from the point of view of the acquisition of competencies in problem solving. We present the structure of the textbook, and we study the resolved problems and the proposed problems and exercises to see the solving strategies that could emerge when solving these tasks. Finally, we conclude.

Keywords: Curriculum, textbook, problem-solving, heuristics.

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1. Presentation of the new curriculum and the new textbook

1.1. The new curriculum

According to the new curriculum (reference) (as well as the previous one), we study mathematics for personal reasons and for social ones. The personal ones consist of helping the person acquire an abstraction aptitude, making him able to model reality, to analyse concepts and explain problems. In the middle school, mathematics is supposed at least to enable the person to grasp the scientific path of research consisting of experimenting, making assumptions, observing, arguing and proving. We can read also that the person in this school level is supposed to control some simple techniques in order to study problems and solve them; mathematics should enable him to give sense to mathematical concepts by seeing them in different frames; all these reasons could be reached in practicing problem solving.

The major purpose of the new curriculum is to make learners acquire some skills that help them solve problems. These skills are of three kinds: the global skill, the final skill, and the transverse skill. The global skill is the aptitude to solve problems, the final kill is the control of knowledge by using it to solve problems in number theory, in geometry, and in data analysis and function, and the transverse one consists of acquiring some behaviours resulting from practicing mathematics through problem solving (building concepts, questing strategies, formulating arguments, investigating, listening to others arguments, etc.).

At the beginning of middle school, in the field of number theory, we must begin by building concepts through solving problems, signed numbers should be introduced through a palpable situation, and routine exercises are not sufficient for acquiring the competencies; in the field of data analysis and function, the concept of linearity is suitable to link mathematics to solving problems from different fields of science; geometry is the suitable field to initiate pupils to proving and arguing.

1.2. Education and learning strategies in the new curriculum

The concepts are built through solving problems, and from the beginning of middle school, proving, arguing and using models must be practiced. Problem solving is given the basic place, considering that the pupil is trained to the true mathematical activity which consists of understanding the problem, guessing, experimenting, justifying, redacting, reporting answers and confirming them. Learners work alone and in small groups while solving problems. The teacher must choose educational strategies centred at the learner, he must put himself in logic of learning and guidance. In the classroom, the first step consists of the devolution, by introducing the learners to the problem and then letting them work alone; he leaves them to work on the problem for a while, then he lets them expose their ideas and discusses them, coming after the lap of resume and the lap of the reinvestment of the acquired concepts. All these directives must be done in the frame of the theory of skills acquisition.

1.3. The new textbook of mathematics

The new textbook of mathematics directed to first middle school year consists of three units: number theory unit, data organising unit, and geometry unit. Every unit consists of a set of lessons classified in subunits. Every subunit consists of pairs of four steps: the first pair is ‘recalling–discovering’. Recalling is done through a multiple-choice question, and discovering is done through a series of task. The second pair is for resuming–acquiring, resuming is presented to the student, and acquiring is a series of resolved exercises intended to teach procedures for solving them. The third pair is ‘exercising–evaluating’, exercising for appropriating the procedure, evaluating is done through a list of question whose answers are given briefly at the end of the textbook; the last pair is ‘deepening–integrating’ done by solving non-routine problems, integrating is done through solving a complex problem by answering some questions; there are 14 'integrating' problems, one for each sub-unit. Every subunit contains some instructions for learning how to use communication and information technology (calculators, excel, and geogebra) related to it.

Number theory units consist of calculus on natural and decimal numbers, fractions, relative numbers and literal calculus. Data organising unit consists of proportion and data organising. Geometry unit consist on parallelism and orthogonality, plane forms, plane surfaces (length, area, boundary), angles, axial symmetry and parallelepiped.

We give in Table 1 the number of exercises and the number of deepening problems for every sub-unit of a lesson; in Table 2, heuristics used to solve the situations are described by the authors.

2. Theorical framework

2.1. What is meant by problem solving and heuristics?

Savransky (2000, p. 4) defines a problem as the 'gap between an initial situation, and the desirable situation' and problem solving as ' a single or multi-step transformation of the existing situation to the desirable situation; he then defines a step as critical if the solver cannot solve the problem without it, routine problems (as problems where the critical steps to the desirable situation are known, and non-routine problems as problems where at least one critical step of the solution is unknown to the solver; he defines heuristics as procedures for solving problems (Savransky, p. 12). For Henderson and Pingy (1953) (Wilson, Fernandez & Hadaway, 1993) a task is a problem when there is a goal and some obstacles that hinder the way to it, and the consent of the learner to accept to try to overcome these obstacles. Kantowski (1977) defines a problem when the immediate knowledge of the solver is not adequate to solve it, or when the solver does not have an algorithm at hand to solve it straightforwardly, so the solver must think to solve the problem; he shows also that the use of goal-oriented heuristics increases as the problem solving ability develops. Schoenfeld (Shoenfeld, 1979) shows that students who were trained on using heuristics outperformed those who were not trained.

2.2. Polya general strategies and heuristics

Polya (1945) described four general strategies for problem solving. First, the stage of preparation by understanding the problem, which consists of extracting information from the given, determining the goal of the problem, reformulating the problem; second, the stage of thinking by devising a plan, consisting of making a general plan and selecting relevant methods and heuristics; the third stage is the stage of the insight, which consists of carrying out a plan devised before, and finally the stage of verification by looking back to check the steps. During the devising plan strategy, many possible heuristics could emerge, among them: 'change point of view' by approaching the problem from different perspectives when the previous ones fail, 'guess and check' by guessing an answer and checking its validity and if necessary repeating this procedure by making other more reasonable guesses, look for a pattern in the given by careful observation or by making a table to organise the data, restate the problem by rephrasing it in different frames, simplify the problem by changing the complex situation by a simpler one, divide the problem into simpler ones and then solve them one by one, use visual representation to model information in the problem, work backwards from the solution to find what conditions are needed, use an equation to model the problem and use deduction by making logical reasoning.

2.3. Textbooks in curriculums

The curriculum could be considered as a mixture of goals, contents, instructions, evaluations and tools (Kilpatrick, 1996, p. 7). Four aspects of the curriculum have been seen (Schmidt et al., 2001), the first is the intended curriculum, which reflects the political intentions of a country concerning education, and could be found in the official document of the education ministry, this aspect of the curriculum appears particularly in textbooks, teacher books, and the examination contents (Robitaille et al., 1993, p. 27). The second aspect is the implemented curriculum, which appears in the classroom and consists of the mathematical contents to be studied; the contents are translated to the students by the teacher (Schmidt, McKnight, Valverde, Houang & Wiley, 1997). The third aspect is the achieved curriculum and could be noticed on students in the classroom by evaluating them through exams and homework (Robitaille et al., 1993, p. 29). The fourth aspect is the potentially implemented curriculum, represented by textbooks; textbooks are the translation of the intended curriculum into potential tasks (Schmidt et al., 1997) and are considered as the most important tool to implement the intended curriculum in many countries (Valverde, Bianchi, Wolf, Schmidt & Huang, 2002).

3. Methodology

We have used the definition of Savransky to analyse the textbook problems and separate the routine problems from the non-routine ones; since every exercise and every problem can be considered as a tool to evaluate some acquisitions and some skills, the teacher when solving them is an appropriate person to decide if the tasks given in the textbook are routine or non-routine problems because he knows the non-critical steps for the learner. They are those that are supposed to be stepped by using resources supposed to have already been acquired by the learner according to the curriculum. The same could be said for the deepening problems. In the deepening classified as non-routine problems the heuristics described are some of the possibilities as heuristics. We looked for the implicit and explicit theories of learning from the intended curriculum to see whether or not the textbook is faithful to them in the case of solving problems.

Table 1. Exercises and problems of the textbook

Sub-units	Exercising	Deepening problems
1. Naturel and decimal numbers	41	5
2. Adding and subtracting natural an decimal numbers	17	9
3. Multiplying and dividing natural and decimal numbers	47	9
4. Fractions	39	8
5. Relative numbers	21	13
6. Literal calculus	18	12
7. Proportion	34	6
8. Organising data	17	4
9. Parallelism and orthogonality	26	8
10. Plane forms	33	7
11. Plane surfaces	37	11
12. Angles	41	7
13. Axial symmetry	24	8
14. Parallelepiped	15	15

Example of proposed deepening problem in the new textbook

Problem 7 page34

The weight of Younes and Ines together is 47.9 kg, the weight of Younes and Mohamed together is 66.25 kg, and the weight of all of them together is 82.65 kg. What is the weight of each one of them.

Problem 8 page 66

Consider the number $A = 5\Delta 2*$ where the hundred digit and the unit digit are unknown.

a. Give some numbers A divisible by 2 and 5
b. Give some numbers A divisible by 2 and 3
c. Give some numbers A divisible by 3 and 4

Table 2. Heuristics used in 'integrating' problems in the textbook

Sub-units	Heuristics
1. Natural and decimal numbers	Dressing a table and using entries to solve the situation
2. Adding and subtracting natural and decimal numbers	Simple addition
3. Multiplying and dividing natural and decimal numbers	Dressing a table and making calculus on entries
4. Fractions	Dividing the problem to small problems and solving each one of them
5. Relative numbers	Visual representation by a segment
6. Literal calculus	Using equation
7. Proportion	Dividing the problem to small problems and solving each one of them
8. Organising data	Visual representation by a segment
9. Parallelism and orthogonality	Visual representation by plane geometric figures
10. Plane forms	Visual representation and dividing to small problems
11. Plane surfaces	Dividing the problem to small problems and solving each one of them
12. Angles	Using geometric representation
13. Axial symmetry	Using geometric representation
14. Parallelepiped	Dividing the problems, using geometric representation

Example of 'integrating' problems (fractions)

The perimeter of a rectangular agricultural land is 800 m and its width is 2/3 of its length. We took a non-interest loan of 75,00000 da from the bank. We planted 2/3 of its area with apple trees, one tree in every 12 m^2, and planted the reaming area with pomegranate, one tree in every 17m^2.

What is the mean price of one planted tree?

Note that directives in the form of questions are given to the solver.

Example of evaluating situation (fractions), page 67

A medium school organised a day trip. There were 5 organisers, 1/3 of the pupils of the first-year level and ¼ of the second-year level. We know that the number of the pupils who went to the trip is 243, and that there are 27 pupils of the first-year level more than the number of the pupil of the second year. The price of the trip is 12,800 da. The school paid for 2/5 of the price, the organisers didn't pay anything as well as 12 pupils. The remaining pupils paid equally for the trip. How much did every pupil from this remaining pay?

Example of non-routine deepening problems

Consider 5 points in which no three of them are collinear. What is the number of straight lines that can be drawn? What is this number in the case of 10 points?

Table 3. Heuristics used in the evaluating situations

Evaluating situation	Heuristics
1. Natural and decimal numbers	Look for pattern
2. Adding and subtracting natural and decimal numbers	Use a table and organising data
3. Multiplying and dividing natural and decimal numbers	Use a table
4. Fractions	Modelling the situation, using equation, dividing the problem
5. Relative numbers	Geometric representation
6. Literal calculus	Dividing the problem and geometric representation
7. Proportion	Dividing the problem
8. Organising data	Use table
9. Parallelism and orthogonality	Simple deduction
10. Plane forms	Simple deduction and modelling
11. Plane surfaces	Divide the problem
12. Angles	Divide the problem
13. Axial symmetry	Simple deduction
14. Parallelepiped	Use table and simple deduction

4. Discussion

The second-generation curriculum is putting the skill to solve mathematical problems as the most important one. This means that every learner can become a problem-solver, but the curriculum does not describe how it could be achieved, nor does it point to a known study or a theory of how to do it; besides this, the 'accompanying paper' which is a description of how teachers must proceed to achieve the curriculum goals and the teacher textbook does not mention how heuristics could be acquired nor do they describe some of them on a concrete example. Since the teachers are not educated in the sense of producing problem-solvers, the task is of great demand for them (Shoenfeld, 2007).

We can read that the curriculum is building on the didactical situation theory when it describes how concepts can be built, on the constructivism theory when it says that the concepts must be built, on the bottom-up learning when it declares that the concepts should be studied first through examples before making general statements.

But we can notice that all of the 'integrating problems' are accompanied by a series of questions modelled according to Polya general strategies, questions about reading and understanding the problem, and questions about analysing the situation to choose a strategy, then carrying out the strategy; this is an example of the Topaze effect (Brousseau & Sarrazy, 2002), where the teacher unveils the answers for the students and surmounts their difficulties instead of them. The student is not given the chance to find the questions to ask in order to devise a plan and to carry it out to construct the critical steps to the solution and there are only few heuristics used (Table 2).

In the 'discover part' of the lessons, where the concepts are supposed to be built, the tasks do not contain critical steps, and in the evaluating-situation problems, the heuristics used are immediately seen, and although some problems need to be divided, it remains that the steps are not critical (see Table 3). In the resume part of the lessons, where learners are supposed to formulate in general terms the knowledge objected in the problem situations, with the assistance of the teacher, knowledge is found given to the learner in the textbook, turning the textbook oriented to knowledge, and not to the learner.

The deepening problems are supposed to serve the scientific method of research consisting of experimenting, making assumptions, observing, arguing, proving and discussing. The analysis of the possible solutions of the deepening problems reveals that very few of them are committed to it (see Table 1). They are routine problems except for a few of them. Problem 1 on page 24 is the sub-unit of adding and subtracting natural and decimal numbers: this problem was given in a foreign contest. This problem is not easy, in the sense that one needs to make some trials and rectify them, and then deduce the right numbers. Problem 2 page 52 is the subunit of dividing and multiplying natural and decimal numbers: the solution to this problem needs to know a critical step, which cannot be seen if the student does not link the previous calculus with the new task. Problem 7 page 52-53 is the problem that consists of discovering a rule by inducing it from one multiplication. Problem7 page 66: this problem needs a suitable geometric representation to be solved. Problem 5 page 95 in the literal sub-unit: here the student needs to induce a rule by observing three cases and this cannot be done without linking the property of numbers with the givens, then apply it to other similar problem situations. Problem 2 page 95 in the literal subunit: to make the calculus, the student needs a strategy to do it to deduce a general rule. It could also be done by using a table and looking for a pattern. Problem 7 page 96 same sub-units: this problem needs to find a general model in the form of a procedure and explains the reasons in the results of applying it. Problem 10 page 96 is also a non-routine problem: the first critical step is to letter for one suitably chosen unknown and then write the right equation to solve the puzzle. Problem 11 page 96: the student needs to model the problem by using geometric representation or literal representation of the unknown. Almost all the trials without modelling fail in the first step to solve it. Problem 4 page 144 in parallel and orthogonal sub-unit: to solve it we need to translate the problem from the term of orthogonality to the terms of parallelism by the mean of a known rule. Problem 7 page 144: to solve this problem we need to observe other not given similar situations by using a table and then discovering a pattern that leads to formulate a general rule and then solve the problem. Problem 6 page 178 in the plane area sub-unit: we need to divide the problem to sub-problems by introducing another plane area and solve each of the appearing sub-problems. Problem 8 page 178: to solve it one needs to solve another problem. Problem 10 page 178: to solve it one needs to calculate an area of another known surface constructed by cutting and pasting. Problem 6 page 212 in the sub-unit of axial symmetry: this very difficult problem for first year middle school student could be solved by making all the possible tries and then study the new situation when the probable solution appears. Problem 1 page 229 in parallelepiped sub-unit: it is a problem given in 1995 Belgium Olympiad, to solve it one needs to divide the problem into small problems.

There are 14 sub-units and 16 non-routine problems. The number of supposed non-routine problems is 122. In average, there are 1.15 % really non-routine problems by sub-unit which is very poor. There is no allusion in the curriculum and in the textbook to the use of heuristics except when the curriculum mentions the scientific method stressing on the importance of problem solving.

5. Conclusion

The textbook is supposed to be committed to the theory of skill acquisition; a skill is an actual integration of resources that are concepts, knowledge and procedures, and the skill appears when a learner solves non-routine problems that cannot be realised without developing heuristics and learning to use them. So a skill cannot be built without practicing problem-solving but the textbook is nearly empty of non-routine problems and complex situations, so it can neither serve the theory of skill acquisition and be faithful to the curriculum, nor can it measure the skillfulness of the learners, unless the teacher gets educated in the direction of problem-solving, and the textbook is endowed with many real non-routine problems some of which must be solved in the classroom. The World Wide Web contains many sites dedicated for the objective of the new curriculum, and studies have been done on how to help teachers teach heuristics.

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