Links Between the Teacher's Atmosphere Postures and the Pupils' Study Postures When Solving Proportionality Problems, identified under Implicative Statistical Analysis in ICHC-MGK

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ABSTRACT

This article aims to examine the possible links between the teacher's atmospheric postures and the students' learning postures during the teaching of mathematics, particularly with regard to solving proportionality problems in 3rd grade at Bourbon College on Reunion Island. This analysis will be based on the observation of teaching practices through video sequences, and will be deepened through the use of Implicative Statistical Analysis (ISA) according to ICHC-MGK. The study results show that maintaining a space for dialogue encourages students to adopt an academic posture. Creating this space for dialogue also helps to capture their attention. As a result, the study highlights the importance of providing teachers with in-depth training and a better understanding of their pupils' individual needs. This would enable them to adapt their teaching methods more effectively to the particularities of each learning context, in order to improve student success.

INTRODUCTION

At present, France is cited as one of the countries in Europe that is suffering from a drop in the level of its pupils, more specifically in mathematics. According to the 2019 TIMSS (Trends in International Mathematics and Science Study) survey, "the mathematical skills of French pupils show a worrying trend". This decline even extends to France's overseas territories. For Réunion, the results in mathematics from the national assessments of September 2023 for 4th year classes are worrying, placing the island among the French overseas departments with a low level in mathematics.

These findings are very different from UNESCO's objectives for education in less than a decade's time. Indeed, by 2030, UNESCO aims to establish education systems that guarantee inclusive, equitable and quality education for all, in line with its SDG-4 (Sustainable Development Goal 4).

In this article, in line with UNESCO's objectives, we are interested in the teacher's body with the aim of improving the transmission and acquisition of knowledge in the classroom. Our study will focus particularly on the management of the classroom environment that should be conducive to learning, following on from and complementing our work on the interdependencies between the teacher's postures and the pupils' study postures in the teaching-learning of mathematics on solving proportionality problems, in the 3rd (or 9th) year class at Bourbon College on Réunion Island, continuing the work of Ravelomanana *et al.* (2024) and Razafindrabehita *et al.* (2024). This study is still based on theory of Bucheton & Soulé (2009) of the reciprocal of the teacher's postures and the pupils' study postures.

Postures or gestures are very important to teaching/learning in the classroom because the teacher's body speaks just like his or her voice (Tellier, 2013).

So we asked ourselves the following question: what are the links and relationships between the teacher's attitudes to managing the classroom atmosphere and the pupils' attitudes to studying?

In order to provide some answers to this question, we are going to detect some atmospheric postures of the teacher and study postures of the pupils present in the videos of teaching sessions on proportionality, filmed in this 3rd year class, before proceeding to the analysis of the data collected in relation to our observation grid drawn from the grid of (Hella *et al.*, 2019). The processing and interpretation of the results will be based on the said Implicative Statistical Analysis according to the M_{GK} measure (ISA-M_{GK}) implemented under the ICHC-M_{GK} software in order to be able to open discussions.

MATERIALS AND METHODS

An observation of videos filmed in 3rd classes at Bourbon College on Reunion Island, focusing on the teaching of mathematics and more specifically on solving proportionality problems, was carried out. This observation was carried out using the pedagogical theory of Bucheton and Soulé (2009) as well as a number of informatics tools.

Tools Used

Based on the theory developed by Bucheton & Soulé (2009), which focuses on atmospheric postures, we are able to understand the variety of approaches adopted by the teacher to guide pupils' activity in the classroom.

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These postures represent the teacher's attitudes aimed at creating an environment conducive to learning in the classroom (Atm$_1$, Atm$_2$, Atm$_3$):

- Atm$_1$: Create a space for dialogue,
- Atm$_2$: Maintain a space for dialogue,
- Atm$_3$: Capturing students' attention.

In response to the teacher's atmospheric postures, Bucheton and Soulé (2009) identify six possible postures for pupils (Pel$_1$,...,Pel$_6$):

- Pel$_1$: "a school posture", characterising more the way in which the pupil tries above all to fit in with the expected school norms, tries to fit in with their teacher's expectations.
- Pel$_2$: "a first-doing posture", describing the way in which pupils throw themselves into the task without thinking too much, letting all sorts of ideas or solutions come to light without going into it any further.
- Pel$_3$: "a playful-creative posture", translating here that the pupil uses creativity to reinvent the task he has been given.

- Pel$_4$: "a reflective posture", which is one that enables the pupil not only to be in the act, but to look back on this act, to "secondarise" it in order to understand its aims, failures and contributions.
- Pel$_5$: "a posture of refusal", designating the refusal to do, to learn, the refusal to conform, which is always an indicator to be taken very seriously. It often leads to identity and psycho-affective problems, and to symbolic or real violence suffered by pupils.
- Pel$_6$: "a dogmatic stance", which manifests an assertive lack of curiosity. The "I already know", the "my former teacher, my mother, etc. have already told me". In this case, the pupils are not involved in what they have to learn.

The digital tools used included YouTube to transcribe the videos, which lasted a total of 256 minutes, subdivided into 128 sequences of 2 minutes each. Excel was used to create an observation grid, while ICHC-M_{GK} was used to analyse the data collected (Table 1).

Table 1: Extract of binary table.

Sequences	Atm$_1$	Atm$_2$	Atm$_3$	Pel$_1$	Pel$_2$	Pel$_3$	Pel$_4$	Pel$_5$	Pel$_6$
Seq$_1$	0	0	0	1	0	0	1	0	0
Seq$_2$	0	0	0	1	1	0	0	0	0
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
Seq$_{127}$	1	0	0	1	1	0	0	0	0
Seq$_{128}$	0	0	0	0	1	0	1	0	0

The teacher's atmospheric postures and the students' study postures observed during all the sessions of the course are recorded in the observation grid in order to produce a binary table (Table 1) which will be used for subsequent analysis.

Methods

The data collected is processed and studied using the theory of Implicative Statistical Analysis (ISA) Gras, (1979), which is a non-symmetrical method of analysing data that crosses subjects or objects with variables of different types (in our case Boolean). The technique of extending Implicative and Cohesive Hierarchical Classification - ICHC (Ratsimba-Rajohn & Gras, 1992) called Implicative and Cohesive Hierarchical

Classification based on M$_{GK}$ (ICHC-M$_{GK}$) (Rakotomalala, 2019) is applied to the analysis of these data collected to deal with the numerical and graphical problems required by the use of ISA. This application is also used to classify M$_{GK}$-valid rules according to the cohesion index based to M$_{GK}$ (Rakotomalala & Totohasina, 2018) in order to obtain meta-rules to facilitate interpretations of the analysis results.

Let (K,S,T) be a binary context (Table 1). Consider the set of sequences S= {Seq$_1$, Seq$_2$,..., Seq$_{128}$} and the set of items (Postures) T = {Atm$_1$, Atm$_2$, Atm$_3$, Pel$_1$,..., Pel$_6$} (Table 1). The association rules between two Boolean variables are defined by analyzing the contingency table obtained by crossing them (Table 2).

Table 2: Table of contingence and the conjoint probability associate

	V	$\overline{V}$	Σ			V'	$\overline{V'}$	Σ
U	n_{UV}	$n_{U\overline{V}}$	n_U		U'	$P(U' \cap V')$	$P(\overline{V'} \cap U')$	$P(U')$
$\overline{U}$	$n_{\overline{U}V}$	$n_{\overline{U}\overline{V}}$	$n_{\overline{U}}$	$\Rightarrow$	$\overline{U'}$	$P(\overline{U'} \cap V')$	$P(\overline{V'} \cap \overline{U'})$	$P(\overline{U'})$
Σ	n_V	$n_{\overline{V}}$	n		Σ	$P(V')$	$P(\overline{V'})$	$\dfrac{card(S)}{n} = 1$

Mathematical Modelling

Consider a discrete finite probability space $(S,T(S),P)$ such that for any event X in $T(S)$, $P(X)=(card(X)/card(S))$. Let us note the set of n sequences, over which we have measured m Bernoulli random variables, and let I be the set of items $I = \{i_1,i_2,i_3,...,i_n\}$. For all $X \in P(I) \setminus \{\varnothing ; I\}$, for all $x_i \in X, x_i$ is an application from S to $\{0 ; 1\}$ and $P(x_i=1)=(card(x_i^{-1}(1)))/n$, where n = card(E). Any non-empty part of I will be called a motif of I. So for the motif $U, U'=U^{-1}(1)$ and $nU=card(U')$. For the motifs U and V, $nUV=card(U'\cap V')$ the number of transactions that use both U and V. Agree to $\overline{U}=I\text{-}V$ be the logical negation of a motif U. The real number $P(U')$ will be called the support of the motif U noted $supp(U)= (card(U'))/n$ (Agrawal *et al.*, 1993).

A probabilistic interest measure is a real function μ of $T(I) \times T(I)$ such that for any association rule $U{\rightarrow}V$, with $U\cap V = \varnothing$, the value of $\mu (U{\rightarrow}V)$ is computed from the four quantities n = card(S), P (U'), P (V') and $P(U'\cap V')$ = supp$(U\cup V)$. Finally, for two motifs (or items) U and V in a binary context, the measure of interest M_{GK} is defined by

$$M_{GK} = \begin{cases} M_{MGK}^f(U \to V) = \dfrac{P(V'/U') - P(V')}{1 - P(V')} & \text{, if } U \text{ favours } V ; \\ 0 & \text{, cases of independence ;} \\ M_{MGK}^d(U \to V) = \dfrac{P(V'/U') - P(V')}{P(V')} & \text{, if } U \text{ disfavours } V. \end{cases}$$

Theoretical research in Rakotomalala *et al.,* (2017) and Rakotomalala *et al.*, (2018) allowed us to develop an M_{GK}-valid association rule extraction algorithm (Rakotomalala & Totohasina, 2018).

• The extraction of association rules is based on the M_{GK} measure of interest, which detects a possible non-symmetrical relationship between two of the variables, the validation of the extracted rules is done with respect to the favorable component M_{GK}^f which is implicative and the critical value $M_{GK}^f (\alpha)$ having a relationship with the χ^2 statistic of independence or dependence of degree of freedom 1 at the risk threshold α chosen by ourselves such that $M_{GK}^f > M_{GK}^f (\alpha)$ with

$$M_{GK}^f(\alpha) = \sqrt{\frac{1}{n}\frac{n-n_U}{n_V}\frac{n_V}{n-n_V}\chi^2_{Theorical\,(\alpha)}}$$

In our case, $\alpha=10\%$, which gives the critical value of χ^2 equal to 2.7.

• The value of the support according to M_{GK}^f such that supp $M_{GK}^f(U{\rightarrow}V)$ = supp$(U)[(1$-supp$(V))$

$M_{GK}^f(U{\rightarrow}V)$+supp$(V)]$ is generally small (Rakotomalala *et al.,* 2017). It is therefore essential to normalise this value (Rakotomalala & Totohasina, 2018), and we denote it by supp$_{(n)}^f M_{GK}$, with

$$supp_{(n)M_{GK}}^f(U \to V) = \frac{supp_{M_{GK}}^f(U \to V) - P(U')P(V')}{P(U')(1 - P(V'))}$$

• An implicative graph, denoted G, consists of a finite set of variables representing the vertices of the graph, and edges associated with the normalised support value of valid rules. For ease of interpretation and to highlight meaningful relationships, only implications with a support value supp$_{(n)}^f M_{GK}$ $(U{\rightarrow}V) \geq 0.5$ are retained; alternatively, the implicative tendency of U over V is preferred to neutrality (Gras *et al.*, 2001).

• The value of supp$_{(n)}^f M_{GK} \in$]0.5;1] is used to establish the value of cohesion between two items, denoted coh$_{supp_{(n)M_{GK}}}$ (Rakotomalala & Totohasina, 2018) with:

$$coh_{supp_{(n)M_{GK}}}(U,V) = \begin{cases} \sqrt{1 - (supp_{(n)M_{GK}}^f(U \to V))^2}, & \text{if } supp_{(n)M_{GK}}^f(U \to V) > 0.5 \\ 0 & \text{, if } supp_{(n)M_{GK}}^f(U \to V) \leq 0.5 \\ 1 & \text{, if } supp_{(n)M_{GK}}^f(U \to V) = 1 \end{cases}$$

• The hierarchical classification implicative and cohesive method according to the M_{GK}(ICHC-M_{GK}) measure of interest is based on the cohesion coh$_{supp_{(n)M_{GK}}}$ (Rakotomalala *et al.*, 2018).

RESULTS AND DISCUSSION

In this section, we will analyses the characteristics of the variables. We will then talk about the im-plicative graph of the postures and the interpretation of the rules extracted by the ICHC-M_{GK}. Finally, we are opening the discussions about the results.

Characteristics of the Variables

Tables 3 and 4 below show the characteristics of teacher postures and student postures in different atmospheres. It appears that the pupils' postures, in particular the school posture (Pel$_1$) and the first-doing posture (Pel$_2$), are the most common, with rates of 81.25% and 64.84% respectively. Less frequent postures, with rates below 50%, are classified as rare postures. These include creating the space for dialogue (Atm$_1$), maintaining the space for dialogue (Atm$_2$), capturing students' attention (Atm$_3$), reflective second (Pel$_4$), dogmatic (Pel$_6$), playful-creative (Pel$_3$) and refusal (Pel$_5$), with respective rates of 9.38%, 10.16%, 34.38%, 28.12%, 19.53%, 7.81%, 2.34%.

Table 3: Characteristics of the variables.

Postures	Atm$_1$	Atm$_2$	Atm$_3$	Pel$_1$	Pel$_2$	Pel$_3$	Pel$_4$	Pel$_5$	Pel$_6$
Occurrence	12	13	44	104	83	10	36	3	25
Average (%)	9,38	10,16	34,38	81,25	64,84	7,81	28,12	2,34	19,53

Table 4 below summaries the frequency of these postures, which are ranked according to the average number of occurrences. The teacher and the students all have postures classified as rare, while the very frequent ones are those of the students.

Table 4: Frequency of the postures.

Very frequent postures	Rare postures
Pel$_1$ et Pel$_2$	Atm$_1$, Atm$_2$, Atm$_3$, Pel$_4$, Pel$_6$, Pel$_3$ et Pel$_5$

Results Obtained with ICHC-MGK

Table 5 presents the value of the support normalised according to M_{GK} of the favouring rules, sets out the links between the different atmospheric postures of the teachers and the study postures of the pupils. It seems likely that there is a link between teachers maintaining the space for dialogue (Atm$_2$) and pupils adopting the academic posture (Pel$_1$). Furthermore, it is common to see students adopting a dogmatic posture (Pel$_6$) while being in the school posture (Pel$_1$), suggesting a possible influence of students' attitudes on their engagement in the learning process. However, it seems unlikely that teachers will maintain the space for dialogue (Atm$_2$) when students adopt the school posture (Pel$_1$).

Table 5: Table showing normalised supports based to M_{GK}: $supp_{(n)MGK}$

	Atm$_1$	Atm$_2$	Atm$_3$	Pel$_1$	Pel$_2$	Pel$_3$	Pel$_4$	Pel$_5$	Pel$_6$
Atm$_1$		0,258	0,619						
Atm$_2$	0,236			1					
Atm$_3$	0,122								
Pel$_1$		0,026							0,044
Pel$_2$									
Pel$_3$								0,078	0,254
Pel$_4$									0,31
Pel$_5$						0,277			
Pel$_6$				0,787		0,089	0,499		

Taking into account normalised supports greater than 0.5 on the valid rules according to M_{GK} in Table 5, we obtained three rules which describe an implicative graph G composed of five vertices and three edges (Figure 1). The academic posture (Pel$_1$) is linked to two other postures: maintaining the space for dialogue (Atm$_2$) and dogmatic posture (Pel$_6$), with respective involvement values measured by M_{GK} of 1.0 and 0.787. This indicates that "the maintenance of the space for dialogue by the teacher often puts the pupils back in the academic posture and the pupils in the dogmatic posture are probably both in the academic posture". The creation of the space for dialogue (Atm$_1$) is associated with an outgoing edge that connects to the posture of capturing students' attention (Atm$_3$), with a normalised support value of 0.619, i.e. "often, the teacher creates a space for dialogue by capturing students' attention".
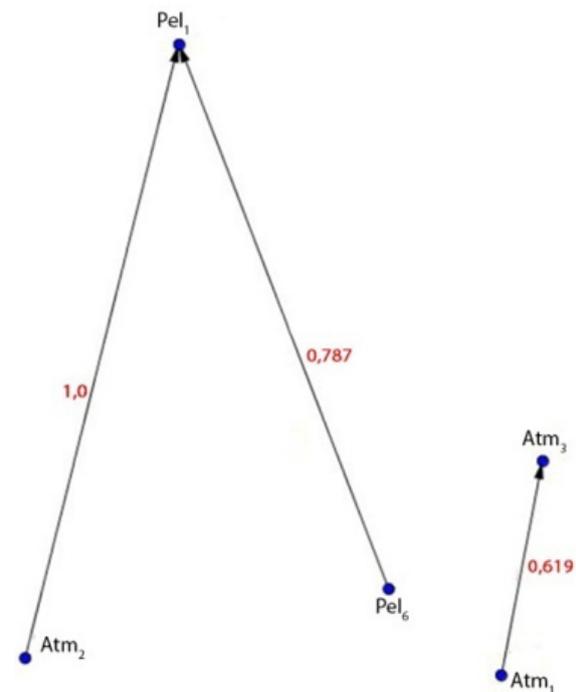
Tables 6 and 7 show significant cohesion between the different postures observed. In particular, there was a strong cohesion between the teacher's maintenance of a space for dialogue (Atm$_2$) and the pupils' academic posture (Pel$_1$), as well as a moderate link between the academic posture (Pel$_1$) and the dogmatic posture (Pel$_6$). On the other hand, the relationship between creating space for dialogue (Atm$_1$) and capturing students' attention (Atm$_3$) seems feeble.

Figure 1: Implicative graph G of the teacher's atmospheric postures and the students' study postures

Table 6: M_{GK} cohesions for pairs of variables

	Atm$_1$	Atm$_2$	Atm$_3$	Pel$_1$	Pel$_2$	Pel$_3$	Pel$_4$	Pel$_5$	Pel$_6$
Atm$_1$		0	0,284						
Atm$_2$	0			1					
Atm$_3$	0								
Pel$_1$		0							0
Pel$_2$									
Pel$_3$								0	0

Pel$_4$									0
Pel$_5$						0			
Pel$_6$				0,665		0	0		

Table 7: Cohesion values for pairs of sorted variables

Pair of variables	$Coh_{supp(n)M_{GK}}$
(Atm$_2$, Pel$_1$)	1.0
(Pel$_6$, Pel$_1$)	0.665
(Atm$_1$, Atm$_3$)	0.284

According to the hierarchical classification of valid rules according to, two meta rules stand out, represented in table 8 and as a dendrogram in figure 2:

• R1: (Atm$_2$→Pel$_1$) : When the teacher maintains the space for dialogue, the pupils are generally in a scholastic posture;

• R2: (Atm$_1$→Atm$_3$): Creating a space for dialogue generally engages students' attention.

Table 8: Hierarchical rules with interclass cohesion, interclass implication and significant value

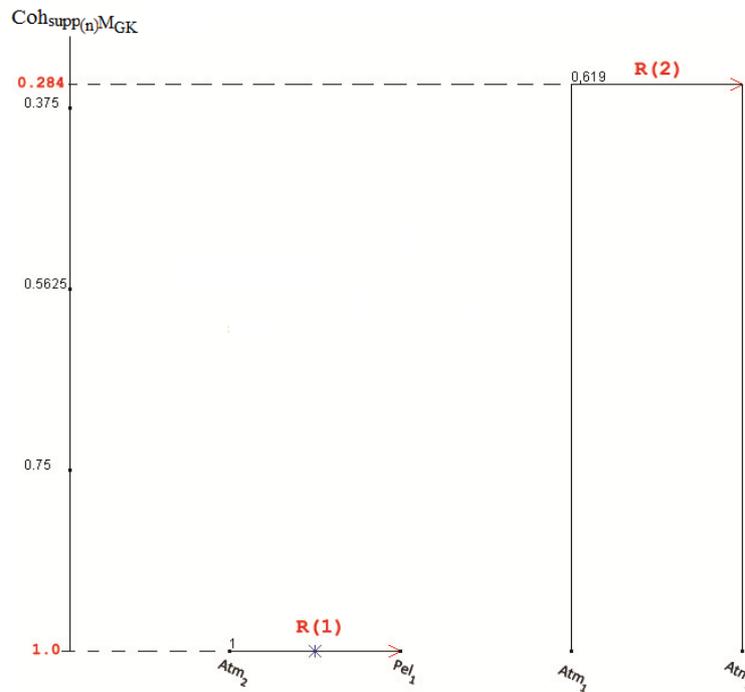| Level	Rule	Inter-Class Cohesion	Inter-Class Involvement	Significant Value
1	(Atm$_2$→Pel$_1$)	1.0	1.0	0.02406090
2	(Atm$_1$→Atm$_3$)	0.284	0.619047	3.3895319130506404E-4

Figure 2: Dendrogram of the meta-rules

These meta-rules (Table 8 and Figure 2) provide important insights into the dynamics observed in the classroom, highlighting the impact of teacher actions on student behaviour. They could be used as a basis for improving teaching practices and fostering a more effective learning environment. For example, by understanding that maintaining a space for dialogue fosters an academic posture in students, teachers could be encouraged to use this strategy to encourage student engagement in the learning process.

Discussions and Suggestions

The results of the analysis of the characteristics of the variables (Tables 3 and 4) seem to indicate some interesting trends in the postures adopted by teachers and students in the classroom. The prevalence of postures such as the school posture and the first-done posture among students perhaps suggests a certain passivity or an expectation of direction from teachers, while the less frequent postures, such as creating the space for dialogue or maintaining the space for dialogue, could indicate a need to encourage more interaction and active engagement by students in the learning process.

The observations in Table 5 reveal complex links between teacher and student postures in the classroom. In particular, the likely relationship between teachers' maintenance of the space for dialogue and students' adoption of the school posture (R(1)) highlights the

importance of open communication and interaction in encouraging student participation. This suggests that when teachers maintain an environment conducive to exchange, pupils are more inclined to adopt an attentive and receptive attitude.

In sequence 16 (Seq16), a pupil calls out to the teacher while the others are chatting (Figure 3): "[...] Teacher! Teacher! [...] ". The teacher is still responding to another pupil: "[...] I think I'm talking here? [...] You've called me four times and I haven't answered [...], so when you call me and I don't answer, it's because I'm helping another pupil. [...] Raise your hand, wait your turn [...]". Immediately afterwards, the pupils keep quiet to listen to what the teacher is explaining and wait for their turn to speak.

Figure 3: Image extract from sequence 16

Furthermore, the finding those students are likely to adopt a dogmatic posture (Pel6) while being in an academic posture (Pel$_1$) (Tables 6 and 7) raises questions about classroom dynamics and the impact of students' attitudes on their engagement in the learning process. Further exploration of this relationship is crucial to understanding the factors that influence students' active participation and the quality of their learning.

However, the low probability of teachers maintaining the space for dialogue (Atm$_2$) when students adopt the academic posture (Pel$_1$) (Tables 6 and 7) is a point of interest. It may be that teachers are less likely to encourage dialogue when students appear to be focused on academic tasks. However, this raises the question of whether ongoing communication might further enrich the learning experience and foster a deeper understanding of the topics being discussed.

Thus, to improve classroom dynamics, we suggest promoting strategies that encourage open communication and active participation on the part of both teachers and students. Teachers could be trained to maintain a balance between structuring academic activities and promoting an environment where ideas and questions are valued. In addition, pedagogical techniques such as small group discussions, debates and interactive activities could be used to stimulate student engagement and foster collaborative and reflective learning.

CONCLUSION

In this study, we explored Bucheton & Soulé's (2009)

hypothesis concerning the reciprocal adjustment of teachers' and pupils' postures. Data were collected by observing mathematics teaching sessions focusing on solving proportionality problems in 3rd classes at College Bourbon on Réunion Island, then analysed using ICHC-MGK software. We identified links between teachers' atmospheric postures and pupils' study postures during teaching practices.

After examining the videos, divided into 128 sequences, we found that the teacher rarely adopts an atmospheric posture, just as the students rarely adopt a secondary reflective posture. In addition, we observed that the maintenance of a space for dialogue by the teacher generally leads to an academic posture in the students, particularly when the creation of this space for dialogue is associated with student attention.

It is important to stress that proportionality is one of the most delicate concepts in science teaching. Indeed, this study of postures during the teaching of proportionality is of vital importance because of its impact on rectifying any misconceptions pupils may have in this complex area.With a view to improving the education system and guiding public policy in the field of education, it is imperative to stress the need for in-depth training for teachers, equipping them with a better understanding of pupils' individual needs. This would enable them to adapt their teaching approaches more effectively to the specific characteristics of each learning context.

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