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Perception of Mathematical Proficiency, Assessment of Derivatives, and Stated Representations of the Derivative Among 9th-Grade Students in the Science Track at MBANDAKA, DEMOCRATIC REPUBLIC OF CONGO (DRC)

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ABSTRACT

This study analyzes the perception of mathematical competence, the understanding of the concept of derivatives, and students' reported conceptual representations of the derivative among one hundred third-year science high school students from four schools in downtown Mbandaka. A descriptive and analytical quantitative approach was adopted using a four-question survey. The results show that 57% of students self-assess their mathematics proficiency as rather good or very good. However, 55% report only partially understanding the chapter on derivatives, and 51% state that they do not truly know what a derivative is. Furthermore, 63% believe they understand the connection between limits and derivatives. Inferential analysis reveals a statistically significant association between the self-reported level in mathematics and the understanding of the derivatives chapter. In contrast, no significant relationship is observed between the students' descriptions of the derivative and their reported ease in establishing the connection between limits and derivatives.

Keywords: perception, derivative of a function, representation, understanding, mathematics.

1. INTRODUCTION

Mathematics education in the Democratic Republic of the Congo faces structural, pedagogical, didactic, and summative challenges. In the third year of the science track, current educational curricula require that the concepts of derivatives of functions be taught and mastered. Furthermore, this concept is fundamental to mathematical analysis; its understanding requires students to grasp the concepts of instantaneous rate of change, the slope of the tangent to a curve, and the limit of the rate of increase. However, in many school settings, its teaching continues to be reduced to a mere mechanical application of calculation rules. Such an approach leads students to perform calculations without necessarily realizing the mathematical significance of the steps they are taking.

In Mbandaka, we found no empirical research describing either the perceptions that 9th-grade students in the science track have regarding the concept of the derivative, nor their assessment of the concept of the derivative and the mental models they associate with this essential knowledge. The lack of local empirical data limits the ability to adapt teaching practices to the problems actually expressed by students. Consequently, it is necessary to examine how these students assess their own level in mathematics and their attitudes toward derivatives and thereby identify the meanings they ascribe to this concept. Furthermore, we aim to determine whether their self-reported level in mathematics is associated with their perception of the chapter and whether their self-reported understanding of the derivative is associated with the ease they report in establishing the connection between limits and derivatives.

Based on previous studies conducted along similar lines, we can cite: (Fuentealba et al. 2017), (Borji et al. 2018), (Fuentealba et al. 2019), (Nurwahyu et al. 2020), and others. These studies primarily focus on university students and have paid less attention to the affective dimension, particularly students' perception of their own level in mathematics and their assessment of the chapter on derivatives. It should also be emphasized here that these studies were conducted in the African context and not specifically in the Democratic Republic of Congo, particularly in downtown Mbandaka.

We therefore believe it is important to simultaneously examine students' perceptions of their own math proficiency, their understanding of the concept of derivatives, and their reported conceptual representations of derivatives among third-year science track students at the targeted secondary schools in Mbandaka. The aim of this study is to produce a scientific paper that will contribute to enriching theories of mathematics education by adding knowledge about the cognitive and affective aspects associated with learning the derivative in the Congolese context, particularly in the city of Mbandaka.

Considering the above, the following question arises:

- How do third-year science track students at four selected schools in Mbandaka assess their own level in mathematics?
- Do they understand the concept of the derivative?
- What representations do they have of certain meanings of the derivative?

Thus, the objective of this study is to analyze the perceived level of proficiency in mathematics, the students' assessment of the chapter on derivatives, and their stated conceptions of the derivative among third-year science track students at four schools in downtown Mbandaka. We can tentatively conclude that third-year science track students in downtown Mbandaka exhibit perceptions, evaluations, and conceptions of the derivative that reveal discrepancies between their self-reported level in mathematics and their self-reported understanding of this concept.

An analysis of research on the teaching of differential calculus and more specifically, the concept of the derivative highlights a set of pedagogical and epistemological questions that can be organized around two main themes: first, the cognitive obstacles and modes of representation of the derivative among learners; on the other hand, the influence of affective dimensions and self-perception on mathematical performance.

2. COGNITIVE OBSTACLES, REPRESENTATIONS, AND MASTERY OF THE DERIVATIVE

A significant portion of research in mathematics education has focused on documenting the nature of the difficulties encountered by students as they grasp the concept of the derivative. In a study conducted with college students, Fuentealba et al. (2017) highlighted the complexity of constructing a mental model of the derivative and the relationships between successive derivatives. Their analyses emphasize that, despite formal instruction in differential calculus, many learners struggle to integrate the various modes of representation (algebraic, graphical, and physical) and to make sense of the mathematical properties they are working with. This observation is corroborated by subsequent work by Fuentealba et al. (2019), who note that an alarming proportion of students reduce the derivative to a simple algorithmic formula or a mechanical calculation, at the

expense of conceptualizing it as an instantaneous rate of change or the slope of the tangent line.

In the same vein, Nurwahyu et al. (2020) emphasized the persistent gap between mechanical calculation procedures and a deep understanding of the concept. Their findings show that students face a major obstacle in connecting the fundamental concepts of limit, rate of change, and derivative. These findings echo the pioneering analyses of Tall and Rashidi Razali (1993), who argued that the transition to abstract concepts such as the limit or the derivative constitutes a major cognitive leap. According to these authors, the lack of unified connections between graphical, algebraic, and numerical representations leads learners to develop superficial operational skills, explaining why many of them claim to be able to apply a differentiation rule while admitting that they do not know what a derivative actually is from a conceptual standpoint.

To address these shortcomings, innovative pedagogical approaches have been tested. This is the case in the study conducted by Borji et al. (2018) on the "APOS-ACE" approach, which demonstrates that instruction promoting the mental construction of mathematical objects significantly improves the graphical understanding of the relationships between a function and its derivative.

3. THE ROLE OF AFFECTIVE DIMENSIONS AND SELF-PERCEPTION IN MATHEMATICS

While past research has extensively documented the cognitive and instrumental aspects of differential calculus, a second strand of the literature highlights the predominant role of affective factors, particularly self-perception and self-efficacy. In a seminal study, Pajares and Miller (1994) demonstrated that a student's perception of their own competence in mathematics is a predictor of success that is often more robust than prior experience or actual measured ability. Learners with a strong sense of self-efficacy approach complex tasks with greater perseverance.

This perspective is amply supported by the large-scale study by Marsh and Yeung (1998), involving more than 24,000 students, which confirms that academic self-concept in mathematics has a lasting influence on educational choices and future performance. More recently, longitudinal analyses conducted by Arens et al. (2017) have highlighted the existence of a feedback loop between self-concept and academic achievement: students who perceive themselves as competent achieve better results, which in turn reinforces their self-confidence. These theoretical insights shed new light on the paradoxes frequently observed in the field, where students who consider themselves generally good at mathematics may simultaneously experience profound conceptual confusion when faced with specific topics such as derivatives.

4. RESEARCH FRAMEWORK AND DIFFERENCES FROM EXISTING LITERATURE

A critical examination of this literature review reveals clear limitations that the present study aims to address.

First, virtually all of the empirical research cited (Fuentealba et al., 2017, 2019; Borji et al., 2018) has focused exclusively on a population of college students, neglecting the reality of high school students and more specifically those in the science track where the first true formalization of mathematical analysis takes place.

Second, a regrettable dichotomy emerges in the literature: on the one hand, didactic studies on the derivative focus almost exclusively on pure cognition and semiotic aspects; on the other, studies on self-perception and self-efficacy address mathematics in general, without cross-referencing these affective variables with the assessment of a specific conceptual content such as the chapter on derivatives.

Finally, these previous investigations were conducted in Western or Asian socio-educational contexts with stable educational structures and cannot reflect the specific realities of the Congolese context in this case, the under-resourced educational environment in downtown Mbandaka. It is precisely at the intersection of these dimensions by linking the overall perception of mathematics proficiency, the assessment of the chapter on derivatives, and the analysis of students stated representations among third-year science track students that the originality of this research lies.

5. METHODS

5.1 Type and Methodological Approach of Research

For this study, we adopted a quantitative, descriptive, and analytical approach. It is based on a survey conducted among 3rd-year science track students at four schools in downtown Mbandaka. This study is descriptive because it presents the respondents' perceptions and stated representations. It is also analytical because it examines the associations between certain variables using statistical tests.

5.2 Population and Sample

According to Grawitz, M. (2001), a study population refers to the set of units involved in a research study and on which observations are based; and according to Quivy, R., & Van

Campenhoudt, L. (2011), a sample is a portion of the study population, selected in such a way as to allow conclusions to be drawn about the entire population.

For the purposes of this study, the target population consists of all 9th-grade students in the science track at schools in downtown Mbandaka. To date, there are 15 officially recognized secondary schools in the area that offer the science track, with an average of approximately 40 students per class in the 9th grade. From this population, a sample of 100 students was selected using simple random sampling. The participants were distributed across four schools, with 25 students per school. The selected schools include two state-subsidized Catholic schools (Institut Mgr. BOWANGA and Institut Frère ILOO), one non-subsidized school (Institut BAKUSU), and one private school (Complexe scolaire la Gloire de l'Eternel). In each school, students were selected at random to ensure that each had an equal probability of being chosen. This approach made it possible to obtain a sample representing the various categories of schools offering a science track in downtown Mbandaka.

5.2.1 Variables Analyzed

Table 1: Overview of the variables analyzed

Variable	Type	Measurement
Self-assessed mathematical level	Ordinal	Very low, low, average, fairly good, very good
Assessment of derivatives	Nominal	Yes, no, partially
Stated representation of the derivative	Nominal	Formula, slope, rate of change, unknown
Reported limit-derivative facility	Binary	Yes, no
Gender	Binary	Girl, boy
School	Nominal	Bakusu, Bowanga Brother Iloo, Glory

5.2.2 Profile of Respondents

Table 2: Breakdown of the 100 Respondents by Gender

Students by gender	Number	Frequency (%)
Girls (F)	43	43
Boys (B)	57	57
Total	**100**	**100**

5.3 Data Collection Techniques

According to Grawitz (2001), there are several methods for collecting data in scientific research. These include questionnaires, interviews, discussions, and so on.

For our study, we used a questionnaire, which was administered to the students in our sample. According to the curriculum, the topic of derivatives is covered in the Analysis course in the third year of the science track. Knowing that each teacher had scheduled a specific time in their lesson plans to teach derivatives, we deemed it appropriate to visit these schools before the end-of-school-year exams, during the review period from May 20 to 25, 2026, to collect data. Upon our arrival at the schools where our participants were studying, the school principals reserved a classroom for us for this purpose.

5.4 Data Collection Tools

According to Grawitz (2001: p. 338), a questionnaire is a "set of questions asked orally or in writing." The written questionnaire serves as an "essential means of communication between the researcher and the respondent." For our study, we developed a questionnaire consisting of 4 (four) questions, divided into two distinct sections:

- **Section 1:** Attitudes Toward Mathematics and the Concept of Derivatives (Questions 1 and 2).

This section aims to assess the self-reported proficiency of the surveyed students in mathematics in general and in the concepts of derivatives. Question 1 evaluates the students' level of appreciation for the subject using a Likert scale. Question 2 asks students whether they like, dislike, or have mixed feelings about the chapter on derivatives.

- **Section 2:** Concept of the Derivative (Questions 3 and 4).

Here, we seek to understand students' statements regarding the concept of a derivative and its meaning, and whether they believe they can make the connection between the derivative and the concept of a limit.

6. PRESENTATION AND INTERPRETATION OF RESULTS

Data was collected through a questionnaire administered to students, and the results of this study are presented in a summary table that compiles data from all targeted schools for each relevant question.

1. How would you rate your overall level in mathematics?

- Very low
- Low
- Average
- Pretty good
- Very good

Table 3: Results for Question No. 1

Likert scale	F	G	Total	Frequency %
Very low	2	2	4	4
Low	8	10	18	18
Medium	11	10	21	21
Pretty good	18	29	47	47
Very good	4	6	10	10
Grand total	**43**	**57**	**100**	**100**

Interpretation

Based on our overall survey, the following findings emerge:

- 4% of the students surveyed consider themselves very weak in math;
- 18% of these students report being weak in math;
- 21% of them consider themselves to be at an average level in math;
- 47% say they are fairly good at math, though they do not consider themselves excellent;
- 10% feel they are very good at math.

Based on these students' statements, we find that the majority rate themselves positively in terms of their math skills.

2. How do you rate the chapter on derivatives?

- I like it
- I don't like it
- I like it somewhat

Table 4: Survey results for Question 2

Respondents' Answers	F	G	TG	Frequency (%)
I like it	15	19	34	34
I don't like it	4	7	11	11
I like it somewhat	24	31	55	55
Grand total	**43**	**57**	**100**	**100**

Interpretation

The results show that:

- 34% of respondents say they like the chapter on derivatives;
- 11% of them say they "don't like it;
- 55% say they like it somewhat.

Thus, the response "I like it to some extent" is the most common, which means that most students feel they do not fully engage with this chapter. It should therefore be noted that the reasons for this partial rejection remain unknown at this time.

3. Which of the following statements best matches your current understanding of the derivative?

X	Primarily a calculation formula	
X	The slope of the tangent line to a curve at a given point	
X	An instantaneous rate of change	
X	I don't really know what a derivative is	

Table 5 : Survey results for question #3

Statement	F	G	Total	Frequency (%)
Primarily a calculation formula	8	14	22	22
The slope of the tangent to a curve at a point	3	10	13	13
An instantaneous rate of change	3	11	14	14
I don't really know what a derivative is	29	22	51	51
Total	**43**	**57**	**100**	**100**

Interpretation of the Results

- 22% of the students surveyed reduced the derivative to a mechanical formula;
- 27% of them equate it with a slope or a rate of change;
- 51% say they do not know what a derivative is.

4. Do you find it easy to understand the connection between the limit and the derivative?

- YES
- NO

Table 6: Survey results for question #4

Reported ease/difficulty	F	G	TG	fi
Reported ease	23	40	63	63
Reported difficulty	20	17	37	37
Grand total	**43**	**57**	**100**	**100**

Interpretation

- 63% of the students surveyed reported having no difficulty establishing the connection between a limit and a derivative.
- 37% reported having difficulty doing so.

So far, there is no evidence that these statements about ease are accurate, as the study did not include a series of questions to test them.

6.1 Statistical Test Results

6.1.1 Profile and Attitude Toward Mathematics

The chi-square test was applied to the grouped cross-tabulation to verify whether there was a relationship between the students reported overall level in mathematics and their assessment of the chapter on derivatives.

Table 7 : Observed Table

Level	Assessment	Do not like	Partially like	Total
Low	8	2	12	22
Medium	5	7	9	21
High	21	2	34	57
Total	**34**	**11**	**55**	**100**

Interpretation

The calculation shows that $\chi^2 = 14.17$, df = 4, and $p \approx 0.00697 < 5\%$ were found. This proves that the associated probability is smaller than the significance threshold. Therefore, the null hypothesis of independence is rejected; there is indeed a statistically significant association between the overall math proficiency of the surveyed students and their assessment of the chapter on derivatives.

6.1.2 Concept of the Derivative

Section B focuses on what students believe they know about the concept of a derivative. We used the chi-square test and the likelihood ratio test.

Table 8: Cross-tabulation of Questions 3 and 4

		Q4		Total
		0	**1**	
Q3	**1**	13	9	22
	2	4	9	13
	3	4	10	14
	4	16	35	51
Total		**37**	**63**	**100**

Interpretation

Of the 100 students surveyed, the results show that, with regard to the definition of the concept of a derivative, it turns out that:

- 22 of them consider the derivative to be a formula;
- 13 see it as the instantaneous rate of change;
- 14 equate the slope of the tangent line with the instantaneous rate of change;
- 51 have absolutely no idea.

Of the 100 students surveyed, the results show that, regarding the relationship between limits and derivatives, it appears that:

- 63 students say “YES,” believing they can establish the connection between limits and derivatives. This shows that even some who said they cannot define the derivative are still able to make this connection.
- 37 students answered “NO.” This means they are unable to establish this connection.

Table 9 : Chi-square Tests

	Value	ddl	Asymptotic Significance (Two-tailed)
Pearson's chi-square	5.942	3	0.114
Likelihood ratio	5.775	3	0.123

Interpretation

Based on the research results presented, the chi-square test yields a value of 5.942; df = 3 and $p \approx 0.114$. It should be noted that the data does not allow us to reject the null hypothesis of independence at the 5% significance level. In other words, the hypothesis that the representation of the derivative influences the establishment of a relationship between the limit and the derivative is not confirmed.

7. DISCUSSION

A cross-analysis of the data collected from third-year science track students in Mbandaka highlights striking paradoxes between learners' perceptions of their own competencies, their affective attitudes toward mathematical concepts, and the reality of their conceptual representations.

7.1 Positive Self-Assessment and the Paradox of Conceptual Mastery

The results from the first question show that an overwhelming majority of students rate themselves rather favorably: nearly 57% consider themselves "rather good" or "very good" in mathematics, compared to only 22% who describe themselves as weak or very weak. This profile of high self-efficacy is consistent with the work of Pajares and Miller (1994) as well as the observations of Marsh and Yeung (1998), who note that students often tend to project a positive academic self-concept.

However, a closer examination of students' conceptions of the derivative (Table 5) qualifies this favorable picture and reveals a profound disconnect. In fact, more than half of the respondents (51%) state that they "don't really know what a derivative is," while 22% reduce it to a simple mechanical calculation formula. Only a minority are able to rigorously identify it as the slope of a tangent line (13%) or an instantaneous rate of change (14%). This finding echoes the work of Fuentealba et al. (2017, 2019) and Nurwahyu et al. (2020), who emphasize that learners frequently develop superficial operational skills without truly grasping the underlying mathematical meaning of the concept. As Tall and Rashidi Razali (1993) had already noted, the transition to the abstraction of the derivative constitutes a sudden cognitive break that students circumvent by memorizing calculation algorithms devoid of conceptual meaning.

7.2 Between Partial Acceptance and an Emotional Connection to the Topic of Derivatives

Regarding the evaluation of the chapter on derivatives (Table 4), the response "I partially like it" was by far the most common, with 55% of the votes, while full approval peaked at 34%. This mixed response reflects the students' ambivalent attitude toward mathematical analysis.

The chi-square test comparing students' self-reported overall math proficiency with their assessment of the chapter (chi-square = 14.17, $p < 0.05$) confirms that there is a statistically significant association: students who consider themselves the highest performers tend to show greater tolerance, or even interest, toward this chapter, while those struggling experience a latent aversion. This result corroborates the longitudinal findings of Arens et al. (2017), who demonstrate the existence of a constant feedback loop between a sense of competence (self-concept) and affective attitude or appreciation toward complex instructional content.

7.3 Discrepancy Between Reported Ease and Actual Perceptions

A particularly troubling finding emerges from the cross-analysis of the perceived ease of relating the limit to the derivative (Question 4) and the reported conceptions of the derivative (Question 3). In fact, 63% of students claim that it is easy for them to establish the connection between a limit and a derivative, even though more than half of them also admit that they do not know what a derivative actually is.

CONCLUSION

The fundamental objective of this research was to analyze students' perceptions of their overall level in mathematics, their assessment of the chapter on derivatives, and their stated conceptual understandings of this concept among third-year students in the scientific track at four schools in the city of Mbandaka, in the Democratic Republic of Congo. Conducted in a context marked by the structural challenges of science education in sub-Saharan Africa, the study aimed to address the lack of local empirical data regarding the relationship between affective dimensions (self-perception, attitudes) and cognitive representations of mathematical concepts.

Following data analysis, the results highlight a striking contrast between the learners' self-efficacy profiles and the reality of their conceptualization. On the one hand, the majority of students exhibit a generally positive sense of

competence in mathematics and express partial or favorable support for the chapter on derivatives. This trend confirms the influence of affective factors on the perception of the subject. On the other hand, this stated confidence masks deep conceptual weaknesses: more than half of the respondents admit to not knowing what a derivative actually is, while a significant proportion reduces it to a simple algorithmic routine. Statistical analysis also confirmed the existence of a significant association between the self-reported proficiency level and the assessment of the chapter, while revealing the absence of a statistical link between the nature of the representation of the derivative and the self-reported ease of relating it to the concept of a limit. This paradox reflects a superficial mastery and an illusion of competence largely attributable to traditional transmissive teaching methods.

From an epistemological and pedagogical perspective, these conclusions offer an original contribution to the Congolese educational context. They underscore the urgent need to rethink teaching practices in mathematical analysis at the secondary level, moving beyond pure formalism to ground learning in a genuine construction of meaning.

Finally, while providing valuable insights into the profile of students in Mbandaka, this study opens the door to new research avenues. In future research, it would be advisable to deepen the investigation through diagnostic assessment tests to measure the effectiveness of reported competencies and to explore the impact of alternative pedagogical approaches such as inquiry-based learning or the use of contextual materials on overcoming the cognitive obstacles associated with learning derivatives.

REFERENCES

Arens, A. K., Marsh, H. W., Pekrun, R., Lichtenfeld, S., Murayama, K., & Vom Hofe, R. (2017). Math self-concept, grades, and achievement test scores: Long-term reciprocal effects across five waves and three achievement tracks. Journal of Educational Psychology, 109(5), 621–634

Borji, V., Alamolhodaei, H., & Radmehr, F. (2018). Application of the APOS-ACE theory to improve students' graphical understanding of the derivative. EURASIA Journal of Mathematics, Science and Technology Education, 14(7), 2947–2967. https://doi.org/10.29333/ejmste/91451

Fuentealba, C., Badillo, E., Sánchez-Matamoros, G., & Cárcamo, A. (2019). The understanding of the derivative concept in higher education. EURASIA Journal of Mathematics, Science and Technology Education, 15(2), Article em1662. https://doi.org/10.29333/ejmste/100640.

Fuentealba, C., Sánchez-Matamoros, G., Badillo, E., & Trigueros, M. (2017). Thematization of the derivative schema among university students: Nuances in constructing relations between a function's successive derivatives. International Journal of Mathematical Education in Science and Technology, 48(3), 374–392.

Grawitz, M. (2001). Methods in the Social Sciences (11th ed.). Paris: Dalloz.

Marsh, H. W., & Yeung, A. S. (1998). Longitudinal structural equation models of academic self-concept and achievement: Gender differences in the development of math and English constructs. American Educational Research Journal, 35(4), 705–738.

Nurwahyu, B., Tinungki, G. M., & Mustangin. (2020). Students' conceptual image and its impact on reasoning regarding the concept of the derivative. European Journal of Educational Research, 9(4), 1723–1734. https://doi.org/10.12973/eu-jer.9.4.1723

Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. Journal of Educational Psychology, 86(2), 193–203. https://doi.org/10.1037/0022-0663.86.2.193.

Quivy, R., & Van Campenhoudt, L. (2011). Handbook of Social Science Research (4th ed.). Paris: Dunod.

Tall, D., & Rashidi Razali, M. (1993). Diagnosing students' difficulties in learning mathematics. International Journal of Mathematical Education in Science and Technology, 24(2), 209-222. https://doi.org/10.1080/0020739930240206.