A Comparison of Inquiry Based, Schema Based and Traditional Teaching Approaches in Colombian Middle School Classrooms

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Juan Malagón

Seminario de Matemáticas Aplicadas - Quantil September 15, 2017

Understanding the problem

Section 1

Education in Latin America and the Caribbean

Section 2

Ut enim ad minim veniam, quis nostrud exercitation

- Duis aute irure dolor in reprehenderit in voluptate velit
- Esse cillum dolore eu fugiat nulla pariatur

Section 3

Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Education in Latin America and the Caribbean

- Participation and progression
- Financial resources
- Quality of education
- Lack of trained workforce and innovation



Gross Enrollment Ratio (GER) - Latin America and the Caribbean







Out-of-school Children, Adolescents and Youth - Latin America and the Caribbean







Financial resources

Mean score in PISA 2015 - Science



Quality of education

Mean score in PISA 2015 - Reading



Latin America and the Caribbean
 Rest of the world

Quality of education

Mean score in PISA 2015 - Mathematics

600 500 400 Dominican Algeria Kosovo FyRoM Brazil Jordan Indonesia Peru Colombia Lebanon Costa Rica Qatar Georgia Mexico Albania Trinidad and Uruguay Montenegro Montenegro Montenegro Montenegro Montenegro Montenegro Chile United Arab Cyprus 1 Bulgaria Romania Coatia United States Israel Israel Israel Israel 300 France France Australia Sweden Russia Viet Nam New Zealand Austria Norway Ireland Poland Cermany Belgium Slovenia Denmark Netherlands Slovak Republic Hungary Littuania Malta Latvia Spain Luxembourg Iceland OECD average Italy United Kingdom Portugal Czech Republic Canada Estonia Switzerland Kore Chinese Taipe Macao (China B-S-J-G (China Hong Kon Singap

Latin America and the Caribbean
 Rest of the world

Quality of education

- Higher-order skills: **foundational literacies** (literacy, numeracy, scientific literacy, ICT literacy, financial literacy, cultural and civic literacy), **competencies** (critical thinking/problem solving, creativity, communication, collaboration), and **character qualities** (curiosity, initiative, persistence/grit, adaptability, leadership, social and cultural awareness)
- Indicators that explain this mismatch are the region's unequal access to education, a perception of low quality and value of the education and training systems, misalignment between education providers and employers on how workers should be trained, and weak performance on international student tests

Lack of trained workforce and innovation

Teaching approaches

- Schema Based Instruction (SBI)
- Inquiry Based Learning (IBL)
- Direct Instruction (DI)

Schema Based Instruction (SBI)

"Schemas are domain or context specific **knowledge structures** that organize knowledge and help the learner **categorize various problem** types to determine the most appropriate actions needed to solve the problem." (Jitendra et al., 2009) "Students can use schemas to **organize information** from a word problem in ways that represent the **underlying structure** of a problem type. Pictures or diagrams, as well as number sentences or equations, can be used to represent schemas." (Powell, 2011)

Schema Based Instruction (SBI)

Schema	Description	Example
Change	A Change situation characterizes a problem in which there is a permanent alteration over time in a measurable quantity of a particular thing.	Stan had 35 stamps in his stamp collection. His uncle sent him 8 more for a birthday present. How many stamps are now in his collection?
Group	A Group situation exists whenever a number of small groups are combined meaningfully into a large group.	In Mr. Harrison's third-grade class, there were 18 boys and 17 girls. How many children are in Mr. Harrison's class?
Compare	A Compare situation exists whenever two things are contrasted to determine which of them is larger or smaller.	Bill walks a mile in 15 minutes. His brother Tom walks the same distance in 18 minutes. Which one is the faster walker?
Restate	A Restate situation is present if a specific relationship is described between two different things at a fixed point in time.	At the pet store there are twice as many kittens as puppies in the store window. There are 8 kittens in the window. How many puppies are also in the window?
Vary	A Vary situation exists when a specified relationship connecting two things can be generalized over other manifestations of those things.	Mary bought a package of gum that had 5 sticks of gum in it. How many sticks would she have if she bought 3 packages of gum?

Inquiry Based Learning (IBL)

IBL corresponds to different ways of instruction where students "are presented with questions to be answered, problems to be solved, or a set of observations to be explained" (Prince & Felder, 2006) IBL "promotes the acquisition of new knowledge, abilities, and attitudes through students' increasingly independent investigation of questions, problems, and issues, for which there often is no single answer" (Lee & Wehlburg, 2012).

Inquiry Based Learning (IBL)

	Dewey	Vygotsky	Wilson & Wing Jan	Murdoch	Short & Harste	Veermans et al
Introductory Performances (Preassessment)	Sensing perplexing situations Suggestive phase	Zone of actual performance	Planning for Inquiry	Tuning in	Building from the known	Constructing working theories
Guided Inquiry (Developing student questions and formative assessment)	Intellectual Phase Hypothesis forming and data gathering Reasoning phase Testing by action	Zone of proximal development New zone of actual performance	Finding Out, Sorting Out Going Further Reflection and Action	Finding out Sorting Out Going further Making connections Taking action	Taking the time to find questions for inquiry Gaining new perspectives Attending to difference Sharing what was learned Planning new inquiries Taking thoughtful new action	Critical evaluation Search and deepen knowledge Generating subordinate questions Developing new working theories Creating the context Setting up new research questions

Direct Instruction (DI)

DI in Colombia has a long tradition in public and religious schools (Echeverry, 2013).

Quality programs implemented by the Ministry of Education (like Classrooms without Borders) adhere to templates corresponding to DI. DI group teaching methodologies featuring at least 50% of class time devoted to teacher's lectures. In general, these lectures go at the beginning of the class and contain definition of concepts, examples and applications, theorems and results (with an explanations of reasonableness rather than strict proofs)

Direct Instruction (DI)

ЕТАРА	DESCRIPCIÓN DE LA ACTIVIDAD	DISTRIBUCIÓN DE LOS ESTUDIANTES	CONSEJOS
ntroducción	 5 min: Presente la agenda de la clase: a) Objetivo de la clase: Fracción de una cantidad. 	Clase magistral	
Explicación	 15 - 20 min: Proyecte el Video № 13 "Fracción de una cantidad." Explique a los estudiantes que para encontrar una fracción de una cantidad, deben resolver una división y luego una multiplicación. Multiplicación de fracciones: Explique a los estudiantes que para multiplicar fracciones, se multiplican los numeradores entre sí y los denominadores entre sí y luego se simplifica el resultado si es posible. 	Video	Puede detener el video de vez en cuando para hacer aclaraciones o dar explicaciones y luego lo puede retomar.
Aplicación	 10 min: Pida a los estudiantes que desarrollen los ejercicios de fracción de un número y multiplicación de fracciones que se encuentran en las Actividades 1 - 3 de la Guía del estudiante. 	Individual	Puede usar las definiciones de resumen. Examine las distinta: respuestas.

The study

- Population and sample
- Mathematics topics
- Quality of education
- Lack of trained workforce and innovation

Population and sample

Population

- 1. Which educational level or grade we are going to work with?
- 2. Where exactly in Colombia is the study going to take place?
- 3. What type of schools (private or public) we are going to work with?

Population and sample

Population

- 1. Which educational level or grade we are going to work with?
- 2. Where exactly in Colombia is the study going to take place?
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- 1. Sixth-grade students
- 2. Bogotá
- 3. Public

Population and sample

Sample

99 sixth-grade students and 5 teachers of mathematics from 3 public schools located in Bogotá (case study)



Mathematics topics

Multiplication principle

Permutations

Combinations

Standards

Grades 6-7. Use models (for example, tree diagrams) to discuss and predict the possibility of an event.

Grades 8-9. Calculate the probability of simple events using different techniques (lists, tree diagram, counting techniques).

Grades 10-11. Solve problems using basic concepts of counting and probability (combinations, permutations, sample space, random sampling, sampling with replacement).

Mathematics topics

Multiplication principle

Permutations

Combinations

Basic Learning Rights

Grade 5. Understand the probability of obtaining results in simple events.

Grade 7. Understand the difference between theoretical probability and the outcome of an experiment.

Grade 9. Solve problems using basic principles of counting (addition and multiplication).

Grade 10. Compute and interpret the probability of the occurrence of an event by counting using combinations and permutations.

Entry and exit test

Entrance Test (30 minutes) Name: School: Grade: Date of birth: 1. Cell-Gel cell phone company offers the following choices: • 1200, 2000, or 3000 minutes • Free internet plan or Pay internet • 1200, 2000, or 3000 minutes plan • Premium or standard phone How many different kinds of plans can you get?	3. A bag has one white marble and one black marble. If you randomly choose one marble, put it back into the bag, and then you choose again one marble, how many possible outcomes you can get?
2. Jesse has four pants and three shirts. In how many different ways he can be dressed?	 4. Miles is making a salad. He wants to put three things on it. Here are his choices. Tomatoes Onions Peppers Pickles Cucumbers How many different salads can he create given these options?
	Source: https://www.ck12.org/book/CK-12-Middle-School-Math-Concepts-Grade-7/ https://www.ck12.org/book/CK-12-Middle-School-Math-Concepts-Grade-8/ CC BY-NC 3.0

Entry and exit test

Go	t It	Not Th	ere Yet	
Evidence shows that the student		Student shows evidence of major		
essentially has the target concept		misunderstanding, incorrect concept or		
or idea.		procedure, or failure to engage the task.		
4	3	2	l	
Excellent: Full	Proficient: Substantial	Marginal: Partial	Unsatisfactory: Little	
Accomplishment	Accomplishment	Accomplishment	Accomplishment	
Strategy and execution meet the content, process, and qualitative demands of the task. Communication is judged by effectiveness, not length. May have minor errors.	Could work to full accomplishment with minimal feedback. Errors are minor, so teacher is confident that understanding is adequate to accomplish the objective.	Part of the task is accomplished, but there is lack of evidence of understanding or evidence of not understanding. Direct input or further teaching is required.	The task is attempted and some mathematical effort is made. There may be fragments of accomplishment but little or no success.	

Entry and exit test



Anova: Single Factor				
SUMMARY				
Groups	Count	Sum	Average	Variance
IBL Diff	29	570.83	19.68	219.37
DI Diff	21	933.33	44.44	350.84
SBI Diff	20	845.83	42.29	479.76

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	9596.56	2	4798.28	14.43	6.13E-06	3.13
Within Groups	22274.48	67	332.45			
Total	31871.03	69				

IBL Diff vs DI Diff		IBL Diff vs SBI Diff			DI Diff vs SB	I Diff	
1/n IBL Diff + 1/n DI Diff	0.082102	1/n IBL Diff + 1/n SBI Diff		0.084483	1/n DI Diff +	1/n SBI Diff	0.097619
s.e. of IBL Diff vs DI Diff	5.224475	s.e. of IBL Diff vs SBI Diff		5.299689	s.e. of DI Diff vs SBI Diff		5.696835
ANOVA t-test	-4.73933	ANOVA t-test		-4.26587	ANOVA t-test		0.37789
df	67	df		67	df		67
t critical	1.995	t critical		1.995	t critical		1.995
Bonferroni t critical	2.45	Bonferroni t d	critical	2.45	Bonferroni t d	critical	2.45
Null hypothesis	Rejected	Null hypothes	sis	Rejected	Null hypothe	sis	Accepted

Since the value of F of 14.43 is greater than the critical F-value of 3.13, we reject the null hypothesis and accept the research hypothesis.

There is a significant difference between the differences among post and pre test scores in the three types of teaching methods.

	Effect size	0.301106
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