African Journal of Educational Studies in Mathematics and Sciences Vol. 17, No. 2. 2021

A correlational analysis of the relationship between Congolese students' achievement in relations in sets and domains of functions

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Abstract

This paper explores whether there is any relationship between Congolese students' achievement in relations in sets and their achievement in domains of functions. Since 2005, in Democratic Republic of the Congo (DRC), the secondary mathematics curriculum reform has brought many changes including the suppression of sets and relations (SR) topics in the first and second forms of secondary. At the same time, the same reform provided for the teaching of the concepts of the domains of definition of functions (DDF) at the final level of secondary schools. Data collection was carried out through a coherent survey questionnaire administered to a sample of 354 out of 3050 finalist students in Bukavu-Town. Those selected students from 7 schools generated 7 pairs of the form data (x, y), where, x represents students' achievement on SR concepts (independent variable), and y represents students' performance on DDF concepts (dependent variable). At 0.05, level of significance, the study reveals existence of strong positive correlation between students' achievement on SR concepts and their performance on DDF concepts among respondents. We don't understand what basis of curriculum designers which motivated them to remove the SR from the mathematics curriculum. The study recommends to the reform designers in order to reformulate a plea to the Ministry of National Education to be able to include the SR concepts back into the DRC's mathematics curriculum.

Keywords: achievement; domains of definition of functions; sets and relations; mathematics curriculum

Introduction

The teaching of mathematics is organized based on related topics: topics that depend on each other; topics that build on other earlier content by logical sequence (Confrey & Kazak, 2006). As a matter of fact, curriculum organization needs to be organized in such a way that this logical sequence is catered for. In Democratic Republic of the Congo (DRC), the secondary mathematics curriculum reform has brought many changes including the suppression of sets and relations topics in the first and second forms of secondary (Direction des Programmes Scolaires et Matériel Didactique [DPSMD], 2005). It is worthy to remind that concepts of sets and relations were introduced in DRC mathematics curriculum since 1970 (DPSMD, 2005). The methodological indications of the 1970 DRC mathematics curriculum supported the insertion of SR concepts to be considered as the prerequisites of the following concepts: interval operations of R, plan transformations, polynomial maps, definitions of addition and multiplication in numerically sets (N, Z, D, Q & R), combinatory analysis, linear and affine functions, linear algebra, numerical functions

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 DOI: https://dx.doi.org/10.4314/ajesms.v17i2.9

and their inverses, concepts of domain of definition of functions (DDF concepts), descriptive geometry, etc…(DPSMD, 1970). Some reasons for the suppression of SR concepts were mentioned by the designers of 2005 mathematics curriculum among others, The Curriculum School Direction and Didactic Tools (CSDDT) had supposed that, so-called modern mathematics (sets and relations topics) had not been systematically taught under other countries for more than a decade, while it continued to be so in the DRC (DPSMD 2005). This was affirmed by the designers of this 2005 reform without illustrating not only a country where the so-called modern mathematics was no longer taught, but also and above all, non-explaining in the reform what a systematic or unsystematic teaching they were alluding to. The second reason is as follows: the designers of the 2005 mathematics curriculum made it clear that the concerns of the Congolese Ministry of National Education were reinforced by the outdated state of the 1970 reform, in order to modernize this discipline of mathematics, which has until then remained unsuited to technological development. Thus they recommended the use of computers and calculators during mathematics lessons (DPSMD, 2005).

One wonders, only the SR concepts made the old 1970 mathematics curriculum to its outdated state so that these SR concepts are not effectively taken up in the reform of 2005? Couldn't the SR concepts also facilitate the rapid evolution of new technology? It appears that in 2005, in Kinshasa, there were unanimous respondents for the proofreading and rewriting of the mathematics curriculum and proposed, among other things, the introduction into the secondary mathematics curriculum, of statistics and probability (DPSMD 2005). These respondents no longer remembered the fact that teaching the concepts of statistics and probability sometimes requires prerequisites on SR concepts. Another reform took place in July 2018 in the DRC. Furthermore, the reforms of the basic framework law N° 14/004 of 11 February 2014, states the following: "It is obvious that the structural innovation requires important changes within the organization of primary, secondary and professional teaching in the DRC. Due to this, a team of experts was established in the effort of adapting the content of educational programmers, especially in the teaching of sciences at the final grades of the basic education. This domain includes the following sub domains: Mathematics, Earth and Life Sciences and Physics Sciences; Technology and technology of Information and Communication" (DPSMD, 2018). This 2018 reform renewed a list of subjects that we believe to be taught based on SR concepts. Among these subjects we can mention: concepts of Probability, Elementary Statistic, Geometry (plan transformations), Computer Science, Mathematical Logic, Combinatory Analysis, Intervals of real numbers, Algebraic structures, domains of definitions of functions, and so on (DPSMD, 2005, 2018). After having carefully analyzed the two above-mentioned curricula, it was observed that there is no explicit content that would enable students to learn to define a set using the three different notions for writing a set. For instance, the set whose elements are 3, 5, 7, 9, may be represented using (i) word descriptive form as $\{odd\ numbers\ between\ 1\ and\ 10\}$; (ii) the list descriptive notation as $\{3, 5, 7, 9\}$; and (iii) the set-builder notation, which defines a relation between two finite/infinite numerical sets, as $\{x | x \in Z,\ x = 2n + 1, 1 < x < 10\}$. However, in the same curricula, finalist students are expected to define function, determine domains of numerical functions, derivatives and plot graphs of functions.

Knowing the importance of SR concepts in the learning of the other above-mentioned concepts and starting from the assertion of the research of Kimengele (2012) on the suppression of SR concepts saying that mathematics teachers of Bukavu resort in a superficial way of teaching which are not to applicable to SR concepts despite their removal. These have inspired to focus on DDF concepts, because these concepts are provided in the current DRC mathematics curriculum of upper secondary school classes and are only determined in numerically defined functions/relations in infinite sets, where SR concepts are no longer taught systematically as was the case in the 1970s. The researchers found a consistent sample of Congolese finalist students who accepted to have already studied SR concepts in a superficial way, before the test provided to them. Kimengele (2012)' s article states that teaching in a superficial way means in this case for example, to teach interval operations, teachers resort to a brief teaching on the finite set operations and without the students taking summary notes on these finite sets operations and finally, they now turn to the teaching of interval operations (same case for plane transformations). Being aware of the suppression of sets and relations in both the 2005 and 2018 curriculum reforms, as well as knowing the importance of these concepts in the secondary school mathematics curriculum, we decided to carry out through this study, a correlational analysis between students' achievement on relations in sets and their performance on domains of definition of functions: case of Bukavu-Town in the DRC, while learning the domains of definition of functions became imperative. The research is expected to bring insight on the importance of logically sequencing mathematical topics. This is achieved through conducting a linear correlation analysis on results obtained from survey questionnaire administered to secondary school students. The biggest research question was whether, is there any relationship between the students' lesser scores on sets/relations theory and their lesser scores in the domains of definition of functions? That is to mean if lesser scores in SR concepts can influence lesser scores in DDF concepts. We expect that if a student obtained low mark in 'sets and relations', he/she is more likely to scoring less in 'domains of definition of functions'. Therefore, hypotheses are formulated as follows:

- Null Hypothesis: There is no statistically significant linear relationship between students' achievement on relations in sets and their achievement on domains of definitions of functions.
- Alternative Hypothesis: There is statistically significant linear relationship between students' achievement on relations in sets and their achievement on domains of definitions of functions.

Review of Literature

Defining set in mathematics Shadrach (2016), defines it as "well, simply put, it's a collection. First we specify a common property among things (we define this word later) and then we gather up all the things that have this common property". According to Partee (2006, p.8) who states that if A and B are any sets and R $\subseteq$A x B, we call R a binary relation from A to B. The relation R $\subseteq$A x A is called a relation in A or on A. Defining the Domain of definition of relation; Partee (2006) assumes that "the set $Dom\ R = \{a| < a, b > \in R\ for\ some\ b\}$ is called **domain** of the relation R".

Relating to Partee (2006)'s definition, the "$Range\ R = \{b| < a, b > \in R\ for\ some\ a\ \}$ is called the **range** of the relation R". According to Panaoura, Paraskevi & Philippou (2016), the concept of function is a

generalized input-output process that defines a mapping of a set of input values to a set of output values. One of the main characteristics of the concept of functions is that they can be presented in a variety of ways (tables, graphs, symbolic equations, verbally) and an important aspect of its understanding is the ability to use these multiple representations and translate the necessary features form one form to another (Paraoura, Paraskevi, & Philippou, 2016). As far as a function is concerned in Mathematics, Bham (2020) describes that "the word function was introduced by Leibnitz in 1694. Function is a special type of relation". In this last part, we will only develop the aspect related to the function, because set theory and relation theory are already described above. All these proved that data on sets and relations enhance the researcher's problem statement of his topic as clearly explained above. According to Bham (2020:17) who had defined the domain and range of a relation/function as "if R is a relation between two sets then, the set of its elements of all the ordered pairs of R is called domain and set of second elements of all the ordered pairs of R is called range of the given relation". By analyzing the above definition of domain of definition of relation which is defined by Bham (2020), it can be seen that; the SR concepts should be taught first to educated before teaching them DDF concepts. Because the interconnection and logical sequence of these two concepts oblige this arrangement of matters, according to their definitions which we have just exposed. The interconnection of SR and DDF concepts inspires what we want to investigate in the performance of the Congolese finalist students. Box 1 is an example of problems involving SR and DDF concepts, whose demands the students are unable to meet, and Box 2 has the solutions to the problems.

Problems with SR and DDF concepts

The relation R is defined from $A = \{x |\ x \in \mathbb{N}\ and\ 0 \leq x < 7\}$ to $B = \{y \in \mathbb{N} | y\ is\ a\ multiple\ of\ 3\ and\ y < 21\}$ by $3x + y = 12$ (20 Marks)

a. Define, in Roaster form, the sets A and B. / 4 marks
b. Draw the sagittal diagram of the defined relation R from A to B. / 3 marks
c. Is R an application/mapping or a function? Explain. / 3 marks
d. Find the Domain of definition (Dom R) and the Range of R (Range R). / 10 marks

Box 1

Solution of problems with SR and DDF concepts

a) $A = \{0, 1, 2, 3, 4, 5, 6\}$ and $B = \{0, 3, 6, 9, 12, 15, 18\}$.
b) By substituting each element x of A in the given mathematical link $3x + y = 12$ then the sagittal diagram of the relation R from A to B will be drawn through its graph below: $R = \{(0, 12), (1, 9), (2, 6), (3, 3), (4, 0)\}$,
c) The relation R is a function because each element of A has at most one image in B,
d) The sets domain and range of the relation R are as follows: $Dom\ R = \{0, 1, 2, 3, 4\}$ and $Range\ R = \{0, 3, 6, 9, 12\}$.

Box 2

Suppose if a Congolese respondent forgets to mark element 0 of B, since he has studied the definition in roaster form of sets in a superficial way, he will then undoubtedly fail the DDF and Range defined in the example above. By composing a questionnaire of this philosophy, we assume that for most of the Congolese respondents who will do good / bad achievement on SR concepts, they will have good / bad performance on DDF concepts. Several authors have support the importance of SR concepts after the years 2005. This support squarely contradicted the words of the designers of 2005 and 2018 DRC curriculum mathematics. The list is not exhaustive. We can recall among others: in his study on set theory, Partee (2006, pp.1-6) affirms that the modern mathematics is based on set theory. This notion is used in, all formal descriptions. And all the major notions of mathematics can be built up around the notion of set. He continues by showing how much of mathematics can be built up from set theory inherited from Philosophers, Logicians, and Mathematicians greatly in the first half of the 20th century. Cited by Partee (2006), Whitehead and Russell argue that the set theory is of great interest for foundations of Mathematics in the sense that it provides "primitive concepts" that serve as basis of other mathematical notions. In the same line, Bagaria (2010) states that being the theory of abstract sets, the set theory occupies a peat deal of place among all mathematical disciplines since (given that) it is not only an area of mathematics, but also it provides mathematics with its foundation. In addition, in that the set theory is a source of the axioms of mathematics and constitutes and sound basis for the existence of philosophical significance. He asserts that, "sets are the fundamental property of mathematics, but warns that sets by themselves seem pretty pointless. But it's only when we apply sets in different situations do they become the powerful building block of mathematics that they are.

On his part, Clark (2016, p.9) defines **function** like that "Let A and B be sets. A function f defined from A to B is a special kind of relation between A and B. Namely, it is a relation $\boldsymbol{R \subseteq A \, x \, B}$ satisfying the following condition: for all $\boldsymbol{x \in A}$ there exist exactly one $\boldsymbol{y \in B}$ such that $\boldsymbol{(x, y) \in R.}$ Because element of y attached to a given element x of A is unique, we may denote it by f(x). Geometrically, a function is a relation which passes the vertical line test: every vertical x = c intersects the graph of the function in exactly one point. In particular, the domain of any function is all of A". This above process is not required in DRC' Curriculum of Mathematics that provides domain notions in 5th and 6th forms learners DPSMD (2005), since the suppression of sets and relations more than 14 years. While the sets and relations notions are exciting the domain of these relations. Shadrach (2016) goes on saying that graph theory, abstract Algebra, Number theory, Real Analysis, Complex Analysis, Linear Algebra, and the list goes on have one thing in common sets". Needless to say that removing those notions as far as our topic is concerned is simply departing relevant elements in understanding better the notions of domain of definition for the relations. Continuing the list Ramis & Waruself (2006, p. 3) of consulted scholars describes that, "in their modern version, all mathematics is based on the set theory and all mathematics subjects are sets".

We continue to agree with Byju (2020) that in mathematics, "sets, relations and functions" is one the most important topics of Set-Theory. Sets, relations and functions are three different words having different meaning mathematically but equally important for JEE Main preparation. Then,

 DOI: https://dx.doi.org/10.4314/ajesms.v17i2.9

from (www.toppr.com) it is confirmed that, sets, relations and functions are all part of the Set-Theory. These tools help in carrying out logical and mathematical set operations on mathematical and other real-world entities. Sets help in distinguishing the groups of certain kind of objects. Regarding the importance and evolution of Mathematics through the concept of sets, it was analyzed by Ferreiros (2020) that, the concept of set appears deceivingly simple, at least to the trained mathematician, and to such an extent that it becomes difficult to judge and appreciate correctly the contributions of the pioneers. Set theory was beginning to become an essential ingredient of the new "modern" approach to mathematics (Ferreiros, 2020). Set-theoretic mathematics continued its development into the powerful axiomatic and structural approach that was to dominate much of the 20th century. Set-Theory has generally been identified with the branch of mathematical logic that studies transfinite sets, originating in result of Cantor has a greater cardinality than. But set theory was both effect and cause of rise of modern mathematics. The traces of this origin are indelibly stamped on its axiomatic structure (Ferreiros, 2020). Kimengele (2012) who was worried by the suppression of the concepts of Sets and Relations in the Curriculum of Mathematics above-identified, through his article entitled "The impact of removing the concept of sets on the teaching program of geometry at the two first classes of secondary schools in the Democratic Republic of the Congo" argues that, the concepts of Sets and Relations theories are required in Teaching and Learning Geometry. He showed that, 11 teachers under 12, or 91.66% of these teachers claimed that, the theories of the sets should be reinserted in the National Syllabus of Mathematics at elementary levels.

As a grand theory, constructivism served as a means of prying Mathematics Education from its sole identification with the formal structure of Mathematics as sole guide to curricular scope and sequence (Confrey & Kazak, 2006). We would argue with Confrey and Kazak (2006) that, constructivism constitutes a research programme, with a theoretical hardcore, that does not directly predict empirical data, but is protected by a belt of bridging theories. While we acknowledge the value of situating constructivism in relation to broader patterns and trends, we warn that attention to issues of content must be maintained if the work is to adequately serve Mathematics Education (Confrey & Kazak, 2006).

Methodology

This section aims at presenting the applied methodology appropriate to this study. It describes the research design, type of research methods which were used, target population, sample size, sampling procedures, the research instrument, data collection methods and analysis techniques.

Research Design

The overall research purpose was to investigate whether there is any relationship between Congolese students' achievement on relations in sets and their achievement on domains of definition of functions for finalist secondary school students at Bukavu/DRC. To successfully achieving this research objective, a "survey and quantitative methodology" was adopted. Marshall, (1996), states that: "the aim of the quantitative research method is to test predetermined hypotheses and produce generalizable results". Indeed, the aim of the present study was to investigate whether every time the student succeeds/fails in the SR concepts, the student also succeeds/fails in the DDF concepts. Participants to the study are therefore Congolese finalist students who evolved under the mathematics curriculum that is no longer contain SR

concepts but learnt the content involving DDF. Based on the theoretical interconnection between the SR and DDF concepts (discussed in section 2), and in relation to a sample of the questions in our questionnaire that we have illustrated in the literature review section, we were able to reformulate the major variables x and y of this study as follows: x represents students' achievement on SR concepts and y represents students' achievement on DDF concepts.

Our target population was composed of students in final classes of secondary schools in Bukavu-Town. Because this Town of Bukavu is made up of three municipalities, we had liked to select, at random, three secondary schools in each of them, or at most four secondary schools in the larger municipality than the others. The reason for this selection was to make the sample more representative of the target population by including secondary school students at the terminal level in the Town of Bukavu. Indeed, three secondary schools were selected in the commune of Kadutu, and four secondary schools in the municipality of Ibanda. This has been done randomly so that all secondary schools in the city of Bukavu are represented in our sample, but also, so that the four statutes of the schools in Bukavu are validly represented. These statutes are distributed as follows: faith based schools (Catholic or Protestant); Government (Official) Schools; and Private Schools. So, the researcher has made sure that all spheres of school administration have been represented.

Based on school data for the 2020-2021school year the overall population size was estimated at 3050 finalist students for which a sample was extracted by applying sampling techniques. Our sampling technique followed the formula of Taro Yamani developed in Pathak (2013): $\boldsymbol{n = \frac{N}{1+N*(e)^2}}$. Whereby where, n = sample size, N = population size and e = precision of error permitted or level of precision or sampling of error. For the case of our study we have: N = 3050 finalists, the sampling of error is e = 0.05. Therefore, $\boldsymbol{n = \frac{3050}{1+3050*(0.05)^2} = \frac{3050}{8.625} = 353.62 \approx 354,}$ this is our computed sample size in which, male and female students were randomly selected from each school based on their willingness to participate in the pre-test that had been composed for them by the researchers.

Research Instrument

The following lines have justified the reason for design of these variables established above. However, we assumed that if Congolese students are not sufficiently informed about SR concepts, then DDF concepts will also go unnoticed by them. And because, the 2005 mathematics curriculum insisted on the applicability of the coherence of Mathematics, we also assumed that, for a coherence-based mathematics questionnaire in which the questions will follow the pattern of the example illustrated in the literature review section, focused on the interconnection between the concepts of: sets, relations and DDF, the following effect cannot escape the current Congolese students. "Having the lowest scores in SR

Table 1 Number of selected schools located in Bukavu-Town

N°	Name of school	Commune	Status	Number of Students		
				Male	Female	Total
1	Institut Tumaini	Ibanda	Faith Based School	23	39	62
2	C. S. Etoile	Ibanda	Private School	22	19	41
3	Lycée Cirezi	Ibanda	Faith Based School	0	81	81
4	Collège Alfajiri	Ibanda	Faith Based School	18	18	36
5	Institut Fadhili	Kadutu	Faith Based School	46	21	67
6	Institut de Kadutu	Kadutu	Government School	22	28	50
7	ITFM	Kadutu	Catholic School	7	10	17
	TOTAL			138	216	**354**

Source: Bukavu-Town school statistics, 2020

knowledge would also lead to the lowest scores in DDF concepts".

It is in this context that the purpose of our research was to examine whether there is a relationship between students' achievement on SR concepts and their performance on DDF concepts. Nothing ignores that any question based on the determination of the DDF, arouses to know beforehand in which sets these functions have been defined. It is at this level that one would list all the elements of the set of departure which have images in the set of arrival. This is the DDF that we need. Because the concepts of DDF were taught in the secondary humanities final classes, we designed our instrument having questions that required students to determine the domains of definition of the relations/functions defined in the finite or infinite sets.

The questions asked in our questionnaire concerned two concepts SR and DDF. Our questionnaire was then reformulated in the above manner, because the current DRC curriculum provides for the learning of DDF concepts in the final grades of secondary school, while at the same time that curriculum suppress SR concepts in the lower grades of secondary school, while the determination of DDF appeals to SR concepts. We have hoped to give for those examined students 4 major questions that they could answer during 2 hours. The first question was scored over 20 marks that was distributed as follows: 10 marks for sets/relations and 10 marks for domains of definition of these relations; the second question was scored over 30 marks and distributed as 15 marks on relations/functions and 15 marks on DDF; the third question counted on 25 marks including 10 marks in sets/relations and 15 in DDF; and the fourth question was counted on 25 marks including 15 marks in composition of relations and 10 marks in DDF. In the end, the sets and relations were marked on 50 marks and the DDF concepts on 50 marks.

Validity of Tools

In this study, construct and content validity have been established. For construct validity, before administering the questionnaire, it has been examined by experienced lecturers including the supervisor of the research and amendments have been made. For content validity, the questionnaire was pre-tested and internal consistency was obtained by calculating Pearson correlation coefficient between the item and the entire questionnaire. The non-homogenous items were eliminated. We state this because we have followed Mathers, Fox & Hunn (2009) who state that, questionnaires can only produce valid and meaningful results if the questions are clear and precise and if they are asked consistently across all respondents. Our test was also reliable because the results obtained in the different schools decreased in both SR and DDF almost in the same way. This statement supports that of Anastaki published by Lovely Professional University LPU (2012), stating that, the reliability of a test refers to consistency or scores obtained with different set of equivalent items. Thus, reliability is that attribute of its results equal. In our study, we found that in each of the selected schools, the more Congolese students failed the SR concepts, the more they failed on DDF. The survey questionnaire has been given for each school selected in different days. This wants to means, one day per commune. The examination has been done secretly so that other schools may not be informed.

Data Collection Procedure

Data collection for our research was carried out in Bukavu in its 7 selected schools. Our data collection was carried out through the permission we had obtained not only the Director of Research and Innovation Unit of

University of Rwanda, dated October 05, 2020, but also and above all by the authorities of the educational sub-divisions of the educational province of South Kivu, Bukavu. Our participants signed a consent form. This consent was sought from all participants involved in the research; consent form was translated into French that is the language of instruction in DRC. To seek to ensure that consent given is fully informed, all potential participants received an information sheet detailing the aims, objectives and procedures of the research in an accessible way. The research has not involved children less than 16 years because, all school children in the selected form are at least 16 years old. The authorities of the selected schools kept confidence in us because they did everything to assign us invigilators in the premises where we examined the Congolese students.

We were able to collect the data through a questionnaire. The participants filled out the questionnaire with their demographic and scientific information on the concepts of SR and DDF. We were inspired by the method of making the questionnaire by agreeing with SAGE P (2020), which states that, the six most common methods of data collection used by educational researchers are: tests; questionnaires; interviews; focus groups; observations and constructed, secondary, and existing data. With these methods of data collection, researchers can have their participants fill out an instrument or perform a behavior designed to measure their ability or degree of skill (test). Researchers can have participants fill out self-report instruments (questionnaires). Researchers use questionnaires to obtain information about the thoughts, feelings, attitudes, beliefs, values, perceptions, personality, and behavioral intentions of research participants (SAGE, 2020).

Methods of Data Analysis

The major research question of this study consisted to know whether there is any relationship between Congolese students' lesser scores on sets/relations concepts and their lesser scores in learning of the domains of definition of functions. This research question prompted the researcher to organize a test survey to investigate the relationship between the SR concepts and the DDF concepts.

After collecting data from seven schools in the city of Bukavu, the researcher grouped them in terms of data pairs in the form of (x, y), where, x represents students' achievement on SR concepts by a selected school, and y represents students' performance on DDF concepts by a same selected school in DDF concepts. The collected data were analyzed and interpreted by calculating the correlation coefficient between the two variables x and y according to the lesser mean scores obtained in 7 schools. We supposed that, the given null and alternative hypotheses should be statistically tested; using t-test at $\alpha = 0.05$ level of significance, for the existing correlated variables, in computing the value of Karl Pearson's correlation of coefficient (r) for the data pairs that were obtained from 7 schools at Bukavu. With regard to Bluman's (2009) approach to such correlational analysis, the researcher drew a scatter plot for the ordered pairs to examine the linear relationship.

Results

Demographics data show that 216 (61%) female students and 138 (39%) male students making a total of 354 students participated to the study. The large number of female students is justified by the fact that an all-female school was selected. But also, in the other selected schools, there were always a proportional number of both female and male students. We were surprised to find that 352 (99.4%) out of 354 students agreed that they

had already studied superficially SR concepts, even though their mathematics curriculum did not include them. Also, DRC secondary education inspectors never allow the learning of concepts that are not in the current school curriculum. This acceptance of the students seems to be true, because when interviewing math teachers in the Town of Bukavu, they affirmed that they teach SR concepts in an unnoticed way, as revisions of the lessons, before introducing other notions for which these SR concepts can intervene.

In the work of the Congolese students, we note that the more they failed in SR concepts, the more they failed excessively in DDF concepts. This connectivity of failures may already lead us to believe that there is a probable correlation between students' achievement on SR concepts and their performance on DDF concepts, in accordance with the results displayed by these Congolese students. The results of their rounded averages can be clearly seen in Table 2.

Indeed, the 7 pairs (x, y) of data marking the mean scores obtained in SR concepts as their first components and these obtained in DDF concepts as their second components are shown below. The purpose of this presentation is to test hypothetically whether their positions in the graph can prompt a full study of a probable existing correlation before calculating it (Bluman, 2014).

Figure 1 shows scatter plots of data pairs of the students' mean scores from the seven 7 selected schools. From the figure, one can notice that the 7 pairs of collected data are positioned in 7 points gravitating around the regression curve, although there are two extreme outliers, one at the top and one at the bottom. The one at the top is far from the others as it represents a school with the highest failure (14/50, 18.4/50) in (SR, DDF) concepts respectively. The one at the bottom moves away from the others because it represents a school with the lowest failure (0.34/50, 0/50) in (SR, DDF) concepts respectively. This means that the students from the other 5 schools clustered among the outlier schools all failed in almost the same way on both SR and DDF concepts.

Table 2 Rounded mean scores obtained from the 7 schools sampled at Bukavu

School	I	II	III	IV	V	VI	VII
Mean score on sets and relations (SR) – out of a maximum of 50 Marks (x)	4.6	7.3	5.9	0.34	7.7	14	2.6
Mean score on domains of definition of functions (DDF) – out of a maximum of 50 Marks (y)	1.6	4.1	4.0	0	3.1	18.4	0.9

Source: Primary data, 2020

Figure 1 Scatter plots of data pairs of students' mean scores from 7 selected schools

(Source: Primary data, 2020)

The hypotheses reformulated for this research are clearly visible and known in this paper. In order to be able to answer this research question, were therefore took the 7 data pairs of the average scores that were collected in 7 schools in the Town of Bukavu, with the objective of examining the existing correlation between them.

A Pearson correlation coefficient was computed to assess the linear relationship between secondary school students' scores on relation in sets and on domains of definition of functions.

There was a strong positive correlation between the two variables, $\boldsymbol{r(5) = .91}$, $\boldsymbol{p = .015}$. From the result of $\boldsymbol{r = 0.91}$, this allows us to reject the null hypothesis which proposed that, there is no statistically linear relationship between the lesser scores of knowledge sets/relations and lesser scores of knowledge the domains of definition of functions to the secondary Congolese students. Since, the found linear correlation coefficient $r = 0.91$ suggests a strong positive relationship between students' achievement on SR concepts and their performance on DDF concepts. (See, Figure 1). The failure in the knowledge of sets and relations leads to a great failure in domains of definition of functions among Congolese students of Bukavu. As this relationship exists, it is statistically required to compute the signification tests of this correlation. The critical values (CV) have been found at $\alpha = 0.05$ and degrees of freedom $d.f = n - 2 = 7 - 2 = 5$, considering the critical values for two-tailed test from Table F, are -2.571 and $+2.571$ (Bluman, 2014, p. 790).

Results Related to the Questions of the Research Questionnaire

Four questions concerned this part of the questions itself represented below in Figure 3. The philosophy inserted on each of them was to determine the domain of definition of

the relations/functions, knowing beforehand the establishment of the starting and arrival sets in which these relations/functions were defined. There was also the philosophy of knowing how to interpret the mathematical links between the elements of the starting sets and these of the arrival sets. This should allow the Congolese students, to well establish the diagrams with arrows between the sets, to identify the conditions of determination of the DDF to in end calculate them.

The blue color in Figure 2 shows the students' scores on the SR. The burgundy color shows the students' scores on the DDF. The numbers 1, 2, 3 and 4 represent questions 1, 2, 3 and 4 respectively. These questions 1, 2, 3 and 4 were weighted out of 20, 30, 25 and 25 marks respectively. For each question, there was a weighting carried out on SR and another on DDF so that in total we could have 50 marks on SR and 50 marks on DDF. Regarding question 1, the Congolese students of Bukavu obtained an average score of 5.2 out of 20 weighted marks, including 3.3/10 for SR and 1.9/10 for DDF. That is, to say 26% of failure to this question of which 33% at SR and 19% at DDF. This score of 5.2/20 was obtained by summing 3.3/10 and 1.2/10 which are the scores obtained by the students on SR and DDF respectively.

As for question 2, the Congolese students obtained an average score of 2.8/30, including 1.6/15 for SR and 1.2/15 for DDF. That is to say 9.3% of failure in question 2, of which 10.6% on SR and 8% on DDF. Concerning question 3, the Congolese students obtained an average score of 1.4/25 including 0.5/10 on SR and 0.9/15 on DDF. That is to say, 4.4% of failure in question 3, of which 5% on SR and 6% on DDF. Finally, for question 4, the Congolese students obtained an average score of 0.23/25 including 0.2/15 on SR and 0.03/10 on DDF. That is to say, 0.92% of failure in question 4, of which 1.3% on SR and 0.3% on DDF. The total average of the scores obtained by the Congolese students is 9.63 on 100 weighted marks including 5.6/50 on SR and 4.03/50 on DDF. That is to say, 9.63% of total failure on all four questions asked, including 11.2% on SR and 8.06% on DDF.

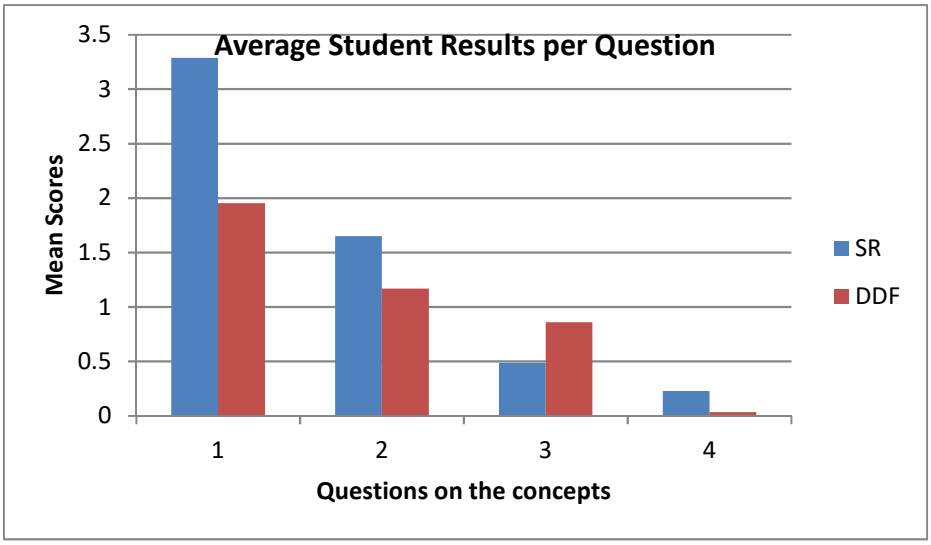

Figure 2 Information on the Actual Questions

(Source: Primary data from respondents at Bukavu, 2020)

Discussion of Findings

Ultimately, it is clear from these low scores that the more Congolese students failed SR concepts, the more severely they failed DDF concepts. This principle immediately confirms our alternative hypothesis, which was considered our claim during this research. To put it another way, this principle identified with the Congolese students' scores, seriously rejected our null hypothesis. These tricks were initiated by the researcher not only to show the interconnectivity of the SR and DDF concepts, but also and especially to castigate the suppression of the concepts on SR in the DRC Mathematics curriculum (DPSMD, 2005). It is through these results that this study sides with the authors who have shown in our literature review that the concepts of sets and relations are considered as a foundation for a logical sequence of constructions of several mathematical theories. We thus recommend to other future researchers who will be interested in studying the impacts of the exclusion of SR concepts in the current DRC mathematics curriculum, to carry out an in-depth study on: the impact of the non-studying of sets and relations on the knowledge of Congolese students in other mathematical concepts namely: Operations on intervals of real numbers, Combinatorial analysis, Notions of probability calculations, Algebraic applications, Laws of internal composition, Linear algebra, Topology, Algebraic structures, Vector geometry, Determination of Ranges of numerical functions, Plane transformations,

This study could be extended not only to Congolese secondary school students but also and especially to other students of different university levels. And not always in Bukavu, we could also project an equivalent look in other parts of the DRC.

Through this study, we have noted that a rapid intervention should be addressed to the Congolese national education authorities, especially to the National Inspectors of Mathematics and to the Technical Team of the Education Project for the Quality and Relevance of Teaching at the Secondary and University levels, including the authors of the removal of the SR concepts in both the 2005 and 2018 reforms, in order to reformulate a plea to the Ministry of National Education to be able to put the SR concepts back into the DRC's mathematics curriculum. There is also a need to order the sustainable and formal learning of SR concepts. It can be hypothetically assumed that the inclusion of these SR concepts in the mathematics curriculum would allow Congolese students to easily find their way around the DDF concepts that we addressed in our survey questionnaire. It has been shown in our part of the literature review that many mathematical concepts are built on the SR concepts. If father scientific research projects on different parts of the DRC are conducted, they may provide more insight on the impact of suppression of SR concepts from the mathematics curriculum.

Conclusion

From the study of Kimengele (2012) and that which we have just carried out, one was addressed to the teachers of Mathematics of Bukavu, and ours was addressed to the Congolese students of the terminal level of the secondary humanities, we affirm then that, the Congolese students have for a long time recorded a breakdown cutting out for them the interconnection between the concepts of the SR and these of the DDF.

All the objectives assigned in this research have been achieved. The hypothesis reformulated in this research, as our claim, has also been confirmed by immediately rejecting the null hypothesis. Some implications, both negative and positive, also emerged, such as the impacts of non-studying SR concepts on Congolese students' DDF

scores. It is well verified that through this study, the concepts of SR should be put back in the school program of Mathematics of the DRC, for a good improvement and future continuation of knowledge of Congolese students in DDF. This study statistically proves that there is a strong positive correlation between having failed in SR concepts and having severely failed in DDF concepts among Congolese students in Bukavu. Also, the suppression of SR negatively impacts the mastery of the DDF concept among Congolese students.

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