A Waterfall Model for Providing Professional Development for Elementary School Teachers: A Pilot Project to Implement a Competency-Based Approach

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Abstract

Supporting the professional development of teachers to enhance mathematics learning is an important consideration of global education initiatives. However, designing and implementing professional development depends on the structures in place in different contexts. For instance, some structures involve different roles played by the different actors in the schooling system. Thus, school board consultants, principals, inspectors and teachers might be in charge of providing information, coaching, training or educating teachers. Those policies and practices are key components when designing and implementing professional development for teachers at a large scale. This article presents an initiative supported by UNICEF in Democratic Republic of the Congo (DRC). In 2015, the DRC undertook a transitional approach to school reform by adopting a situation-based approach "Approche par les Situations (APS)" in the elementary school curriculum. An experimental pilot project to improve teaching and learning Mathematics and Language Arts in elementary school was set up. To this end, learning situations were created and 80 teachers were trained in the use of these situations in class using a waterfall model of professional development. The results indicated positive contributions resulting from the teacher-enacted situation-based approach, but also exposed functional problems of implementing a waterfall model to support teachers at a large scale. Our results highlight the challenge of supporting all teachers in a global context.

Keywords

Teacher professional development, competency-based learning, situation-based approach, The Democratic Republic of Congo

Introduction

In 2011, the Democratic Republic of Congo (DRC) adopted formal strategies for the development of elementary, high school, and professional teaching (2010/2011-2015/2016) in which the general objective was to build an inclusive and quality education system that aimed to increase access to primary school, and to improve the quality and relevance of teaching. The expected outcome was to develop

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competencies in students with basic education in language and mathematics. The Ministry of Elementary, High school and Initiation to the New Citizenship Education (Le Ministère de l'Enseignement Primaire, Secondaire et Initiation à la Nouvelle Citoyenneté (MEPS-INC)) undertook a revision of the programs of elementary teaching on the basis of a situation-based approach, "Approche par les Situations (APS)." Before extending the new program to the national level, the country conducted an experimental pilot to analyze the impact of the changes proposed by this new version of the curriculum on a sample of elementary schools throughout the country. As part of this pilot, pedagogical materials in connection with the curriculum were designed, and teachers were trained to use this material and on the new elements integrated in the curriculum. The different outcomes of this experimental pilot project were in turn evaluated and analyzed. This article takes into consideration this experimentation and draws up a report on the progress of such a project applied in a context like the DRC. We present briefly the national context in DCR prior to discussing the experimental design lead in mathematics.

The National Context in DRC

A Brief Look at The Education System

As in many African countries, the goal of western missionaries to convert the population was at the heart of the structuring of the educational system of the DRC. Before the creation of the colonies in 1885 (year of the birth of the Independent Republic of Congo) Catholic and Protestant missionaries worked in the country. In addition to providing religious Christian education, they endeavored to increase the literacy of the population. From 1960 (the year of the country's independence) through 2000, the Republic paid particular attention to the education system in favoring its growth. The wars that devastated the country and economic crises considerably reduced this growth and it contributed to its deterioration (Banque Mondiale, 2005).

The current education system is divided into two entities: a public system managed by the Republic, and a private system managed by religious organizations. French is the official language of teaching, but the Republic now encourages the use of one of the national languages during the first two years of elementary school (Lingala, Swahili, Kikongo, Tshiluba). In elementary schools, the use of school textbooks developed for young Congolese by western organizations seems to be a recent trend (CONFEMEN, 2011). Even with all the measures put in place, the low graduation rate is still problematic. The schooling of the young (elementary and high school), and professional, technical, and university education are major current concerns.

Improving The Quality of The Education System

The DRC initiative seeks to improve the quality of primary teaching and its relevance by adapting the content to the current socio-economic context. The basis for this initiative is an African reform movement favoring the development of competencies, as prescribed by the Program of Primary School in Africa (UNESCO, 2009). This program recommends to "pass from an approach to learning based on knowledge to an approach by competencies" (p. 8). In mathematics education, one of the reasons for a shift to a competency-based approach was the poor quality of understanding developed by students. In a study conducted in South Africa,

Graven and Coles (2017) highlighted the fact that (teachers) looking at the answer without focusing on the strategies used by students could lead to a lack of foundational reasoning. In its document, UNESCO highlighted the numerous difficulties that the African education system suffers in terms of quality and equity. The report notably mentioned the following problems:

- Highly academic nature of formal education and lack of pertinence of a large part of its content;
- Prescribed curriculum at the national level designed as "content to teach," leaving little space to

  placement in context and to learning adaptations;
- Dominance of traditional teacher-centered pedagogical practices;
- Rigidity and closed-nature of formal education, minimal attention accorded to practices that

  maintain the school learner (p.14)

In response to these problems, DRC, like a number of African countries, opted for a revision of curriculum in accordance to a competency-based approach (CBA). This approach focused on developing competencies in school rather than focusing on knowledge. The movement towards CBA has been observed for 15 years in Africa. This was noted by Bernard, Nkengne and Robert (2007), "The CBA tended to become for a decade an important passage, in fact a standard, in the curricular reform undertaken in Africa" (p.3). However, no empirical results supported the CBA as the solution to the numerous problems that plagued the African education system. In addition, the CBA is a curricular orientation that, if not accompanied by concrete actions on the field, cannot alone claim to improve the learning conditions of students in the classrooms; the structure and the content of the curriculum have only minimal effect on student learning. Important factors that play a more fundamental role to support student learning are the material and pedagogical conditions, as well as the effective teaching that students receive (Bernard et al. 2007; Roegiers, 2008). Moreover, even though the CBA proposes a structure of curriculum and a curricular vision centered on the development of competencies, it does not prescribe the pedagogical means to attain them. According to Bernard et al. (2007), the CBA suggests a pedagogical change aiming to improve the practices, however, it leaves the teacher the liberty of choice in his/her pedagogical approaches to suit the expectations of CBA. Yet, as underlined by Dembélé and Sirois (2018), the professional competencies of African teachers are variable and can sometimes be insufficient to ensure the decentralisation of strategies adapted by the CBA. Bernard, et al. (2007, p.24) commented, "Furthermore, the CBA, relying on the pedagogical talent of the teacher as opposed to the tools that s/he crucially needs, leaves the African teacher, already weakened by a difficult context, more alone than ever in face of the daily difficulties of his/ her profession." This is particularly true in DRC, where teachers teach big size classes, and where so many of them need a second job to live decently. A recent study conducted in North Kivu by Okito Pamijeko and Savard (2018) highlighted the need for teachers to learn more about socio-constructivist approaches. The 151 teachers who participated in this study revealed that they were more comfortable with a "show and tell" approach than a more participative approach. In fact, their needs were so huge, that it indicated that their professional competencies were little mastered (Okito Pamijeko & Savard, 2018). As pointed out by Pryor, Akyeampong,

Westbrook and Lussier (2012), "Teacher education has been identified as both part of the problem and the solution to the challenge of quality" (p. 410).

In addition to these challenges, many definitions of competency exist in the literature. It is possible to find some common points (Joannert, 2011), but they don't all have the same foundation and structure. Therefore, it invites different interpretations of the idea of competencies and, consequently, different means to promote its development in students and its evaluation. To this, an imprecision is added on different levels, in terms of the curricular structure proposed by the CBA. Even though the CBA proposes to structure the curricula around competencies, no indication is provided in regards to the specific competencies to develop by discipline and on the connections that those competencies have to have with societal needs (Bernard et al., 2007).

Reports and studies have analyzed the impact at different levels of these reforms of CBA in Africa and they relatedly analyzed the process of implementation (Bernard et al., 2007; Cros et al., 2010; Roegiers, 2008). A study financed by the French Agency of Development (Agence Française de Développement (AFD)), the African Bank of Development (Banque Africaine de Développment (BAD)) and the International Organisation of Francophonie (Organisation Internationale de la Francophonie (OIF)) to evaluate the process of curricular reformation by the CBA in primary school in several African countries reported a number of problems associated with this reform (Cros et al., 2010). The study notably reported that for the countries where the reform was sustained until the end, difficulties of implementation and limited impact on teaching practices, and on the systems as a whole were observed. Those difficulties included, among others, to short professional developments for teachers, no strategy of communication with the communities involved, absence or insufficient follow-up with teachers, and implementation of the reform in elementary schools, but not beyond that. For other countries, it was difficult to exit the experimental pilot phase and some even stopped implementation because of the difficulties encountered.

These problems can be explained by different factors, some that were previously discussed in regards to the imprecision that surround this approach. Additionally the complexity of the developing competencies, leads to a number of practical difficulties of implementation (Bernard et al., 2007, Gauthier, 2013). For instance, CBA implies that students should have access to different resources, which can be costly, difficult to find or not accessible. Concerning the different reports on the subject, the CBA requires the combination of innovative pedagogical principles in contexts frequently characterized by a scarcity of resources and lack of teacher training or preparation. In this context, where there is a complexity of the approaches and delegation to the teachers of the means necessary to put this approach into practice, teacher training in the CBA takes on increased importance. However, in the implementation initiatives of the CBA in Africa, the reports demonstrated a number of important gaps in the plan of teacher training associated with the reform. One of the models used for providing professional development consisted of a *waterfall model*, which has different layers: the experts at the top train other people, who then train other people, who train other people. Usually, the last layer appears in schools, where teachers train other teachers. This model presents many issues, as stated by Cros et al.

(2010), "The trainings provided have a common characteristic: it is a training designed from the top down according to a waterfall model that induces a progressive loss of quality, errors of measures of regulation, and of control. The duration of the training is a lot longer for the trainers and almost nonexistent for the teachers who, however, are the immediate users of the curriculum" (p.17). These gaps, as a consequence, as noted by Bernard et al. (2007), provoked an important loss of principles of the CBA and a symmetrical increase in power of the principals in this process, who provide sometimes the training.

Curriculum Change and Action Plan

In the face of these obstacles in implementation of this approach in the concerned countries, a reflection is necessary. Without rejecting the CBA, adjustments need to be brought about on the modalities of implementation of an approach aiming to develop competencies in students. Therefore, it appears more and more evident that the solutions do not originate simply from rewriting school curricula or a training for the teachers, but more so on the establishment of a complete action plan of curricular reform at all levels of the school structure: teachers, students, pedagogical materials, textbooks, initial and continuous training, classroom practices, evaluation of acquired knowledge, etc. Ideally, the plan has to be accompanied or preceded by an experimental pilot process aiming to evaluate the effects of such a curricular reform on a representative sample before scale-ups (Bernard et al., 2007; Cros et al., 2010). Considering the importance of investment in time, money and resources, such a reform should be based on experimentation to evaluate its pertinence, viability, and efficacy. Thanks to such an experimental pilot process, it is possible to put in place a group of adequately trained national experts whose function is to elaborate and to coordinate the implementation of the reform and to ensure its continuity once they leave (Cros et al., 2010). It's through this group of experts that the training can be structured on the national scale (Depover et Jonnaert, 2014).

The Experiment in DCR

A Transitional Approach to Reform the Curriculum

With the intent of reforming the school system, the DCR opted for a novice, transitional approach instead of initiating a curricular reform in depth which would have required a complete restructuring of school curricula and pedagogical structures as a whole. The The Ministry of Elementary, High school and Initiation to the New Citizenship Education (Le Ministère de l'Enseignement Primaire, Secondaire et Initiation à la Nouvelle Citoyenneté (MEPS-INC)) of the DRC undertook a transitional approach to reform in 2011, beginning with an update of the Program of Elementary Teaching (Programme de l'Enseignement Primaire). The new version of the curricula, like the original one from 2000, proposed objectives to reach instead of competencies to develop. It was enriched with learning situations aiming ultimately to develop competencies. This approach (situation-based approach or Approche Par Situation (APS)) adopted by the DRC meant that learning situations should be proposed to students instead of teachers. A learning situation is a situation proposed to students to have them mobilize and use various resources: knowledge, processes, strategies, both material and human. Therefore, a learning situation would present some complexity and would be contextualized in

order to be rich enough. When a person masters a learning situation by mobilising diverse resources, he/she has effectively developed one or more competencies: we would therefore say he/she is competent in this learning situation (Jonnaert, Ettayebi et Defise, 2009; Charland et Cyr, 2013). The elementary school program in the DRC did not aim to impose learning situations on a prescriptive basis, oppositely, they were approached as means to allow the learners to develop competencies. In addition, the curriculum did not describe competencies, but proposed, in regards to the previous curriculum, essential ingredients to the development of these competencies, we are referring here to learning situations. Therefore, by adopting this strategy, the DRC made the choice to insist less on the rewriting of its curricula as opposed to the implementation of initiatives aimed at improving pedagogical practices of teachers. In fact, the program aimed to be more student-centered.

Description of The Experimental Design

Initiated in 2011, the revised curriculum was a more coherent version in terms of content and organization. To evaluate this transitional version of the curricula, the country put into place an experimental pilot project supported by different partners, and aimed to widen the protocol to the whole country once the process was analyzed and adjusted. This design was supervised by a group of university researchers associated with the International Consortium of Development in Education (Consortium International de Développement en Éducation (CIDE)) in partnership with The Administration of School Programs and Didactic Material (la Direction des Programmes scolaires et matériels didactiques (DIPROMAD)) of the DRC and with the financial support of UNICEF. Globally, the researchers had the mandate of providing technical support to the DIPROMAD of the MEPS-INC to implement the reform which aimed to improve the teaching and learning of mathematics and languages in the primary school. We will discuss the experimental design lead in mathematics. Improving education outcomes in regard to mathematics is an important focus from bilateral and multilateral donors (Piper, Ralaingita, Akach & King, 2016). In fact, improving mathematics in early grades is a worldwide priority (Education for All Global Monitoring Report Team, 2014; Ginsburg, Hyson, & Woods, 2014), because students' early number sense skills are considered the greatest predictors of academic achievement (Duncan et al., 2007).

The aims of the experimental design consisted of implementing the first milestones for the establishment of a curricular reform on a large scale, and to evaluate this approach by different means, with the goal of increasing the efficiency of the reform. Efficiency was measured according to Depovert, Jonnaert, Gauthier et d'Hainaut (2014) by the relation between the monetary input which are the expenses devoted to the educational project and the output revealed by indicators such as scores of standardized testing. In this instance, the money dedicated to education was not entirely used for education because of the corruption. The schools received less that they were supposed to get to pay teachers, to provide professional development, and resources for teachers to teach better. It thus affected the quality of teaching and impacted students'learning. Citing data from UNESCO (2011), these authors state that the variables that have the highest efficiency factor (impact versus cost) were the availability of school textbooks and the qualification levels of teachers.

Therefore, these data highlight the importance of initial and continuous training of teachers and the availability of basic pedagogical materials, such astextbooks, in order to increase the efficiency of an educational system. These variables are more important for student success than others, such as the condition of school buildings and the number of students per teacher. Moreover, the experimental approaches put in place by the DRC take into consideration these efficiency indicators and are composed of initiatives at different levels of the school structure that we describe here:

(1) Formation of a pool of national experts that act at all levels of the structure of curricular reform;
(2) Training of a pool of experts;
(3) Writing of pedagogical material for the primary teachers (learning situations);
(4) Writing of training module for the school board consultants, principals, inspectors and teachers;
(5) Training of regional school board consultants, principals, inspectors and teachers;
(6) Testing a sample of developed pedagogical material;
(7) Evaluation of different approaches.

Formation of a Pool of National Experts

An approach to curricular reform, whether it is experimental and pilot or national and global, requires the formation of a team around which the different components of the reform are organized (Bernard et al., 2007). Reforming an educational system implies work on different sectors: the curriculum structure, evaluation tools, pedagogical material, initial and continuous teacher training, school administrators, organization, pedagogical approaches in class, etc. The complexity of this dynamic and the diversity of the sectors effected by the curricular reform are documented in the works of Jonnaert, Ettayebi et Defise (2009). Thus, the mandates of such a team are varied and the formation of this team has to reflect the variety of the functions that will be carried out.

In the case of the present project, this team had a mandate to write school textbooks using APS, to organize the training of provincial school administrators and to coordinate data collection associated with the process of evaluation of different approaches, among others, and assessing competencies (CBA). With this vision, it appeared essential to include teachers, inspectors, school board consultants and school principals who understood the classroom context in order to plan the curricular content for the writing of school textbooks. A university specialist in education, in measurement and in evaluation, joined this group, as well as members of the school's administrative network.

Furthermore, the success of such a group, at the light of our observations, passes by the recognition of the permanent status of this team. It is difficult to maintain optimal, regular and constant functioning of such a group if recognition of a permanent status, short or medium-term, is not established. Too frequently, the formation of this kind of a group is carried out by mandates to temporary teachers in the education system, resulting in a loss of team members and a lack of continuity in the process, and in the work product.

Training of a Pool of Experts

The set of elaborated experimental approaches in the context of this work required first, the rewriting of curricula in 2011, and their orientation to the situation-based approach

(APS), and on the development of competencies. In order to integrate this team in the process, it was essential to train these individuals on the theoretical foundations that were the underlie the curricular revision. Therefore, they received training on the situation-based approach (APS), both the theoretical foundations and methodology of elaboration of a learning situation. In this training, they addressed the means of constructing a learning situation from simple beginning data and a context. This methodology specified how to start from an educational intention and a real-life context, and implant useful mathematical concepts to process the learning situation. In this practical training they elaborated a number of learning situations that were submitted to the group for a critical analysis. The goal was to enable the members of this team autonomous in the writing of mathematical situations for teachers to experiment with in class.

Writing of Pedagogical Material for Primary Teachers

In the context of this project, it was important to equip teachers with pedagogical material comprised of a bank of mathematical situations which could be utilizes in class throughout the year. These learning situations covered all of the mathematical content targeted by the new version of the curriculum. The use of these learning situations by the teachers aimed to favor construction of knowledge by the student, a larger teacher-student and student-student dynamic, but more importantly, these situations addressed mathematical content across Congolese real-life contexts. This approach therefore permitted addressing mathematics according to the perspectives of endogenous knowledge that reframe the prescribed knowledge in the curricula in a reality unique to the country (Charland et Cyr, 2013; Hountondji, 1994).

Writing of Training Modules for School Administrators and Teachers

In order to provide material for the trainers, training modules were created. These modules contained essential elements to enable teachers to conveniently treat learning situations in class and to ultimately be able to create their own situations in accordance to their needs.

Training of Regional School Administrators and Teachers

The training process that took place, functioned in accordance to the waterfall model of training. In terms of experimentation, 30 provincial school administrators and 40 teachers in two of the 11 provinces of the country (Orientale Province and city-province of Kinshasa)were trained. In this approach, the training was adapted to the targeted clientele. Even though school administrators and teachers underwent the same process of implementation of the reform, the training requirements were not the same. Furthermore, taking into consideration the recommendations for this topic (Bernard et al., 2007; Tehio et Cros, 2010), the training, even if they unfolded in waterfall, permitted teachers to participate in the same number of training hours as the school administrators. Thus, the training provided to teachers was aligned with the implementation of principles contained in the new version of the curriculum. This training responded more to the practical needs of the teachers, on the other hand, the training provided to school administrators targeted the reform principles as well as aspects relating to school management for supporting teachers in the implementation of the reform, both theoretically and practically.

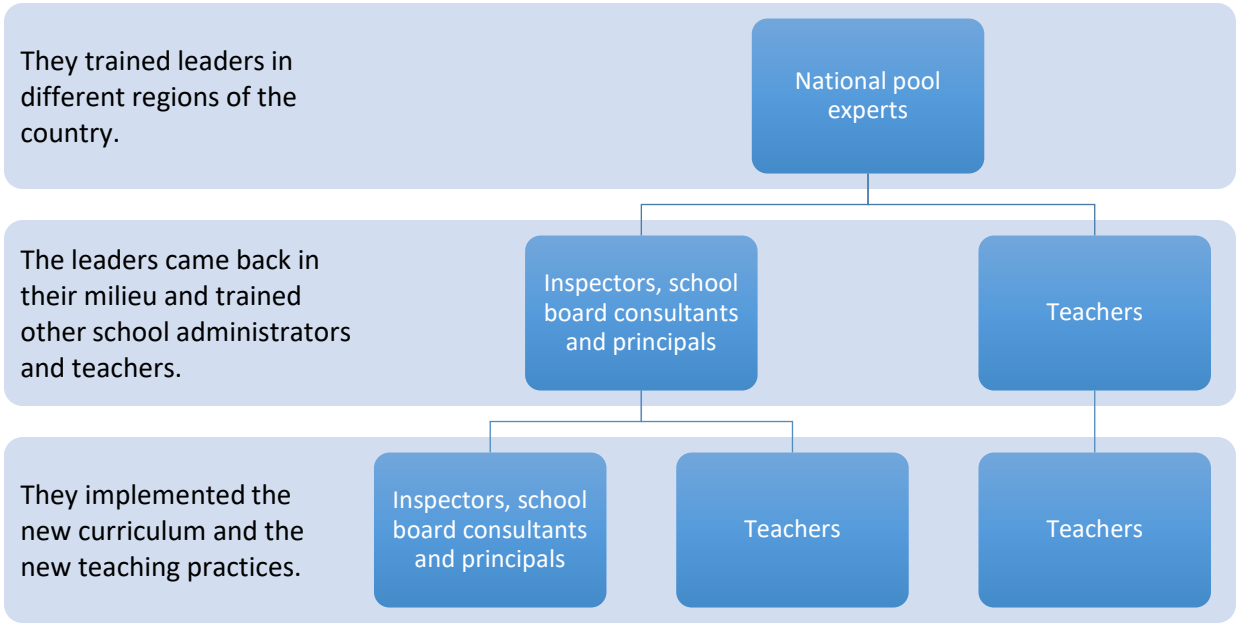

Figure 1. The waterfall model of training

Testing a Sample of Developed Pedagogical Material

The selected teachers implemented three mathematical situations spanning on three weeks for four hours a week for each learning situation in their classes. These teachers were previously trained. This approach permitted teachers to put into practice the situation-based approach and to apply the subject training received.

Evaluation of Different Approaches

The final step permitted to examination of the whole experimental process. In fact, a range of factors can influence the functioning of a reform in a country like DRC. Different approaches were evaluated or observed. For instance, in order to collect information on students' learning, students were provided with photocopied sheets, which they were not used to. Teachers also were not acustomed with this material, because they usually wrote something on the balckboard and students copied it in their notebooks. Thus, some teachers probably left the students alone with the test, without reading the questions aloud. The evaluation of this approach provided the basis for a series of recommendations to modify the processes and materials before spreading the initiative throughout the country.

Methods

Sampling

We had different participants for each kind of data collection: the test to teachers, the pre-test and post-test for students and the observations carried out in classrooms. Our participants for the teacher test were 40 first-grade teachers and 40 second-grade teachers. They were selected by the inspectors of two of the eleven provinces of the country (Orientale Province and city-province of Kinshasa). Students tested were selected at random by the Ministry of EPSP in Kinshasa and Kisangani to participate in writing the pre-test and the post-test. Thus, five students per class (pre and post-test) were selected for a total of 60

first-grade students (30 in Kinshasa ans 30 in Kisangani schools) and 25 second-grade students. Finally, our participants for the classroom observations were 30 teachers from of the province of Kinshasa, selected at random from among the 40 teachers trained.

Procedures

In order to have the most objective outlook possible on these approaches, it is convenient to use targeted and adequate tools for data collection. We first evaluated the level of mathematics knowledge of teachers with a mathematics test encompassing primary grade level mathematics knowledge. We used a second instrument to get feedback of training provided to provincial school administrators and teachers. The training being a fundamental process in an approach to curricular reform, it is essential that the training is adapted to the needs and is accessible to the trained persons. We alsoused teacher observation tools in the classrooms Finally, we wanted to evaluate the impact of using learning situations in the classes on the mathematics knowledge of students. To do this, an experimental procedure of pre- and post-test was employed. Each student completed a mathematics pre-test before starting the learning situations in class. This test like the post-test, was built according to a structure processed by teachers. At the end of the three experimental weeks associated with the learning situations, the students then completed a post-test in which the structure was equivalent to the pre-test.

Instruments for Data Collection

In order to have a just and objective outlook on the impact of the project, different tools for data collection were designed. These tools targeted in turn the students and the teachers. They were administered at different moments throughout the pilot project.

The Test for Teachers

A mathematics test was designed to obtain information on the level of mathematical knowledge and skills of the teachers in connection with the elements treated in learning situations. All the teachers who participated in this experimental process completed the test which included 40 first-grade teachers and 40 second-grade teachers. The whole team participated in designing the test.. The test questions did not surpass a grade level equivalent to 4^{th} grade level of primary school, as concluded by the pool of experts. The test presented 15 questions and worth 50 points. The questions focused on arithmetics concepts, including the four operations, fractions, percent and decimal numbers and on geometry and measurement.

The Observations Performed in Class

During the treatment of experimental situations, the provincial inspectors, who followed the administrator and researcher training of the project by the national pool of experts, observed the unfolding of a learning situation in class and completed an observation grid designed for this purpose. This grid enabled to document the different observable aspects of the teaching-learning process in class associated with the processing of the learning situation. For the province of Kinshasa, 30 teachers were observed during the processing of one of their learning situations. The observation lasted around an hour.

The Pre-Test and Post-Test for Students

Two mathematics tests were designed for first and second grade students (pre- and post-test) by the whole team including the pool of experts. The tests were constructed according to the same format as the learning situations tested during the experimentation. The learning

situations proposed familiar contexts for students, where they had to reason in order to find solutions. The tests permitted evaluation of the impact of the use of situations in the classroom, and the teacher training on mathematical competencies of students in relation with the learning situations. The questionnaires of the pre- and post-test were identical for each year. The pre-test was administered to a selected population by the Ministry of EPSP in Kinshasa and Kisangani in May 2015. A post-test was administered at the end of the school year after the use of the material developed. The first-grade teacher read the questions to ensure the comprehension of the statements by the students who then completed the questionnaire. To ensure data entry in the given time, a sampling of received questionnaires was chosen. Thus, five copies per class (pre and post-test) were selected randomly for a total of 60 first-grade students and 25 second-grade students. The analysis was performed on a sample of cross-sectional data.

Results

The Test to Teachers

The mean score on this test was 46%. In fact, for the majority of the questions, fewer than 50% of the 80 teachers obtained a correct answer. Some success rates were quite alarming (22%, 23% and 26%). Table 1 shows the mean scores achieved by teachers on the targeted concepts.

Table 1

Success average of teachers answers to the mathematics test

Concept	Points out of 50	Average Mean
Arithmetic		
- Fractions and decimal numbers	9	22%
- Whole numbers	13	50%
- Addition	5	60%
- Subtraction	7	55%
- Multiplication	3	78%
- Division	3	80%
Geometry and Measurement		
- Time	2	23%
- Plane Figures	4	26%
- Linear Measures	4	26%

The Pre-Test and Post-Test for Students

Because of the cross-sectional nature of the data, an analysis of variance was first carried out in order to evaluate the homogeneity of schools (tables 2 and 3). The tables 4 and 5 present statistical analyses of the pre- and post-tests given to the students through a within subjects design.

Table 2

Analysis of variance, Grade 1

Source of variation	*Sum of squares*	*Degrees of freedom*	*Mean square*	*F-ratio*	*P-value*	*Critical value for F*
Between groups	1,166	3	0,388	2,555	0,057	2,662
Within groups	23,727	156	0,152			
Total	24,893	159				

Table 3

Analysis of variance, Grade 2

Source of variation	*Sum of squares*	*Degrees of freedom*	*Mean square*	*F-ratio*	*P-value*	*Critical value for F*
Between groups	4,392	4	1,098	7,104	2,554	2,423
Within groups	26,738	173	0,154			
Total	31,130	177				

Table 4

Analysis of variance (two-tailed t-test) – grade 1

	Mean Difference	t	Critical value	Conclusion
Whole exam	–	0,56798	1,99656	Not significant
Situation 1	+	1,98798	2,00171	Not significant
Situation 2	–	–0,28888	2,00324	Not significant
Complementary questions	–	0,19378	2,00664	Not significant

Table 5

Analysis of variance (two-tailed t-test) – grade 2

	Mean Difference	t	Critical value	Conclusion
Whole exam	+	–2,08691	2,02619	H_0 is rejected
Situation 1	+	–0,87634	2,02439	H_0 is not rejected
Situation 2	+	–1,43323	2,01808	H_0 is not rejected
Complementary questions	+	–1,4639	2,0226	H_0 is not rejected

This analysis demonstrates that the data of pre-test (Tables 2 and 3) are homogeneous for data from the 2nd grade (P-value = 2,554) but not for the 1st grade (P-value = 0,057). With the within subjects design, it was therefore possible to infer an impact of treatment on the basis of statistically significant results between the results of the pre- and post-test of the 2nd grade only. The results indicate that, for the students in grade 1, the results of the post-test (45%) was inferior to the results of the pre-test (47%), non-significantly (table 3). For the 2nd grade, the results of the post-test (55%) were superior to those of the pre-test (44%). When the set of questions were considered as a whole, the results were significantly higher in the post-test as compared to the pre-test by 7% (table 5; $t(23) = 2,026$, $p < 0,025$). We discuss further those results in the next section. Many factors render these results slightly representative of the real situation.

The Observations Carried Out In Class

As a whole, observed that teachers were able to implement the learning situations. First, they all respected the instructions of the situation and the general execution of it as suggested in the teacher's guide. This observation suggests that the training that they received on the topic of learning situations was well-integrated. The variations from one teacher to the next was observed in their class and in material management and in the moment chosen to distribute the written situations. Second, in the rare cases where the teachers did not obtain the learning situations, they were able to design one and to treat it in class during our observations. This supports our remark confirming that the training received by teachers was relatively well integrated, at least for the creation of a learning situation.

Furthermore, when it was possible, many teachers had access to manipulative materials in order to provide visual representations for the learning situation and to give it meaning. These materials, and the manipulations done on these, equally permit to give meaning to the mathematics and to facilitate the mathematisation of the situation by the students. At this level, we consider that teachers knew to make an adequate connection between manipulation and mathematics.

However, we noted certain problems with the majority of teachers in relation to material management or the representations of material

on the board. To begin, the manipulatives were only used by the teachers in front of the class or by a single student. There was an insufficient quantity of material to permit all the students to manipulate them. Even though the use of this material can be a positive aspect of an observed change following the use of learning situations, this type of manipulations carried out by one person in front of the class means that the majority of the students are passive in this approach. This problem is evident because the manipulations were too long. In fact, the manipulations occupied the majority of the time reserved for the learning situation. The manipulations are a means to give meaning to the mathematics and to facilitate its comprehension, but should not overshadow the mathematical activity or the mathematisation of the situation.

Discussion of The Waterfall Training

The experimental design that was implemented in the framework of this project included the participation of a number of participants from the world of education of the DRC (members of DIPROMAD, local and national inspectors, school administrators, teachers from experimental schools, international consultants, educational groups from UNICEF). As a pilot project, it was necessary to establish a complex mechanism involving synergy between different actors of the education sector. This structure was necessary to ensure the success of the training and the diffusion of the productions but more importantly, to ensure the smooth functioning of the collection of data for analysis that enabling to create a judgment on the efficiency of this project.

The data collected for this project highlight a positive impact of the training of teachers on their practice. Furthermore, the teachers seem to have abided by the pedagogical practice imposed by the processing of situations. In addition, this impact was marked by the availability of tested pedagogical materials, namely the mathematical situations distributed to all the teachers. This data conforms to the study of the principal factors susceptible to improve the pedagogical practices of teachers: the training of teachers and the availability of pedagogical material (Cros & al., 2010; Depovert & Jonnaert, 2014).

Clearly, the two-week training provided to teachers did not solve all the problems, notably the management of pedagogical materials during the processing of situations and the mathematical weakness of many teachers. The results of the mathematical test appear extremely problematic to us. They underline mathematical weaknesses in the tested teachers. It means to us that teachers who do not understand mathematics well might have additional challenges to implement our learning situations, where the meaning of mathematics is so important.

Continuous long-term training processes should be implemented at the national level in order to achieve an expanded and significant effect on the improvement of teacher competencies.

Other than this aspect of training, what captured our attention was the difficulty for an educational structure of a country such as DRC to ensure the smooth functioning of an experimental design containing a large and varied collection of data. For both the observation grid in class and the pre- and post-tests, data collection was problematic. The difficulties were more apparent for the pre-tests and post-tests which permitted the evaluation of the efficiency of situation processing in class on student learning. For example, some teachers administered the pre-test after the situations, and others administered the pre-test and post-test before the situations, therefore invalidating

the obtained data. In addition, other teachers completed the tests for the students or exaggeratedly guided students in problem solving. We also noticed that certain teachers did not support students enough, mainly those of 1st grad, whose needs were bigger. Moreover, some teachers distributed the questionnaires to students without reading the instructions and questions with them. Finally, other logistical problems also considerably weakened the validity of data on these tests. For example, during data collection, we proceeded to a random sampling of subjects (5 students per class). Furthermore, this sampling was not the same for the pre-test and the post-test. This arrangement of data collection (distribution of different tests, supporting the evaluations in class, in-class observations of teachers) was ensured by the regional school inspectors. Moreover, the project highlighted the importance of a close collaboration amongst the different actors. As the whole experimental design was carried out on a constrained time period and at precise moments, it necessitated a considerable availability from the part of the inspectors. These inspectors having important workloads, considering the very large number of schools to supervise, it was sometimes difficult for them to respond in a timely manner to the needs of the project. These problems were reflected in the evaluation process of students and in the teacher observation in class. Also, in the framework of the project, we constituted a pool of experts who we trained beforehand. These experts were mandated to participate at different stages of the project (creation of material, training of inspectors and teachers). However, the experts participated punctually in the project having all the administrative functions in parallel. Furthermore, in light of our analyses, it appears essential that such a group of experts is able to constitute a permanent entity having for function to ensure the smooth execution of such a project. In this vision, we join the statements of Cros et al. (2010) underlining the importance of such a structure in all curricular reform projects.

Like any waterfall, some water is lost through the process. Thus, a waterfall or cascade model for training implies some loss out of the process. Some information received by the teachers was not exactly the same as the one provided by the national pool experts. For instance, some teachers created learning situations because they did not receive the one already created for them. Other teachers used wrong terminology with students. The terminology presented to teacher was supposed to be used only by the teachers, not by the students. These phenomena highlighted the challenge of training teachers in a short amount of time, without subsequent coaching or mentoring. They also highlighted the complexity for teachers to learn other ways to teach mathematics in another paradigm, while their mathematical knowledge is fragile.

Conclusion

The complexity of this project and the numerous obstacles encountered highlight the importance of an experimental design prior to a complete curricular reform on the national level. In fact, implementing a curricular reform means also supporting the professional development of teachers by involving all the actors in the schooling system: school board consultants, principals, inspectors and teachers. The waterfall model involved all the actors, even if some water was lost in the process of supporting all teachers on a large scale. Having a pilot project of reform appears essential in the sense that it prepares the national actors in education to initiate the process of reform of the educational system. Initiating a reform implies, frequently, a change in paradigm in the processes of teaching/ learning. Competency-

based approach has a strong theoretical basis, but it is a challenge to implement it in different contexts. For this purpose, it is convenient to review the school textbooks, the pedagogical guides, the evaluation processes and the pedagogical practices in class in order to have learning situations (APS) that support competencies development.

These numerous changes do not take place overnight and are especially well thought. It is not sufficient to rewrite curricula according to new curricular approaches to change the classroom practices, improve the educational system of a country and its efficiency in terms of student success. CBA is a framework developed by scholars in a different sociocultural environment. One cannot simply import these ideas without attention to adapting to local contexts.

In fact, we recommend that the orientations of the curriculum should be aligned with the school textbooks and material resources, along with teacher training. Moreover, a pilot project of implementation of an educational approach, or of a reform, is meaningful only if it can be analyzed appropriately and if its impact can be measured with precision. The follow-up and the evaluation of the design by a group of local experts should not be ignored. Also, to observe real and measurable changes of an educational initiative in teachers and students, there should be a certain delay. The evaluation processes have to be spread out on many months if we hope to have significant results of the impact of the project on both the classroom practices and on student learning. Finally, too frequently reforms in African countries are implemented at the same time as the training process begins. This reform therefore settles in a fragile structure and it is not possible to put it into appropriate practice. Thus, the pilot ensures that the training has a sufficiently viable core to ensure expanded implementation of a new curriculum at the national level. But well before implementing a new curricular approach like the situation-based approach, the African countries, in comparable situations to the DRC, should first stabilize the school system with initiatives suggested in our article. An experimental pilot project lead with effectiveness is essential, similarly to continuous training expanded to the whole system and to the establishment of a permanent cell of coordination of its designs.

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