



GRAFEMOS

Bridging Indigenous and Western
Perspectives on Design, Complexity and
Computation in Elementary Grades

Grafemos: Bridging Indigenous and Western Perspectives on Design, Complexity, and Computation in Elementary Grades

Grafemos is an immersive learning-activity where children can learn about **Complex Systems** by engaging in the design and creation of a non-computational language for modeling emergent phenomena. Emergent phenomena are complex, non-linear processes, for example we can see them in the interdependence that exists in an ecosystem. Emergent phenomena arise from simple, linear interactions between many individual agents: like the case of the interactions between predators and preys.

Grafemos uses meaning manipulation as a **pivot object**, particularly representing creating, and explaining symbols. For it, **computational thinking** (CT) has been seen as an important base from which both: scientific modeling and STEM education can be supported in K-12 settings (Sengupta et al., 2013). For example, CT can be used to define and set **agent interactions, visualize the simulation environment, compare behaviors, verify, and refine** models.

Pedagogically, this kind of **constructionist learning** emphasizes embodied participation, where different worlds, identities, languages, and understandings can be present in a particular space or moment. This, in turn, is well aligned with Indigenous forms of knowing.




Following a Methodological Métissage (Lowan-Trudeau, 2012) that is based on Indigenous, and Western epistemologies, it involves recognizing **Indigenous practices and traditions** such as storytelling and symbolizing from Indigenous perspectives as critical for teaching, research, and the researchers. Therefore, Grafemos will be developed in **partnership with Indigenous communities of Guatemala and Canada.**

This is a **design-based study** that requires iterative cycles of design, incorporate stakeholders feedback throughout the length of its duration by short face-to-face interviews, and carrying out artifact and discourse analyses.

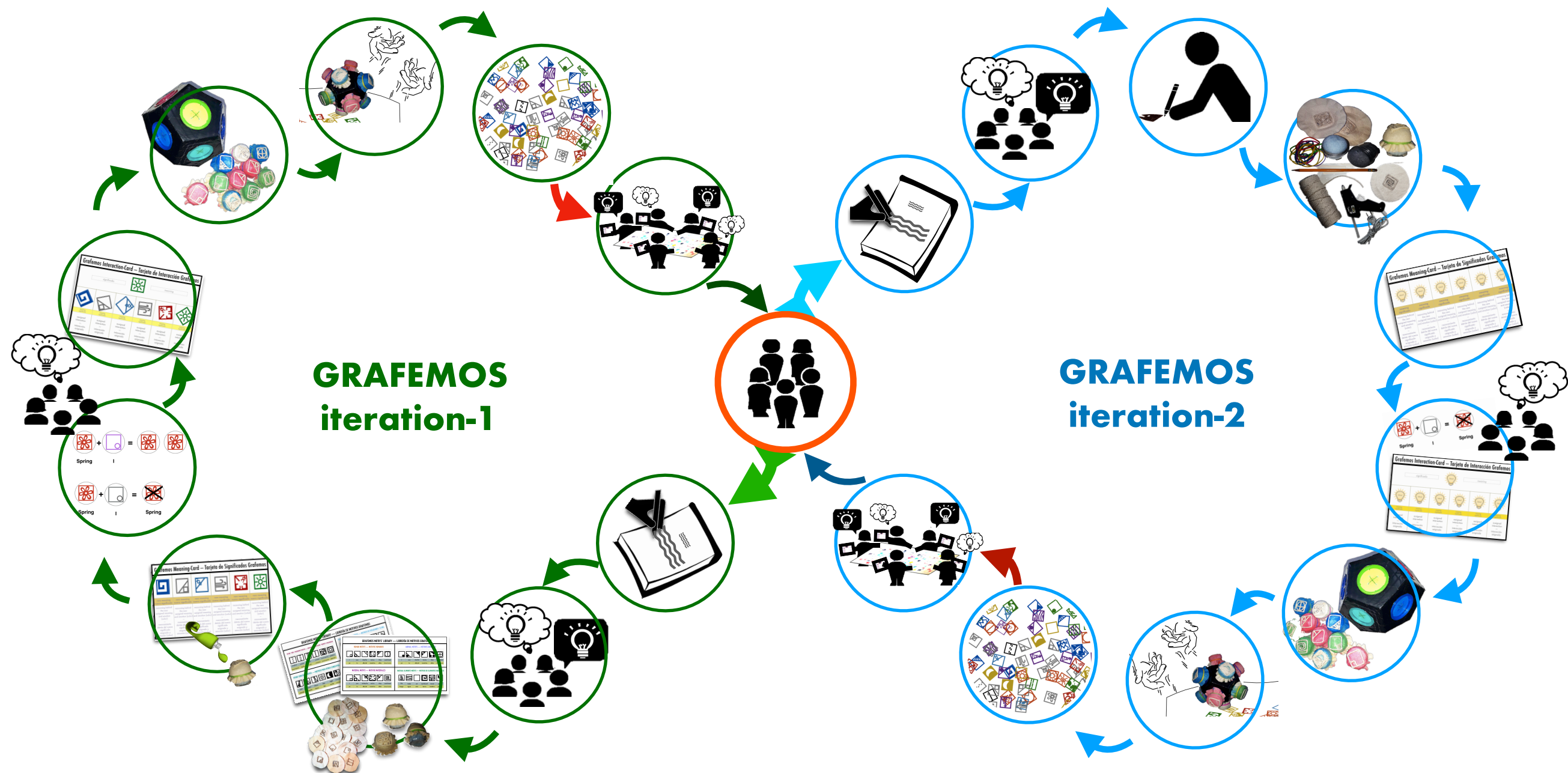
The preliminary pilot studies of Grafemos are aimed to refine the procedure and the devices, examine how these activities are experienced and enacted in pedagogical spaces, and gather opinions on the learning activities from stakeholders (participants, researchers, schools, and communities), from both countries (Canada and Guatemala).

The knowledge obtained from this study will be of great value in guiding professionals to be more effective in educational research by contributing to both the fields of computational thinking and decolonization in STEM education.

STORYBOARDING DESCRIPTION - GRAFEMOS II PILOT PROTOTYPING-STUDY - CALGARY MARCH-2018

Name	Stage Description	Stage Objective	Image	Adult-participants	Adult-Stakeholders	Researcher-PhD Student	Accommodation and Written Material
1 Location	We will realize the pilot in two different locations of Guatemala: Santo Domingo Xenacoj, and Puerto Barrios.	To run Grafemos experiment in both different communities in Guatemala: Maya (Santo Domingo Xenacoj), and non-Maya (Puerto Barrios).		Collaboration of 4 university students	Can include elders, teachers, professors, and/or people of the communities; the effective refinement of the activity depends on the collaborative work among all stakeholders.	Plan and coordinate the study.	STEM LAB
2 Previous to the Study	Designed to explain the activity procedures, expectations, and objectives of the whole activity	Establishment of a teamwork that can promote a smooth performance during the Grafemos pilot-study.		Contact participants to participate in the prototyping	N/A	Introduce and coordinate the pilot-study	-1 Sets of the document with all the information of the project (in English). -1 Timing sheet -Set of Observation Protocol Sheets
3 Preparation	Includes all the activities we have to do previous to the Grafemos activity	Coordinate the whole group, and get all permissions and consents done		Read and sign the Consent for the prototyping	All participants adults will read and sign their consent, and put on their work shirts or aprons so as not to stain their clothes.	Coordinate the pilot-study	N/A

Grafemos Iterations



In Grafemos children will be engaged in a modeling environment, working in groups where they will collaborate to design their own expressive symbolic language. It will be used for modeling a story, revise the designed language, engage in reflexively sharing experiences with peers, teachers and community elders. It allows the observation of 'Intersubjective experiences' which are a sharing of meanings constructed by peoples' interactions with each other, a sharing common sense, as it happens in languages.

GRAFEMOS MOTIFS' LIBRARY — LIBRERÍA DE MOTIVOS GRAFEMOS

HUMAN MOTIFS — MOTIVOS HUMANOS

I	you	she/he	we/us	they	soul/heart
yo	tu	ella/el	nosotros	ellos	alma/corazón

ANIMAL MOTIFS — MOTIVOS ANIMALES

I	you	she/he	we/us	they	soul/heart
yo	tu	ella/el	nosotros	ellos	alma/corazón

MATERIAL MOTIFS — MOTIVOS MATERIALES

I	you	it/she/he	we/us	they	soul/heart
yo	tu	ella/el	nosotros	ellos	alma/corazón

NATURAL ELEMENTS MOTIFS — MOTIVOS DE ELEMENTOS NATURALES

fire	water	air	earth/soil	wood	plant
fuego	agua	aire	tierra	madera	planta

SPEED / TIME / FREQUENCY MOTIFS — MOTIVOS DE VELOCIDAD / TIEMPO / FRECUENCIA

brief/fast	medium	slow	constant	chaos/spinning	repetition
breve/rápido	regular	lento	constante	caos/rotación	repeticón

SEASONS / WEATHER MOTIFS — MOTIVOS DE ESTACIONES / CLIMA

snow	rain	spring	summer	fall	wind
nieve	lluvia	primavera	verano	otoño	viento

OTHER CONCEPTS MOTIFS — MOTIVOS PARA OTROS CONCEPTOS

past	present	future	day	night	dawn/twilight
pasado	presente	futuro	día	noche	amanecer/ocaso

OTHER CONCEPTS MOTIFS — MOTIVOS PARA OTROS CONCEPTOS

close	separation	joint	home	idea	God/deity
cerca	separación	unión	hogar	idea	Dios/deidad

Grafemos Meaning-Card – Tarjeta de Significados Grafemos

[illegible]

Grafemos Interaction-Card – Tarjeta de Interacción Grafemos

significado

meaning

meaning
significado

meaning
significado

meaning
significado

meaning
significado

meaning
significado

meaning
significado

assigned
interaction

—
interacción asignada

assigned
interaction

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interacción asignada

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interaction

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interaction

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interacción asignada

assigned
interaction

—
interacción asignada



GRAFEMOS



Focus of Calgary

II Prototyping: **iteration-1**

STORYBOARDING - GRAFEMOS

iteration-1

1

Introduction GRAFEMOS iteration-1



2

Choosing a Legend and Creation of a Short Story

3

Identifying Six Key Elements



4

Transforming Elements to Grafemos - Marking Points of Reference



5

Identifying Symbols' Emotions



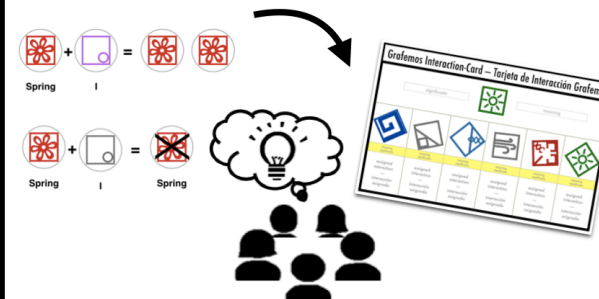
6

Creation of Grafemos Meaning-card



7

Creation of Grafemos Interaction-card



8

Assembling the Grafemos Dodecahedron



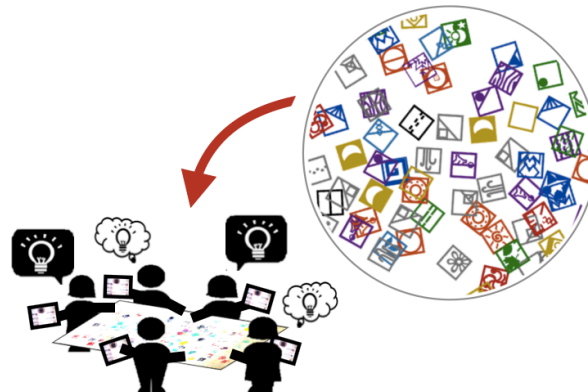
9

Throwing the Dodecahedron and Printing



10

Observing and Explaining Symbols' Interactions



11

Grafemos' Closing the Iteration-1 Circle



Iteration-1



1 Introduction GRAFEMOS iteration-1

iteration-1 STORYBOARDING DESCRIPTION



Stage Description

Give welcoming words to all, introduce the team, provide general information, explained general activity, and answer any questions.

Stage Objective

Introduce a problem/challenge. Formulate the problem to solve. To create an appropriate and friendly atmosphere to promote a smooth performance during the Grafemos pilot-study.

Children-participants


Children will be divided to work in two groups of four.
Fill the name-tags with their names.


Adult-Stakeholders

They will be divided into two teams of observers, one for each group of children.
Fill the name-tags with their names.

Group Leaders (community-school)

Be part of one of the two teams of local observers.
Fill the name-tags with their names.

<div>2</div> <div>Choosing a Legend and Creation of a Short Story</div>		<div>iteration-1</div> <div>STORYBOARDING DESCRIPTION</div>
	Stage Description	Stage Objective
	Participants will choose and discuss a story, reflect on feelings, perceptions, and concerns related to the narrative. Then create their own new story.	To engage in explore, reflect on, and share their thoughts on the emotions, relationships among characters, environment, and details of the story. Analyze the material and gather key elements to work with; collect, analyze and extract data.
Children-participants	Adult-Stakeholders	Group Leaders (community-school)
<p>Gather and discuss a legend or story of their community. Ask each other questions and define the problem. Then they will talk about any lesson learned through the analysis of the narrative and create and write a new short story based on it.</p> <p>Answer questions of the interviewer.</p>	<p>Observing.</p> <p>Can help to suggest a story to work with.</p> <p>Answer questions of the interviewer.</p>	<p>Be part of the local team of observers.</p> <p>Observing.</p> <p>Can help to suggest a story to work with.</p> <p>Answer questions of the interviewer.</p>


3 Identifying Six Main Elements		iteration-1 STORYBOARDING DESCRIPTION
	Stage Description	Stage Objective
	<p>With their story, participants will share reflexively their thoughts about it to get in an agreement on six main elements to work with.</p>	<p>Break or decompose the whole. Identify stories' key elements belonging different categories such as human, animal and plant agents, emotions, seasons, time, duration, natural elements, and others. Get involved in discussing evidence. Build explanations and design strategies to follow.</p>
Children-participants	Adult-Stakeholders	Group Leaders (community-school)
<p>They will discuss their story and select the <i>six</i> most relevant elements of it.</p> <p>Answer questions of the interviewer.</p>	<p>Observing.</p> <p>Answer questions of the interviewer.</p>	<p>Be part of the local team of observers.</p> <p>Observing.</p> <p>Answer questions of the interviewer.</p>

4

Transforming Elements to Grafemos' Motifs - Marking Points of Reference

iteration-1

STORYBOARDING DESCRIPTION

	Stage Description	Stage Objective						
 <p>The image shows a 'Grafemos Motifs Library' which is a grid of various geometric and symbolic motifs. Below the library, there are several circular stamp devices, some of which are already marked with motifs. The motifs include squares, circles, and other geometric shapes, some with internal patterns.</p>	<p>Participants select their own set of symbols Grafemos Motifs Library, along with that, they mark directions on the Grafemos Printable-surface. Motifs and concept of directions follow the sense of points of reference are design-based the representational system of Maya fabric of Santo Domingo Xenacoj, also present in other Indigenous epistemologies.</p> <p>Points of reference examples:</p> <table border="1"> <tbody> <tr> <td>Top/North/ Forward/Up</td><td>Left/West/ Sideward-a</td><td>Right/side-b/East</td></tr> <tr> <td>Backward/South/ Down/Bottom</td><td>Center/Origin/ Core</td><td>Head/right-shoulder/ left-shoulder/feet</td></tr> </tbody> </table>	Top/North/ Forward/Up	Left/West/ Sideward-a	Right/side-b/East	Backward/South/ Down/Bottom	Center/Origin/ Core	Head/right-shoulder/ left-shoulder/feet	<p>Create their own language for modeling a short story using Grafemos' motifs. Practice the process of abstraction (design, use, estimate, calculate, verify abstractions). Locate directions or point of reference on the round surface.</p>
Top/North/ Forward/Up	Left/West/ Sideward-a	Right/side-b/East						
Backward/South/ Down/Bottom	Center/Origin/ Core	Head/right-shoulder/ left-shoulder/feet						
Children-participants	Adult-Stakeholders	Group Leaders (community-school)						
<p>Next, from the library of Grafemos' motifs, each group will decide which motifs are the most accurate to represent their story's elements. With this action, the motifs will become the new symbols of the story, to be placed on the Grafemos stamp' devices (twice). Along with that, children will mark five positions over the round-printing surface (this step is aligned with the sense of directions perceived by IP, e.g., Maya designers in its fabrics and embroidery).</p> <p>Answer questions of the interviewer.</p>	<p>Observing. Answer questions of the interviewer.</p>	<p>Be part of the local team of observers. Observing. Answer questions of the interviewer.</p>						

5 Identifying Symbols' Emotions

iteration-1 STORYBOARDING DESCRIPTION



Stage Description

Based on the analysis and reflection on the symbols' behaviors and roles in the story, participants allocate emotions to each symbol through the use of colors. Based in the representational system of Maya fabric of Santo Domingo Xenacoj, the perception of color as bright or dull represents the designer's personal feeling of happiness or sadness, as well as a historical passage of an older spirit.

Stage Objective

Identify and designate a colour to express the initial emotion to each of their six symbols. Follow a Mayan epistemology that connects and embody emotions through colors.

Children-participants

Then, based upon their stories, children will discuss the **emotion** of the element itself and assign the colours: Choose a **bright color** if the emotion of the element goes to the side of happiness or positive feeling. Conversely, a **dull colour** if their assigned emotion tends to be sad or a negative feeling.

Answer questions of the interviewer.

Adult-Stakeholders

Observing.
Help with handling the paints, assembling, and soaking the seals.
Answer questions of the interviewer.

Group Leaders (community-school)

Be part of the local team of observers.
Observing.
Help with handling the paints, assembling, and soaking the seals.
Answer questions of the interviewer.

6

Creation of Grafemos Meaning-card

iteration-1

STORYBOARDING DESCRIPTION



Stage Description

This stage is to design the characteristics of their six symbols to role-play with them during the activity. The Grafemos Meaning-card is an engaging-tool that helps as an aid to observe, explore, and discuss different outcomes. This card's making process helps participants practice and build high-level processes of thinking and skills.

Stage Objective

Create general standards/principles to follow. Create a tool that can provide support to the participants when they will be engaged in identifying elements in the modeling activity, i.e., represent an event. Analyze elements. Use logical reasoning and critical thinking.

Children-participants

They will create a **Grafemos Meaning-card**, printing on the card each symbol with its selected colour (using the stamps), write the “**new**” assigned meaning, adding the reasoning behind the assigned meaning and emotion (color) in the description box of the card. Answer questions of the interviewer.

Adult-Stakeholders

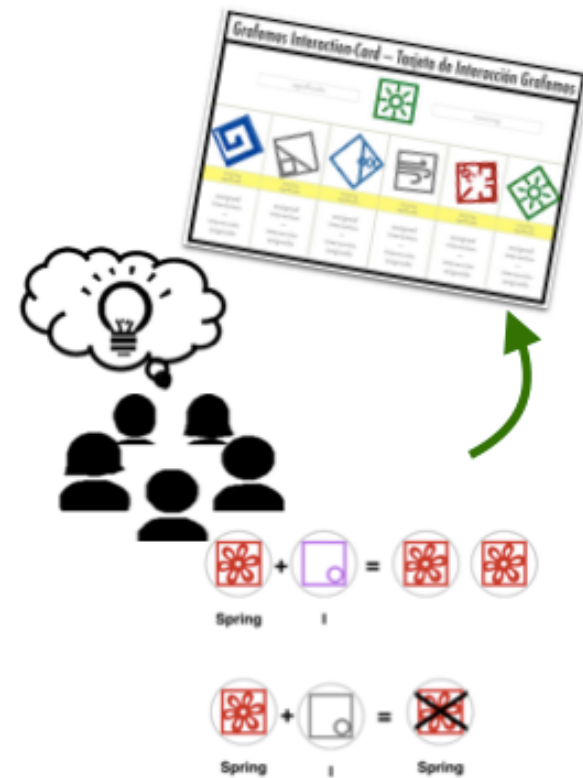
Observing.
Help with handling the paints, and soaking the seals if necessary.
Answer questions of the interviewer.

Group Leaders (community-school)

Be part of the local team of observers.
Observing.
Help with handling the paints, and soaking the seals if necessary.
Answer questions of the interviewer.

7

Creation of Grafemos Interaction-card



Stage Description

Children first get into an intensive thinking stage while creating the characteristics that will shape their symbols behaviors. Then, they discuss, imagine, and set the behavior that the symbols will perform when these randomly will touch to each other in the printed pattern. Behavior examples:

Motion: print the <u>same</u> symbol forward 2-distance-units to (x) direction.	Increasing: Print (x) number of the <u>touched</u> symbols in the (x) direction in Happy/Sad emotion.	Decreasing: remove/delete (x) number of the <u>same</u> symbol in any place.
Motion: print <u>touched</u> symbols backwards 1-distance-unit.	Increasing: If 3 of <u>this</u> symbols are together, print multiplying <u>this</u> symbol (x) times, in the (x) direction, in Happy/Sad emotion.	Decreasing: remove/delete (x) number of the <u>touched</u> symbol in the (x) area.

iteration-1

STORYBOARDING DESCRIPTION

Stage Objective

To create an ordered set of rules, steps, and systematic operations that will allow make a prediction/calculation and find the understanding/solution to a type of problem (step by step sequences). Use logical reasoning and critical thinking. In Grafemos the **representational** work goes hand to hand with the **thinking**. The objective is to use this combination, to create a progression of activities that leads children to learn about systems' complexity, while assigning meaning and observing interactions between symbols.

Children-participants

Having the Meaning-card, they will proceed to create the Grafemos **Interaction-card**. Based on the story, children will discuss the interaction behavior to be assigned between each element (e.g., motion, emotion, increasing or decreasing the number, and such). They will create one card for each element, printing the main element in card header (first road), and the others in the meaning road (second road), writing under each symbol the interaction behavior agreed by the group.

*Define distance units, for example: one hand, one crayon, 8 cm., etc.
Answer questions of the interviewer.

Adult-Stakeholders

Observing.
Help with handling the paints, and soaking the seals if necessary.
Answer questions of the interviewer.

●

Group Leaders (community-school)

Be part of the local team of observers.
Observing.
Help with handling the paints, and soaking the seals if necessary.
Answer questions of the interviewer.

8

Assembling the Grafemos Dodecahedron

iteration-1
 STORYBOARDING DESCRIPTION


Stage Description

Following a constructionist approach for Grafemos environment, this stage was designed to provide a rich experience for children. For instance, it gives the opportunity to handle artifacts, get in contact with different means, and use simple materials that over time will have a personal meaning for them.

Stage Objective

Provide intellectual and close-up aesthetic experiences, space for personal learning-journeys and narratives (design, use, estimate, calculate, verify abstractions). Give opportunity for working in social spaces to foster collaboration, knowledge and consciousness sharing, all fundamental to build interpersonal relationships and formation of ideas.

Children-participants

Once they have the stamps, the Interaction and Meaning cards ready, they will soak well the stamps in their selected colours (with sufficient paint to prevent it from drying out) and assemble the seals on the **Grafemos Dodecahedron**. In total, they will have six symbols represented twice over the dodecahedron device.
Answer questions of the interviewer.

Adult-Stakeholders

Observing.
Help with handling the paints, assembling, and soaking the seals.
Help the children with the assembly of the Grafemos' Dodecahedron, if necessary.
Answer questions of the interviewer.

Group Leaders (community-school)

Be part of the local team of observers.
Observing.
Help with handling the paints, assembling, and soaking the seals.
Help the children with the assembly of the Grafemos' Dodecahedron, if necessary.
Answer questions of the interviewer.

9

Throwing the Dodecahedron and Printing

iteration-1 STORYBOARDING DESCRIPTION



Stage Description

Similar to rolling dice, Grafemos Dodecahedron leaves a printed path that can be used as a mean to inquire towards topic or problem of any ambit (i.e., social, identity, historical). It allows children to play and observe at the same time.

Stage Objective

Use of simple means (paper, paint, symbols, fabric), as means to observe the emergence that arises from the interactions between printed symbols, and how these evolves to a complex system. Use logical reasoning and critical thinking.

Children-participants

They will roll the Grafemos Dodecahedron over the prepared round-surface (inside the (Grafemos Containment-barrier) the times that they consider necessary, that is when the impressions begin to intersect with each other. Answer questions of the interviewer.

Adult-Stakeholders

Observing.
Help with handling the paints, assembling, and soaking the seals.
Help the children with the assembly of the Grafemos' Dodecahedron, if necessary.
Answer questions of the interviewer.

Group Leaders (community-school)

Be part of the local team of observers.
Observing.
Help with handling the paints, assembling, and soaking the seals.
Help the children with the assembly of the Grafemos' Dodecahedron, if necessary.
Answer questions of the interviewer.

10

Observing and Explaining Symbols' Interactions



Stage Description

Participants observe the behavior of each symbol with now is an agent of the printed pattern in play, make predictions, see how agents interact with each other and apply behaviors following the information they have put on the cards.

iteration-1

STORYBOARDING DESCRIPTION

Stage Objective

Observe printed paths to identify and apply interaction between symbols. Identify eventual events of 'emergence'. This in order to represent an emergent outcome. Find patterns (similarities, differences). Use logical reasoning and critical thinking. Apply and develop problem solving skills, computational thinking, analytical thinking.

Children-participants

When they will have enough printed symbols. Children will disassemble the six different used symbols from the dodecahedron and use them manually. They will gather around the printed area to observe, analyze, and apply symbols' behaviors with the aid of the meaning and interaction cards; (e.g., identify, interpret, interconnect, cover, multiply, and so on). This step can take from 25 to 40 min. Better if the time is settled with a timer.
Answer questions of the interviewer.

Adult-Stakeholders

Observing.
Help with handling the paints, assembling, and soaking the seals.
Help the children with the assembly of the Grafemos' Dodecahedron, if necessary.
Answer questions of the interviewer.

Group Leaders (community-school)


Be part of the local team of observers.
Observing.
Help with handling the paints, assembling, and soaking the seals.
Help the children with the assembly of the Grafemos' Dodecahedron, if necessary.
Answer questions of the interviewer.







11

Grafemos' Closing the Iteration-1 Circle

iteration-1

STORYBOARDING DESCRIPTION

	Stage Description	Stage Objective
	<p>Following Indigenous epistemologies on storytelling and learning circles, Grafemos iterations close in a circle of reflective discussion that can serve a deeply reflexive means to learn about complex systems.</p>	<p>Share stories to examine and exercise problem-solving, provide even opportunities to everybody to talk and participate, and provide an opportunity to share multiple perspectives. Get involved in discussing evidence. Observe and discuss the printed model/simulation, evaluate and refine the pre-established interactions, discuss the experiment, and refine/debug or improve processes.</p>
Children-participants	Adult-Stakeholders	Group Leaders (community-school)
<p>Finally, all participants will gather to create a learning circle to talk about the experience, the shared stories, discoveries, solved problems faced during Grafemos, share multiple perspectives on the activity, possible improvements, and any other comment that the participants wish to contribute.</p>	<p>Share their thoughts on the activity, give opinions, comments and suggestions about the activity. Share what they learned about the activity. Raise doubts or concerns they have about the activity. Be interviewed.</p>	<p>Share their thoughts on the activity, give opinions, comments and suggestions about the activity. Share what they learned about the activity. Raise doubts or concerns they have about the activity. Be interviewed.</p>

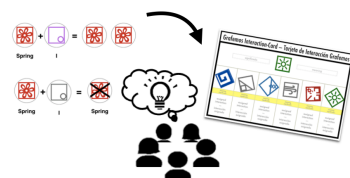
Materials-Equipment	STORYBOARDING - GRAFEMOS	iteration-1
1- Introduction GRAFEMOS iteration-1	2 - Choosing a <u>Legend</u> and Creation of a Short Story	3 - Identifying Six Main Elements
		
-2 Video cameras -1 Video camera stand -2 Voice recorders -Work aprons (for all participants) -Blank name-tags. -Markers.	-2 Video cameras -1 Video camera stand -2 Voice recorders -Work aprons (for all participants) -Name-tags. -6 Notepads -Pencils and erasers	-2 Video cameras -1 Video camera stand -2 Voice recorders -Work aprons (for all participants) -Name-tags. -6 Notepads -Pencils and erasers
4 - Transforming Elements to Grafemos - MarkingPoints of Reference	5 - - Identifying Symbols' Emotions	6 - Creation of Grafemos Meaning-card
		
-2 Video cameras -1 Video camera stand -2 Voice recorders -Work aprons (for all participants) -Name-tags. -4 Grafemos Library Displays -2 Grafemos printing-surface -2 Sets of Grafemos Printable-motifs -12 Grafemos Stamps -Rubber bands -Markers	-2 Video cameras -1 Video camera stand -2 Voice recorders -Work aprons (for all participants) -Name-tags. -Water-based washable paint for children handcrafts in prepared containers. -Selected printable motifs -12 Stamps -Rags to clean	-2 Video cameras -1 Video camera stand -2 Voice recorders -Work aprons (for all participants) -Name-tags. -1 Grafemos Meaning-card (per group) -Water-based washable paint for children handcrafts in prepared containers. -Assembled Stamps -Rags to clean

Materials-Equipment

STORYBOARDING - GRAFEMOS

iteration-1

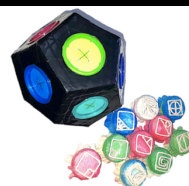
7 - Creation of Grafemos Interaction-card



- 2 Video cameras
- 1 Video camera stand
- 2 Voice recorders
- Work aprons (for all participants)
- Name-tags.

- 6 Grafemos Interaction-cards (per group)
- Water-based washable paint for children handcrafts in prepared containers.
- Assembled Stamps
- Rags to clean

8 - Assembling the Grafemos Dodecahedron



- 2 Video cameras
- 1 Video camera stand
- 2 Voice recorders
- Work aprons (for all participants)
- Name-tags.

- The group's Grafemos Meaning-card (as colors guide)
- 1 Grafemos Dodecahedron (polyhedron of 12 sides)
- 12 Assembled stamps.
- Water-based washable paint for children handcrafts in prepared containers.
- Assembled Stamps
- Rags to clean

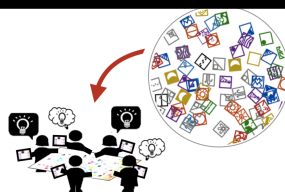
9 - Throwing the Dodecahedron and Printing



- 2 Video cameras
- 1 Video camera stand
- 2 Voice recorders
- Work aprons (for all participants)
- Name-tags.

- The group's Grafemos Meaning-card (as colors guide)
- 1 Assembled Grafemos Dodecahedron
- 1 Grafemos printing-surface
- 1 Grafemos Containment-barrier (to roll the dodecahedron)
- Water-based washable paint for children handcrafts in prepared containers.
- Rags to clean

10 - Observing and Explaining Symbols' Interactions



- 2 Video cameras
- 1 Video camera stand
- 2 Voice recorders
- Work aprons (for all participants)
- Name-tags.

- 1 Timer
- The group's Grafemos printed surface
- Round-coverings and glue (to erase printings).
- The six group's Grafemos Interaction-cards.
- The group's Grafemos Meaning-card
- Water-based washable paint for children handcrafts in prepared containers.
- Rags to clean

11 - Grafemos' Closing the Iteration-1 Circle



- 2 Video cameras
- 1 Video camera stand
- 2 Voice recorders
- Work aprons (for all participants)
- Name-tags.

- The groups' Grafemos printed surfaces
- The groups' Grafemos Interaction-cards
- The groups' Grafemos Meaning-cards

Iteration-1



Boxes to collect all the material and equipment used.

Grafemos Pilot Study for Prototype and Refinement - Iteration Timing				
Done	Date	Stage Name	No.	Time in minutes
	March26 2018	Introduction GRAFEMOS iteration-1	1	10
		Choosing a <u>Problem, Legend, Fairy Tale</u> and Creation of a Short Story	2	10
		Identifying Six Key Elements	3	10
		Transforming Elements to Grafemos - Marking Points of Reference	4	10
		Identifying Symbols' Emotions	5	10
		Creation of Grafemos Meaning-card	6	10
		Creation of Grafemos Interaction-card	7	10
		Assembling the Grafemos Dodecahedron	8	10
		Throwing the Dodecahedron and Printing	9	10
		Observing and Explaining Symbols' Interactions	10	15
		Closing iteration-1	11	15
		Total time		120

Grafemos Pilot Study II for Prototype and Refinement

Grafemos Observation Protocol		Criterion					Date: Mar-26-2018	Place: University of Calgary, STEM Lab
Stage name:	#	never	seldom	sometimes	often	always	Observations made by: Marilu	
Grafemos allows, promote, gives room for...							<u>Additional notes</u>	
Cross-examination								
Contribute with ideas								
Highlight important ideas								
Represent ideas in different ways								
Discover important ideas								
Propose new ideas								
Formulate/plan solutions								
Generate/realize solutions								
Manipulate concepts								
Construct new concepts								
Decompose								
Divide problems and issues into pieces								
Create sketches/diagrams as support								
Unleash strategies to solve problems individually								
Solve problems								
Unleash strategies to solve problems in a group								
Engage								
Engage in constructive debates								
Engage in multi-approaches								
Engage in demonstrations								
Explore diverse approaches, themes, points of interest								
Argue using other materials								
Interplay								
Interact by reviewing								
Interact answering								
Interacts by asking								
Encourage collaboration								
Actively get involved								
Contribute with feedback								
Teamwork								
Practice listening carefully								
Show autonomy of thought								
Multi-faceted thought								
Use thinking transcending cultures/identities								
Use critical thinking to debate and argue								
Question and discuss procedures								
Interpret evidence								
Make predictions								
Detect patterns and consequences								
Construct defense								
Compare results								
Argument evidence								
Performance								
Propose diverse choices								
Propose new procedures								
Offer explanations								
Work on fixing issues								
Work individually								
Follow the procedures								
Demonstrate familiarity with procedures								
Show independency using materials								
Show independency using tools								



GRAFEMOS

Focus of future Guatemala

III Prototyping:

iteration-1 and **iteration-2**

STORYBOARDING - GRAFEMOS

iteration-2

1

Introduction Grafemos iteration-2



2

Choosing a Problem that Affects the Community, and Writing a Short Story



3

Identifying *Six* Main Elements



4

Designing and Making Their Own Symbols - Rethink about the Points of Reference



5

Identifying Symbols' Emotions



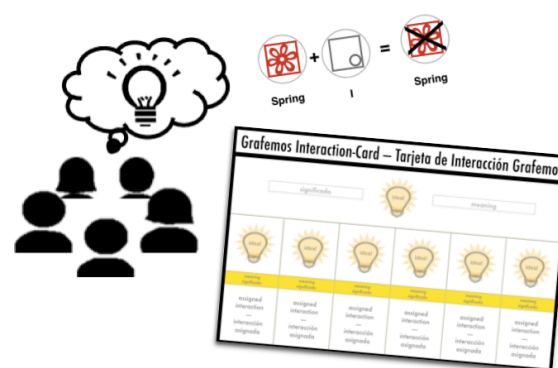
6

Creation of Grafemos Meaning-card



7

Creation of Grafemos Interaction-card



8

Assembling the Grafemos Dodecahedron



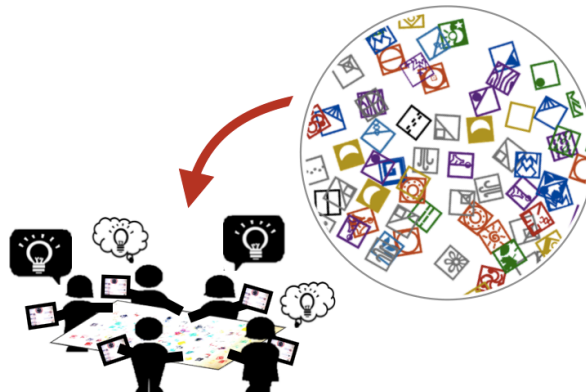
9

Throwing the Grafemos Dodecahedron



10

Observing and Explaining Symbols' Interactions



11

Grafemos' Closing Circle



Iteration-2

