CURRICULUM REFORM IN PRIMARY MATHEMATICS EDUCATION: TEACHER DIFFICULTIES AND DILEMMAS

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This paper examines primary classroom teachers' preparedness of implementing a new curriculum model. The new curriculum displays a paradigmatic shift from a behaviourist approach to more of a constructivist one. The development of problem solving skills is particularly emphasised in the new curriculum. Two questionnaires including items on students' different solution strategies to problems are applied to roughly 500 teachers to seek how teachers value and make sense of different strategies. The data reveals that the teachers are not open to different strategies, have difficulties in evaluating students' responses to the open-ended questions and experience serious mathematical difficulties in assessing students' solutions. We discuss issues raised by the findings with regard to the curriculum implementation.

INTRODUCTION

Dissatisfaction with the long-lasting poor conditions of the educational system has compelled the Turkish Ministry of National Education to put the system in the primary level under close scrutiny. Parties concerned with the poor conditions of the system have decided that what need to be done is more than just window dressing. A paradigmatic shift regarding how learning and teaching are viewed and conducted was considered to be necessary. Endeavours in this direction eventually, unsurprisingly, resulted in a massive curricular change at primary level (MEB, 2004).

In Turkey, primary education lasts for eight years. Students are taught by one classroom teacher in the first five years and different teachers who are specialists in their subject areas in the last three years. Compared with the previous one, the new school mathematics curriculum for the first five years in which we are interested in this paper displays a shift from a behaviourist approach to the one with constructivist flavour (Babadogan & Olkun, 2005). It proposes fundamental changes in learning, teaching and assessment. It adopts a student-centred approach where students are active in their learning. More emphasis is placed upon conceptual understanding rather than procedural one. Such macro skills as problem solving, reasoning, communications and use of technology are emphasised (ibid.).

Teachers' roles are redefined and new roles are assigned to them. They are deemed as facilitators rather than sole transmitters. Teachers are expected to conduct activity-based teaching in which students are encouraged to reason, work cooperatively, communicate with others and share their ideas. The new curriculum also proposes changes in terms of how assessment is conducted. Process and performance-based evaluation rather than product evaluation is emphasised. Students' performance evaluation with such tools as portfolios and projects is suggested.

The curricular change works started in 2004. The new curriculum was piloted in the academic year of 2004-2005 and started to be implemented in 2005-2006 nationwide. Classroom teachers were trained only for a week to get to know about the whole new primary school curriculum. As mentioned above, the new curriculum particularly defines and determines new roles for teachers that they were never used to before. With little training, it is not known how well equipped classroom teachers are to handle their new roles. This study takes a step in this direction and aims to shed light on this issue. The question of how we do this is the focus of following two sections.

THE THEORETICAL FRAMEWORK OF THE STUDY

A curriculum with its philosophy behind, at least theoretically, defines and determines roles for students, teachers, school administrators and parents. It does shape how textbooks are written, which technologies and teaching tools are going to be employed, and how teacher education programmes are/should be designed. A curriculum change, therefore, means changes in all these parameters' roles or uses.

The literature provides evidence that change in a curriculum does not necessarily mean a change in the actual classroom practices (e.g. Ball&Cohen, 1996). Cuban (1992) uses the terms 'intended' and 'taught' curriculum to draw attention to this issue and notes that change in the intended curriculum does not easily reflect itself in delivery in classrooms. Papert (2000) also points to difficulties of implementing a new curriculum with the idea(s) behind it. He claims that when ideas go to school they lose their power and are subjected to disempowerment. He notes his appreciation and shares intentions of contemporary movements of school reform but claims that "in practice these would-be reform movements have allowed themselves to be assimilated to School's way of thinking and in the end bolster rather than reform the fundamentals of School mentality they set out to reform" (p. 722).

The reason that the ideas lose their power or meet resistance when they enter the school is perhaps because they enter an institution in which institutional rules are already well-established, organisational patterns are firmly structured, space and time utilisation is well configured, and roles and authority relations are customarily appropriated (Waks, 2003). A new curriculum with a powerful idea behind it means introducing new institutional rules and therefore fundamental changes in all these parameters (Cuban, 1992). Any attempt in this direction would perhaps encounter the resistance of 'the establishment' particularly formed by the school teachers and administrators (Waks, 2003). The resistance against the implementation of a new curriculum does not come solely from within. Such external factors as standard textbooks, achievement tests and university admission requirements can also hinder the implementation of a new curriculum (ibid.).

The related literature suggests that one of the main reasons that new curricula have not a deep influence on school practice is because the influences of teachers on their curriculum had been neglected too often by curriculum researchers and designers (e.g Manouchehri & Goodman, 1998). The lack of research on teacher influence has since forced researchers to examine how teachers cope with the demands of new curricula (e.g. Manouchehri, 1998). A large body of studies have come into being particularly examining teachers' beliefs, practices (e.g. Middleton, 1999), their subject matter and pedagogical content knowledge with reference to new curricula (e.g. Manouchehri, 1998; Ball & Bass, 2003). These studies suggest that teachers' beliefs, experiences, personal theories, level of content and pedagogical content knowledge all have influences on how they teach and implement a curriculum.

Teachers surely have the chief role in the implementation of a new curriculum. With the new curriculum model in Turkey, the big idea is to shift learning and teaching from a behaviourist approach to more of constructivist one. This assigns dramatically new roles and responsibilities to teachers. Development of problem solving skills is one aspect that is particularly emphasised and teachers are expected to create classroom environments in which students' non-standard solutions to open-ended problems are encouraged. In this study, we aim to explore how well-equipped classroom teachers are to take up their new role in this regard through the following two research questions.

- How open are the primary classroom teachers to different solution strategies to mathematical problems?
- How do primary classroom teachers evaluate students' responses to the open-ended questions?

THE CONTEXT AND METHODOLOGY OF THE STUDY

The project that gave rise to this paper set out to investigate the level of preparedness of classroom teachers in coping with the demand of the new curriculum. We aimed to explore this in two phases: (1) to elicit a large group of teachers' preparedness through questionnaires; (2) to follow a small representative sample of the teachers in the classroom settings to see how they get on with the new curriculum. The data we provide in this paper comes from the first phase.

Two questionnaires with open-ended questions were developed to seek whether teachers themselves are actually open to non-standard solutions and value them. Both questionnaires included items regarding mathematical concepts covered in primary school mathematics curriculum. In this paper, due to space limitations, we focus only on one item from each questionnaire. The first item is related to multiplication (item-1) and the second one is concerned with the calculation of the area of a rectangle (item-2). In both items, teachers are presented with students' different solutions to the problems and asked to evaluate these fictional solutions.

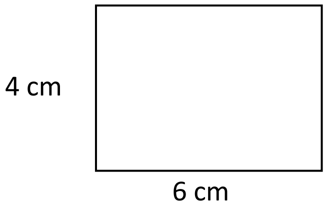
Item-1: $\begin{array}{r} 32 \\ \times\ 25 \\ \hline \end{array}$ Below students' three different responses to this multiplication are presented. All three students have reached the same result. Please evaluate each response and explain which one or ones you would accept as an answer and why? (adopted from Ball & Bass, 2003).

A
32
x 25
160
64
+ 800

B
32
x 25
10
150
40
600
+ 800

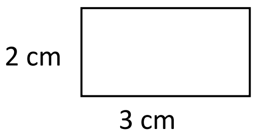
C
32
x 25
50
150
600
+ 800

Item-2: Fourth and fifth grade students are presented with following problem:



What can be the dimensions of a rectangle with exactly half the area of this rectangle? Please explain your answer.

The responses of two students to this problem are presented below. How would you grade these responses **over a range from 0 to 10 and please explain why**? (adopted from Hansen et al., 2005).

	Student's Answer and Explanation	**Score**	**Reason**
Student K	To find out half area of the rectangle, I do this: $\frac{6+4}{2}=5$. Then each dimension can be 5 cm.		
Student L	"I would have the half of each dimension: $6 \div 2 = 3$ and $4 \div 2 = 2$. Then I would come up with a rectangle with a one side being 3 cm and the other 2cm". And draws the following figure: 		

The first questionnaire that included item-1 was applied to approximately 300 classroom teachers and we had 216 returns. The second questionnaire that included item-2 was applied to approximately 200 teachers and we had 177 returns. Of them, 148 teachers responded to item-2. The participating teachers differed in terms of the years of teaching experiences ranging from 2 to 35 years. Those teachers taking the first questionnaires were working in 104 different schools in a large province and those taking the second one were working in 10 different schools in three different provinces in Turkey.

DATA ANALYSIS AND RESULTS

This section presents data analysis and results concurrently. The analysis and related results of each item are provided respectively.

With regard to item-1, a frequency analysis is first carried out to determine the number of teachers accepting any of solutions of A, B, C; both of any A, B, C; or all of them. Table 1 shows that a vast majority of teachers (67%) states that they would accept only solution A, 15% accept both A and B, and only 17% accept all A, B, and C as an answer to the multiplication problem.

	A	**A&B**	**A&B&C**	**No answer**	**Total**
Number	145	33	36	2	216
Percentage	67%	15%	17%	1%	100%

Table 1: Teachers' responses (frequencies–percentages) to item-1

A further analysis is conducted on those teachers who cited accepting only solution A. The aim was to find out why they would accept only solution A. This analysis consisted of repeated readings of participants' reasons for accepting solution A. The analysis eventually generated five categories which encompass the teachers' reasoning for their choices (Table 2):

Categories	**Explanations for categories**
Rule	Teachers cite algorithmic rule of multiplication
Practical	Teachers cite responses like "Solution A is easy, practical and take little time"
B and C being difficult	Teachers' finding these solutions difficult and complex to understand or/and teach
Accept A but listen to B and C	Teachers cite to be open to both B and C solutions but would accept only A as an answer
Not categorised	No reasoning or statements like "I accept only solution A"

Table 2: Analysis of teachers' reasoning for accepting only solution A in item-1

Establishment of the categories is carried out by two researchers simultaneously and 100% agreement was reached for every teacher's response to a category. Frequencies of these categories are presented in Table 3 below. Note that some responses fall under more than one category and hence the total percentage exceeds 100%.

Those teachers who accept only solution A (145)					
	Rule	Practical	Accept A but listen to B and C	B and C being difficult	Not categorised
Number	79	39	16	17	20
Percentage	54%	27%	11%	12%	14%

Table 3: Responses of teachers who only chose solution A in item-1

Of those teachers who state to accept only solution A, 54% cites rule and 39% cites practicality in explaining their reasons (Table 3). Only 11% of the teachers indicates to listen to B&C solutions too and 12% finds these two solutions difficult.

With regard to item-2, it was applied to 144 teachers to see how teachers view different solutions to open-ended questions, how they evaluate erroneous student answers, whether they are aware of, and able to propose any remediation to, common student misconceptions. A frequency analysis is first conducted to determine how teachers grade student K and L's responses over a range from 0 to 10 (Table 4).

Scores	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Student K	76 51%	13 9%	7 5%	7 5%	5 3%	13 9%	4 3%	3 2%	4 3%	1 1%	15 10%
Student L	35 24%	4 3%	6 4%	6 4%	6 4%	18 12%	3 2%	3 2%	1 1%	0	65 44%

Table 4: Teachers' responses (frequencies–percentages) to item-2

The data reveals that teachers graded students' wrong responses for different reasons over a range from 0 to 10. For solution K, 51% of the teachers gave a score of 0, 10% gave a score of 10 and the rest ranged between. For solution L, 44% of the teachers unexpectedly gave a grade of exact 10 to the wrong response of the student L, 24% gave a grade of 0 and the rest ranged from 1 to 8. Those teachers who knew that the responses were wrong but gave grades from 1 to 5 provided various reasons including "because at least students attempted to solve the problem", "as an encoura-gement or award", and "because the student knows at least how to calculate the area".

DISCUSSION

The results, overall, have shown that classroom teachers are not open to different solution strategies to mathematical problems (Table 1), have difficulties in evaluating students' responses to the open-ended questions, and experience serious difficulties in assessing whether student solutions to open-ended problems are mathematically correct or not (Table 4). Further examination of teachers' reason reveals that they value 'routine', 'rule' and 'practical' aspects of mathematical solutions (Table 3).

We interpret these findings as signalling three potential difficulties in the implementation of the new curriculum. The first one is related to the classroom teachers' difficulties in mathematics. This is particularly evident in the teachers' evaluation of student L's wrong response to item-2 to which 44% of teachers gave a grade of exact 10 (see Table 4). Such a high percentage was unexpected to us and we do not, on the basis of our data, tend to over-generalise this trend to the whole primary teacher population in Turkey. Yet this is an important proportion and points to a possible source of challenge, that is lack of mathematical content knowledge, in implementing the new curriculum. These findings, in fact, before anything else, raise concern with regard to the competency of the teachers' teaching mathematics to the students let alone the implementation of the reformed curriculum.

The second challenge, as our data indicate, is related to the issues of assessment of students' non-standard solutions to open-ended questions. The new curriculum puts a heavy emphasise on the use of open-ended questions for both formative and summative assessments. Yet asking and expecting teachers to employ open-ended questions is one thing but using such questions during instruction and in exams is quite another. Open-ended questions mean variations and unexpected responses in students' solution strategies to the questions that sometimes raise challenges for teachers to make sense. The teachers' responses to item-1 clearly show that teacher tend to privilege rule-based and practical solutions and have difficulties in making sense of different (but correct) solutions (see Table 3). Further to this, on what bases responses to open-ended questions would be evaluated especially if students make an effort to answer? Responses to the item-2 show great variations even in grading of those who found the solutions wrong. For instance, 51% of teachers graded solution of student K in item-2 with 0 and expressed that because it was wrong. Yet student K's solution also received the grades ranging from 1 to 5 from those teachers who, while stating the inaccuracy of the solution, noted that "the student at least tried". This variation in our view is important as the grades send signals to the students what is valued (mathematical accuracy or making effort). To some extent a certain level of variation might be understandable for subjective judgements yet this indicates lack of assessment criterion which teachers draw on in the evaluation of students' work.

The third one is related to overall teachers' already formed personal theories, views, orientations and beliefs with regard to mathematics, its learning and teaching. This is particularly evident in the teachers' reasons for choosing solution A in item-1 in that some appear to hold the view that solutions to mathematics problems should take little time, be practical and employ procedural rules. Of these teachers, for instance, one cites to accept only solution A "because there is only one way to the truth (*right conclusion*)" and another one cites not to accept B and C as correct answers and if his students "attempt to do the multiplication like in B and C, he would interfere at the very beginning not to do so". This stance, in fact, is sharply in conflict with what the new curriculum sets out to achieve, which encourages teachers to "create classroom environments in which students can bring different solutions to the posed problems so that students learn to value different solution strategies in the process of problem solving" (MEB, 2004, p. 11). Our findings, however, suggest that most teachers themselves are not appreciative of and do not value non-standard solution strategies.

We do not see classroom teachers' mathematical difficulties and problems arising from these with regard to assessment and not being open to non-standard approaches in learning and teaching just being peculiar to Turkey. There is evidence that teacher difficulties in mathematics and other aspects especially at primary level is a reality all around the world (e.g. see Ma, 1999; Manouchehri, 1998). This might be understandable given the fact that these teachers are not specialised in mathematics and responsible for teaching different subjects. Yet we, as mathematics educators, need to take these difficulties seriously and to search ways of improving in-service primary teachers' mathematical content knowledge in a wide scale, probably nationwide. This certainly requires serious consideration about not only the content of such in-service courses but also methods of implementing them. Achieving this collaboration at an international level could be a possibility and perhaps a necessity. Without attending to teachers' mathematical difficulties in the first place, in the words of Papert (2000), curricula changes with its big idea behind (in Turkish case this being constructivism) would meet resistance from the teacher and run the risk of giving into the school way of thinking, losing its power and hence being disempowered.

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