Reception: **January 11, 2020** | Acceptance: **March 9, 2021**

CORN GROWTH IN LUNAR PHASES, DIDACTIC ACTIVITY DESIGN FOR A TZELTAL COMMUNITY

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Erivan Velasco Núñez
erivel79@hotmail.com
orcid.org/0000-0001-7202-8924

Mercedes Cancino Flores
merce_cf9@hotmail.com
orcid.org/0000-0001-9251-3206

Alejandro de Jesús Mazariegos Liévano
alex94ml@outlook.com
orcid.org/0000-0002-0383-3804

Universidad Autónoma de Chiapas, México

To quote this article:
Velasco Núñez, E., Cancino Flores, M., & Mazariegos Liévano, A. de J. (2021). Crecimiento del maíz en fases lunares, diseño de una actividad didáctica para una comunidad tzeltal. *Espacio I+D, Innovación más Desarrollo, 10*(27). https://doi.org/10.31644/IMASD.27.2021.a03

— Abstract—

We consider that it is possible to incorporate social environment elements in didactic activities, such as the cultural aspects of native peoples, to favor the understanding of the relationship between the pending parameter concerning the inclination of a straight line. Variational thinking and language can also be incorporated into the didactic activity to play an important role in understanding those mathematical topics. The cultural aspects from the Tzeltal perspective are the stages of corn cultivation in different lunar phases. A three stages methodological strategy is established, in which the first stage the theoretical contributions that correspond to Dietz's cultural reproduction were used, in the second stage elements of the notion of prediction have been incorporated to promote rationality of thought and Variational language for understanding the relationship between the pending parameter concerning the inclination of the straight line. A third methodological stage consists of a staging, where it is expected that arguments arise that show approval for the understanding of the relationship between mathematical concepts.

Keywords

Variation, growth of plants, phases of the moon.

This paper proposes a didactic activity design based on corn growth in lunar phases, which has been taken from the cultural aspects of a Tzeltal collaborator, a student of the Civil Engineering degree (CE) at the Universidad Autónoma de Chiapas (UNACH). Although there are more collaborators from other ethnic groups, in this article only the Tzeltal language is mentioned because it is the most worked activity.

Concerning the educational panorama in which the didactic activity is intended to be incorporated, it should be mentioned that from the field of Educational Mathematics (EM) a problem is pointed out within the mathematics classroom. This problem recognizes a confrontation between mathematical work and school mathematics, which is assumed as an element that hinders meaningful learning of mathematics or lacks meaning. Then it is said that school mathematics is not functional, some works in this discipline have reported that school mathematics does not transcend the student's daily life (Gómez, 2015), interpreting that "...: what is learned at school, stays at school" (Mendoza & Cordero, 2015, p. 1).

On the other hand, and in the case of Tzeltal communities, we are facing a problem with different numbering systems. One is decimal, which is taught in the classroom, and the Maya (from the Tzeltal community) is vigesimal. Therefore, the measurement systems are different. This becomes more complex in education when children bring empirical knowledge from the family since they are different categories of thought and taxonomies. However, Micalco (2009) shows the knowledge developed in various community practices related to mathematics in a group of young Tzeltales from Chiapas, both schooled and unschooled. In this study, they use the vigesimal system linked to cultural practice and the use of the first language in the community. Schooled students often use multiplication referring to the base 20, while non-schooled students use the number twenty of the vigesimal system of the Tzeltal language. Thus, Micalco points out that there is an interrelation between the Indo-Arabic decimal numbering system and the knowledge of the vigesimal system. In this same sense, Cruz and Butto (2013) point out that socializing the structure of the vigesimal *tu'un savi* system based on the extremities of the body, specifically on the fingers and toes, it can serve as a didactic resource to teach how to group natural numbers.

Then it can be proposed to incorporate cultural practices inherent in the Tzeltal communities as didactic resources in the teaching of mathematical content. In this sense, our proposal would be the incorporation of these practices for teaching linear functions and the concept of slope, the particular case of the relationship between the slope parameter to the straight line inclination. Since in the particular case of the linear function, Córdoba *et al.* (2013) point out that students present some difficulties in establishing

the existing relationship between the slope parameter concerning the inclination of the line, the relationship that exists between the algebraic representation and the sketch of the graph, and the representation of the intersections with the coordinate axes using the function criterion.

Therefore, it is considered that from the social environment, it is possible to construct phenomena of teaching, learning, and communication of mathematical knowledge. That allows a frame of reference for the functionality of a mathematical topic such as the relationship between the slope parameter concerning the inclination of the straight line. In the sense of considering the social environment for the design of didactic situations, Peña-Rincón and Blanco-Alvarez (2015) tell us that

> We are so naturalized with the idea that mathematics is unique and has a universal character, that we do not even imagine the possibility of the existence of other mathematical knowledge and practices that expand and complement the mathematics disseminated by the West. But if we analyze mathematics from a sociocultural approach, we can see that they do exist... (p. 216).

These phenomena of teaching, learning, and communication of mathematical knowledge based on sociocultural approaches can be introduced to the mathematics classroom, therefore López and Victoria (2015) tell us that "teachers must propose didactic strategies that respond to the essential features that characterize each culture, this to make the teaching and learning of mathematics a formative pretext." (p.53). However, when performing a design, there are "...difficulties manifested in the linguistic interpretation, in the problem statements, [that] influence the free and rapid learning of the basic concepts of a given topic." (Lopez & Victoria, 2015, p.54).

Therefore, a harmonization must be made between the proposed statements in Spanish and the community of native language speakers where the design is to be implemented therefore, "...from the social environment, the task must go further because it becomes necessary to harmonize the terms. The social uses and meanings that the terms have in one and the other language must be identified..." (Avila, 2018, p. 192).

Given this scenario, the construction of didactic activities based on practices related to the culture of an ethnic group can be proposed. This is to incorporate them into the mathematics classroom of native peoples' communities. For this reason, we have taken up the cultural aspects of a collaborator at the higher level, on which we have based the design of a Didactic Activity with corn planting growth in different lunar phases that involve predicting a time after the initial one, involving variational thinking and language to promote understanding of the relationship between the slope parameter concerning the inclination of a straight line. It was decided

to work with high school students due to the harmonization between aspects of Spanish and the language of the native people of origin, as well as in the translation of the didactic activity for the community's children. If they have difficulties reading the didactic activity in Spanish or the native language, the collaborators can harmonize the activity for them. However, the Tzeltal language has linguistic variants "territorially delimited" by municipalities. In that sense, Polian (2015) comments that:

> Tzeltal is a language with moderate dialectal variation: it presents undoubted differences from one municipality to another, so it is made up of a certain number of what we call here "geolects" (so as not to say "dialect", a word with a negative connotation in common speech), that is, varieties with their linguistic features, linked to certain geographical areas. (p. 4)

The National Institute of Indigenous Languages (INALI) classifies them into four categories: Western Tzeltal, Northern Tzeltal, Southern Tzeltal, and Eastern Tzeltal. Within which are located several municipalities in the state of Chiapas. (INALI, 2021).

Therefore, the participation of the Tzeltal-speaking collaborator in this research is considered relevant to harmonize the Spanish terms of the Didactic Activity with their respective community of origin.

METHODOLOGICAL STRATEGY

The methodological strategy that this research followed was in three stages. The first stage consisted of inviting people from native peoples who are students of CE in the School of Engineering (SE) of the UNACH to participate in the research. From this stage, a sample of four women speakers and passive speakers of native languages accepted the invitation. Their participation will have a double role since first, we will obtain from them cultural aspects related to the culture of plants in lunar phases and at a later stage, they will have the role of harmonization between the didactic activity and the children to whom we plan to apply the activity in the community of origin of each one of them. In the first methodological stage, cultural aspects were identified, about agriculture, through a story that each student elaborated on and in an interview conducted with each one of them.

The second stage consists of the use of the cultural aspects identified in the previous stage, which are put into play in the design of didactic activities for each of the collaborators' communities of origin, that is, for a Tzeltal collaborator the design will be for their community of origin, and so on for each of the collaborators. For the Didactic Activity design, theoretical aspects of Socioepistemology are taken up again.

The third, a staging of the didactic activities in the communities of origin of each one of the collaborators, where the narratives and the developments made by the elementary level students of each collaborator locality of origin will be recovered and analyze what arguments they use to establish the existing relationship between the slope parameter concerning the inclination of the straight line.

FIRST METHODOLOGICAL STAGE

For the incorporation of cultural aspects to a didactic activity designed for native peoples, it is proposed to take them up from a cultural reproduction, as Dietz (2017) comments:

> ..., the members of a specific ethnic group..., do not reinvent their culture daily, nor do they constantly change their group identity. Cultural reproduction, both intra- and intergenerationally, elicits - through everyday praxis - processes of what Giddens (1995) coined as "routinization," which, in turn, structures that praxis. (p. 198)

From this routinization, according to Dietz (2017), individuals manage their continuity, both in **objectified cultural aspects** such as institutions, rituals, and pre-established meanings and in s**ubjectified cultural aspects** such as practices and representations by members to the ethnic group to which they belong. For the case, this would consist of the following breakdown (image 1)

Aspectos Culturales Objetivados			Aspectos Culturales subjetivados	
Instituciones	Ritual	Significados	Prácticas	Representaciones
Instituciones comunitarias que intervengan en la agricultura	Ritual a alguna deidad, del cielo, de la tierra o del agua	Significados que se relacionan con la agricultura	Prácticas subjetivas asociadas a la agricultura	Representaciones sociales asociadas al cultivo de plantas

Image 1. Breakdown of cultural aspects for agriculture. Source: Own elaboration

We consider that one or both cultural aspects can be used for the construction of didactic activities that use variational thinking and language for the existing relationship between the slope parameter concerning the inclination of the straight line, that is, identified in the plant that is planted in each collaborator's community of origin. The instruments used to obtain information were a narrative that consisted of a story and an interview with each collaborator.

In this first methodological stage, sampling was carried out at UNACH's School of Engineering, and four collaborators decided to participate in this research (see Table 1). This educational center is interpreted as a place of

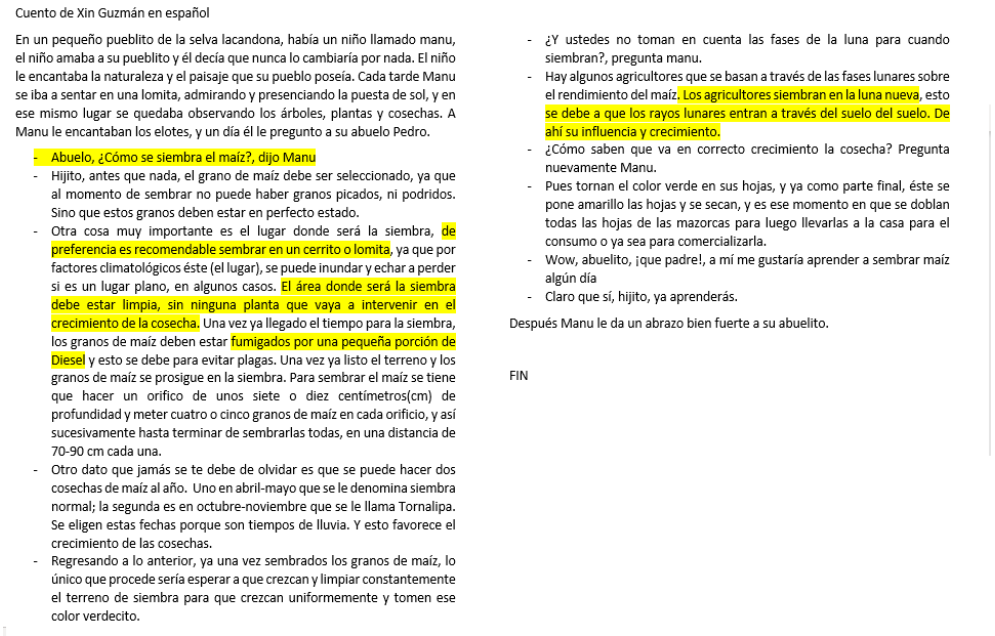
convergence of students from different regions of the state of Chiapas. The four collaborators are currently in their fourth semester at the CE. The collaborators will actively participate in the research since they will harmonize terms between Spanish and the native language to which they belong. The purpose of the story was to provide a way for them to externalize how a plant is cultivated in their community of origin, and that its growth is related to a specific lunar phase. They were asked to communicate with their relatives to support them in the realization of the story. As a result of this story, the type of plant and the lunar phase when the planting is done in each collaborator community of origin was identified. For example, in the case of the Tzeltal collaborator, as well as the *Ch'ol* collaborator, it is corn plant growth, which can be related to the linear function. For a Zoque collaborator, the plant identified is the plantain stalk, and for the other, it is the pumpkin culture. But what is shown in this paper corresponds only to the contribution of the Tzeltal student. The result of the *Ch'ol* community and the two Zoque communities' designs will be shown in another paper.

Table 1
Provenance of research collaborators

Collaborator	Speaking Language	Student's community of origin
1	Tzeltal	Nuevo Monte Líbano, municipio de Ocosingo
2	Zoque	Ocotepec, municipio de Ocotepec
Collaborator	**Passive speaker**	
3	Zoque	Tecpatán, municipio de Tecpatán
4	Ch'ol	El Limar, municipio de Tila

Source: Own elaboration with collaborators information

The following story was constructed with the Tzeltal collaborator (See Image 2).



Cuento de Xin Guzmán en español

En un pequeño pueblito de la selva lacandona, había un niño llamado manu, el niño amaba a su pueblito y él decía que nunca lo cambiaría por nada. El niño le encantaba la naturaleza y el paisaje que su pueblo poseía. Cada tarde Manu se iba a sentar en una lomita, admirando y presenciando la puesta de sol, y en ese mismo lugar se quedaba observando los árboles, plantas y cosechas. A Manu le encantaban los elotes, y un día él le pregunto a su abuelo Pedro.

- Abuelo, ¿Cómo se siembra el maíz?, dijo Manu
- Hijito, antes que nada, el grano de maíz debe ser seleccionado, ya que al momento de sembrar no puede haber granos picados, ni podridos. Sino que estos granos deben estar en perfecto estado.
- Otra cosa muy importante es el lugar donde será la siembra, de preferencia es recomendable sembrar en un cerrito o lomita, ya que por factores climatológicos éste (el lugar), se puede inundar y echar a perder si es un lugar plano, en algunos casos. El área donde será la siembra debe estar limpia, sin ninguna planta que vaya a intervenir en el crecimiento de la cosecha. Una vez ya llegado el tiempo para la siembra, los granos de maíz deben estar fumigados por una pequeña porción de Diesel y esto se debe para evitar plagas. Una vez ya listo el terreno y los granos de maíz se prosigue en la siembra. Para sembrar el maíz se tiene que hacer un orifico de unos siete o diez centímetros(cm) de profundidad y meter cuatro o cinco granos de maíz en cada orificio, y así sucesivamente hasta terminar de sembrarlas todas, en una distancia de 70-90 cm cada una.
- Otro dato que jamás se te debe de olvidar es que se puede hacer dos cosechas de maíz al año. Uno en abril-mayo que se le denomina siembra normal; la segunda es en octubre-noviembre que se le llama Tornalipa. Se eligen estas fechas porque son tiempos de lluvia. Y esto favorece el crecimiento de las cosechas.
- Regresando a lo anterior, ya una vez sembrados los granos de maíz, lo único que procede sería esperar a que crezcan y limpiar constantemente el terreno de siembra para que crezcan uniformemente y tomen ese color verdecito.
- ¿Y ustedes no toman en cuenta las fases de la luna para cuando siembran?, pregunta manu.
- Hay algunos agricultores que se basan a través de las fases lunares sobre el rendimiento del maíz. Los agricultores siembran en la luna nueva, esto se debe a que los rayos lunares entran a través del suelo del suelo. De ahí su influencia y crecimiento.
- ¿Cómo saben que va en correcto crecimiento la cosecha? Pregunta nuevamente Manu.
- Pues tornan el color verde en sus hojas, y ya como parte final, éste se pone amarillo las hojas y se secan, y es ese momento en que se doblan todas las hojas de las mazorcas para luego llevarlas a la casa para el consumo o ya sea para comercializarla.
- Wow, abuelito, ¡que padre!, a mí me gustaría aprender a sembrar maíz algún día
- Claro que sí, hijito, ya aprenderás.

Después Manu le da un abrazo bien fuerte a su abuelito.

FIN

Image 2. Story by Xin Guzmán

Upon analyzing the story, corn is identified as the plant to be used in a Didactic Activity. The new moon is also identified as the beginning of planting and can be interpreted as an initial condition. After analyzing the story, other cultural aspects related to the cultivation of corn can be found, both objectified and subjectified, which are described in Image 3.

Aspectos Culturales Objetivados			Aspectos Culturales Subjetivados	
Instituciones	Ritual	Significados	Prácticas	Representaciones
Familia de la comunidad de origen. ***Manu le pregunta a su abuelito Pedro***	La montaña, como una representación de la tierra, sigue siendo para los tzeltales un símbolo de la fertilidad. (D'Alessandro y González, 2017, p.282) ***Sembrar cerca de un cerrito o lomita.***	Significado sobre el Efecto lunar sobre el crecimiento del maíz. ***Esto se debe a que los rayos lunares entran a través del suelo. De ahí su influencia y crecimiento.***	Practicas transmitidas de una generación a otra y asociadas al cultivo del maíz. ***Limpieza del terreno.*** ***Los granos de maíz fumigados con Diesel.***	El género masculino asociado al cultivo del maíz. **Manu (un niño), le pregunta a su abuelito Pedro (Hombre)**

Figure 3. Objectified and subjectified cultural aspects that emerge from the Tzeltal collaborator's story.

An interview was also conducted with the Tzeltal collaborator, to complement the cultural aspects obtained from the story. In the interview with the Tzeltal community collaborator, she gestures about the plant's growth in the variation of the lunar phases. This is interpreted as a behavior where

the plant stops growing for some lunar phases with growth for later phases. This resulted in the construction of the graph shown in image 4.

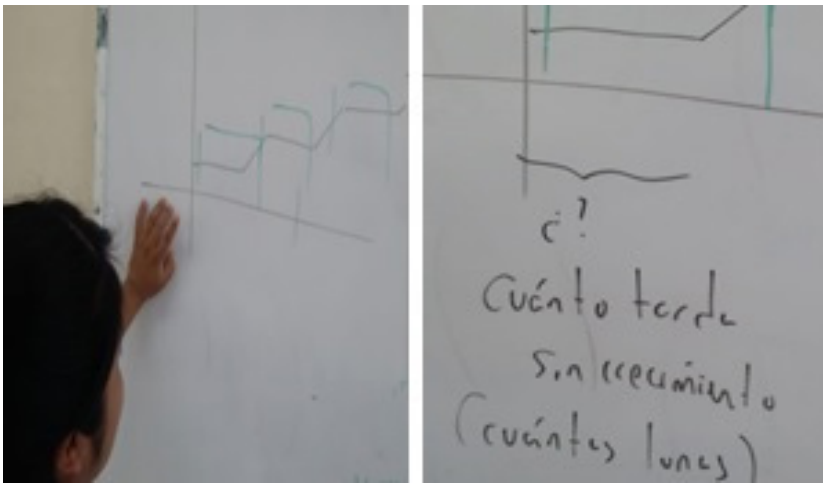


Image 4. Construction of a graph of a plant's growth behavior

This methodological stage ends with elements on the cultural aspects, both objectified and subjectified by the Tzeltal collaborator, student of UNACH's School of Engineering. It is considered to retake part of them for the Didactic Activity design for the Tzeltal community. As well as each contribution of the other collaborators will be taken in the respective didactic activity design for each one of their communities of origin.

SECOND METHODOLOGICAL STAGE

For the Didactic Activity design for the Tzeltal community, we based ourselves on the Socioepistemological theory, taking up some cultural aspects of the story and the interview with the Tzeltal collaborator. This theory, "focuses attention on knowledge-generating practices beyond the mathematical object" (Balda, 2018, p.91). As a knowledge-generating practice, aspects of prediction are taken up, which according to Caballero (2018), is carried out by human beings and allows the generation of variational thought and language. In our case, this will be used to promote the understanding of the relationship between the slope parameter concerning the inclination of the straight line.

To recognize the notion of variation in the didactic activity, it is necessary to consider the following aspects (Caballero, 2018)

> ... at least three essential aspects are required to be aware of the notion of variation. The measurement of change consists of the quantitative recognition

> of that which changes [concerning a second aspect], the analysis of how that measure evolves consists of describing and quantifying how the measure of change is modified in an interval. [Finally], the recognition of why variables change in the way they do allude to a characteristic of prediction, it is a matter of establishing a rationale for the evolution of change in an interval. (pp. 49-50)

Therefore, we consider that the phases of the moon, Image 5, can be used to establish a quantitative recognition of change, descriptions, and quantifications of how the measure of change in plant growth is modified in the phases and finally, the recognition of why plant's growth changes in the way it does.

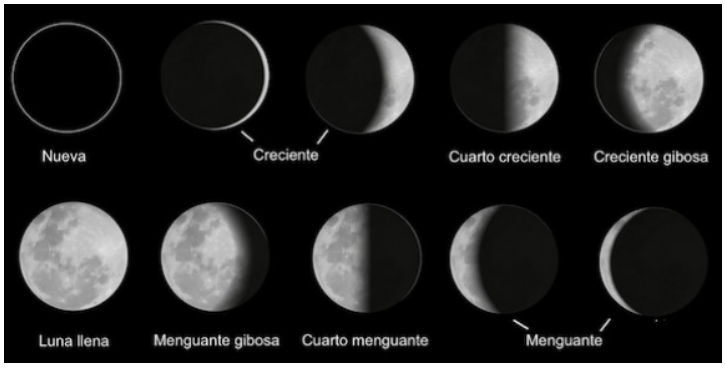


Image 5. Names of the phases of the moon as seen from the northern hemisphere of the Earth. Source: Geoencyclopedia (2019)

Therefore, it is proposed to place in the Didactic Activity a height measurement for a corn plant in a lunar phase and a different measurement in a later lunar phase. With this, we consider it is possible to establish quantitative recognition of that which changes as mentioned by Caballero (2018), see image 6.

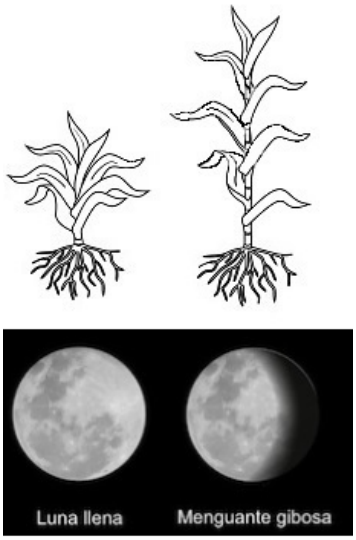


Image 6. Quantitative recognition for different lunar phases. Source: The authors

On the other hand, "Studying change in a phenomenon requires recognizing intermediate states to analyze the process of variation of variables, that is, to give a sense of temporization to the phenomena of variation, which allows us to address the question "how does it change?" (Caballero, 2018, p. 95), this for the analysis of how that measure evolves. In this sense about temporization, Caballero (2018) clarifies:

> Timing comprises two senses: the first is the identification of states that are suggested or explicit in some activity or situation, for example, in the case of a numerical table, each of the numerical values of the dependent variable can be considered states, while, in a graph, each of the values of the horizontal axis can be considered states if it has an explicit numerical scale. The second sense consists in the construction of the states when they are not explicit in the given situation, for example, when establishing specific values of the variables in a graph that does not have an explicit scale, or when recognizing specific instants of time in the movement of a body. (p.96)

Therefore, the following design is proposed, where the analysis of how this measure evolves consists of describing and quantifying how the measure of change is modified in a lunar interval by establishing specific values of the variables in a graph that does not have an explicit scale, as shown in image 7. We can propose different slopes in the linear growth in three lunar phases and question the corn plant's growth speed. Where a steeper slope would mean a faster growth rate for the plant. We consider that the existing relationship between the slope parameter concerning the slope of the straight line can be gestated in the analysis of this behavior when studying the change in a phenomenon requires recognizing intermediate states to analyze the process of variation of the variables as mentioned by Caballero (2018).

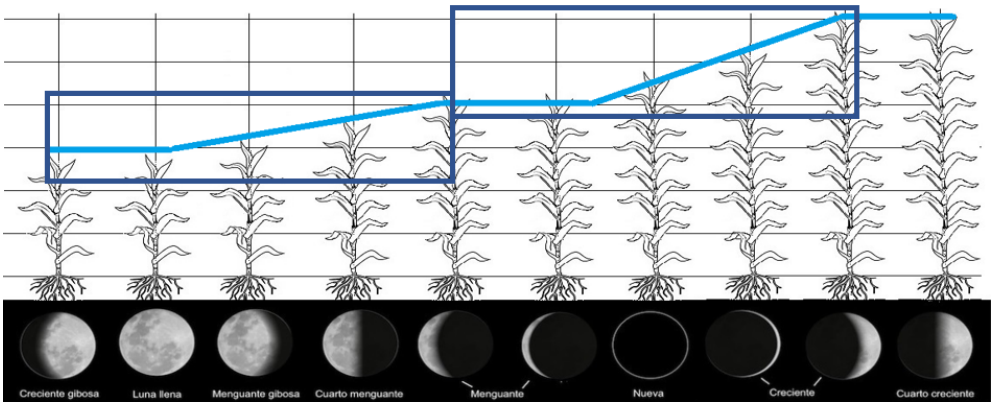


Figure 7. Behavior of maize-based on cultural aspects of the Tzeltal university student collaborator

Finally, the recognition of why the variables change in the way they do alludes to a characteristic of prediction, it is about establishing ***rationality*** to the evolution of change in an interval. Caballero mentions that this rationality is manifested in a variational reference system (image. 8).

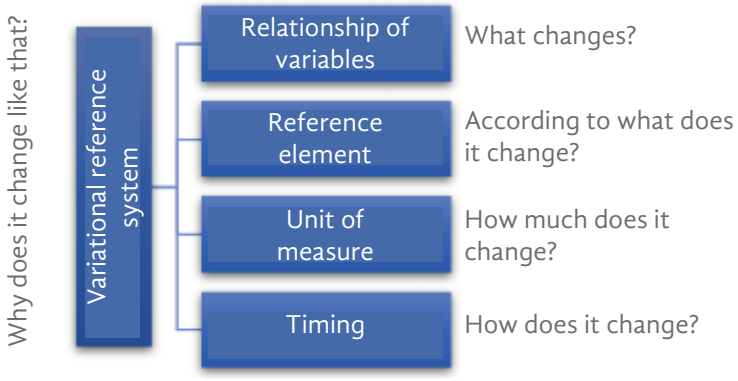


Image 8. Rationality for variation. Caballero (2018, p.99)

A boy or girl from the community of origin of the Tzeltal collaborator, in the third methodological phase, could associate in his or her rationality with some of these cultural aspects to justify the variational in the understanding of the existing relationship between the slope parameter concerning the inclination of the straight line (image 9), to mention a few.

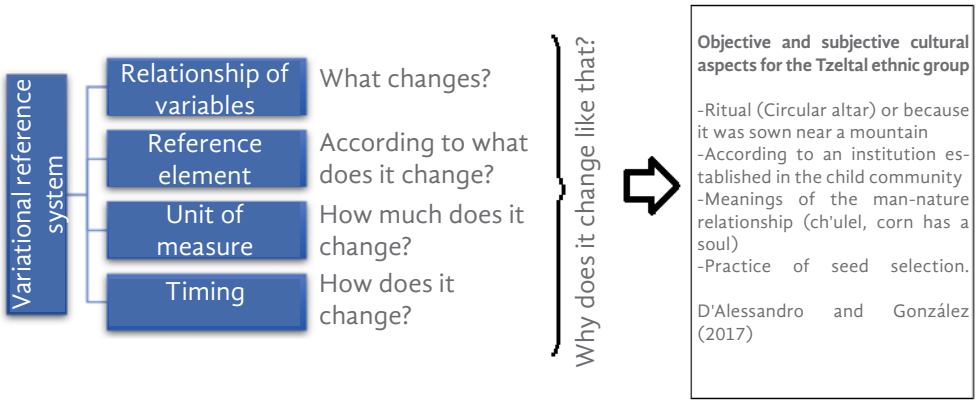


Image 9. Cultural aspects that can emerge as arguments for the variational in the Nuevo Monte Líbano community's children

Although it is expected that he or she identifies a unit of analysis and the type of inclination in each of those units. It is expected to establish a relationship between vertical growths concerning horizontal growth according to the type of inclination observed (image 10).

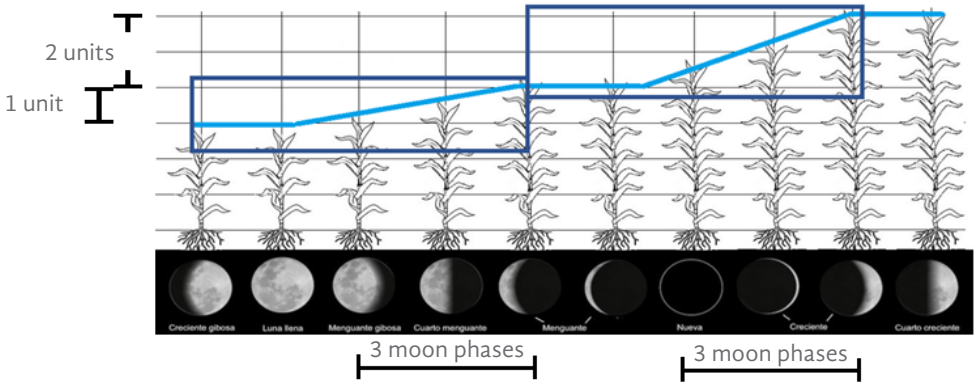


Image 10. Identification in the unit of analysis of a different slope for the straight line

Recalling that the notion of slope (m) of a straight line is a quotient relation between the distances of the ordinate with the distances of the abscissae. (Lehmann, 1989).

$$m = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

And its relation with the straight line's inclination is

$$m = tan \propto$$

Where $\propto$ is the angle between the straight line and the positive x-axis (see Image 11).

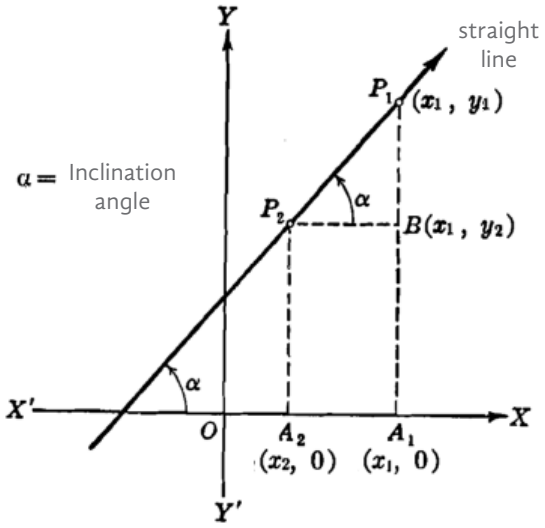


Image 11. Graphical representation of the inclination angle. Source: Lehmann (1989, p.18)

The second methodological stage ends with a Didactic Activity built for the Tzeltal community of Nuevo Monte Líbano, as shown in APPENDIX A and B.

IN CONCLUSION

It has not been possible to carry out phase three of the methodological strategy, due to the academic pause due to the pandemic caused by the virus Covid-19. This has resulted in a limiting factor for the continuity of the research project. The strengths that we consider can emerge from a proposal such as this one, is to create a frame of reference that denotes how it is possible to favor the understanding of the existing relationship between the slope parameter concerning the inclination of the straight line using the objectified or subjectified cultural aspects of a community speaking an original language for the state of Chiapas, as is the design shown in this paper and for the community of Nuevo Montelíbano. We agree with Cantoral (2013) who pointed out "A fundamental question of contemporary importance consists of adapting a teaching, in the broadest sense of the term, to the demands of thinking, learning and the historical, institutional and cultural contexts that mathematical activity requires" (p. 13). In this sense, we rely on the practices of corn culture about the lunar phases, which make sense culturally speaking for the children of Nuevo Monte Líbano, since they, at an early age, take care of the harvest, and are familiar with following the moon, according to what Xin comments to us.

> "...from ten years old, children already go to the fields..., they already know how it is, how plants grow...and if they would understand it, based on those questions..." (Interview excerpt).

On the other hand, an opportunity that we visualize for this proposal is to consider cultural aspects such as corn growth in different lunar phases incorporated into the variational thinking of the Tzeltal collaborator, a student of the School of Engineering of UNACH. One interpretation of this is when the collaborator suggests constant behaviors to then continue with the plant's growth. This is interpreted as a variational graph and we consider that it is her contribution that we can reflect it in the graph of Image 4, to apply it to the children in her community. In that sense Avila (2018).

> To perform the task of harmonizing terms, it would be very useful to generate spaces of speech, communication, and exchange between teachers and students in the classrooms, so that children also collaborate in the construction of a relevant and meaningful school mathematical language. (p.193)

Thus, a return to the community of origin of the Tzeltal collaborator in this research is proposed, for students' significant learning of concepts such as the slope of a linear function implicit in the figures proposed in the didactic activity, such as the straight line in the case of the first part of the design, as shown in image 12, where last plant's growth represented does not coincide with the inclination of the straight line implicit in the activity.

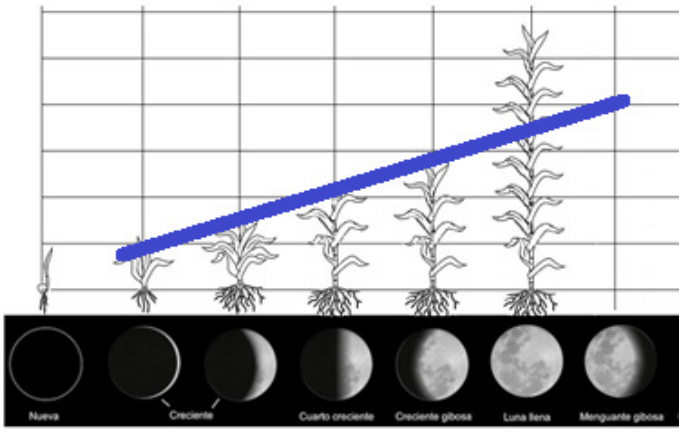


Image 12. Implicit straight line in plants' growth with a certain inclination

In the second part of the Teaching Activity a form similar to the integer part function, $f(x)=[x]$, where constant growths are perceived in certain lunar phases, but at different heights of the "y" axis, and in others with linear growths, for example, $f(x)= x$, is proposed. Setting up a piecewise function, as shown in image 13. And it will ask for the plant growth in a future lunar state, which does not appear in the lunar phases of the graph.

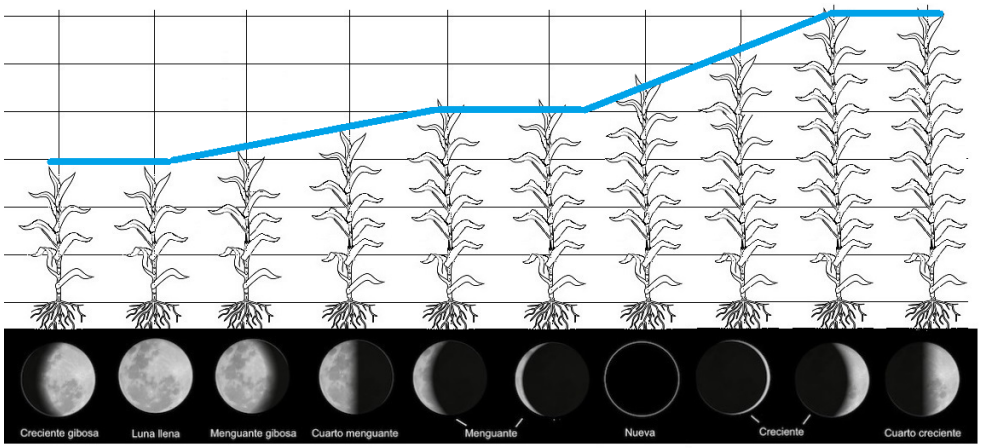


Image 13. Implicit function to stretches in the plant's growth in different lunar phases

This concludes the two proposals for the design of the Didactic Activity for the Tzeltal community of Xin. These proposals are based on lunar phases that the members of the Xin community do not know by name, but they do know their behavior in the sky since they have observed the moon.

> "well yes, [But, how do they do it?] they observe the moon, but in and on itself, but they know what it is... they don't know the specific name... they only do it close to the full moon or the new moon" (Fragment of interview).

We consider it relevant to base ourselves on the two strands that emerge from routinization for cultural reproduction (Dietz, 2017), for the arguments that may arise in the children of a Tzeltal community to justify the use of variational thinking by complementing concepts such as the existing relationship between the slope parameter concerning the inclination of the straight line when the third methodological phase is performed. When intervening in the mathematics classroom at the elementary level in a rural community in the state of Chiapas, we can mention that the ages of the children to whom a Didactic Activity will be applied will depend on the information provided by the collaborators in this research. As in the case of the information provided by the collaborator from Nuevo Montelíbano, municipality of Ocosingo, we can establish an age of 11 years old to apply it.

REFERENCES

Ávila, A. (2018). Lenguas indígenas y enseñanza de las matemáticas: la importancia de armonizar los términos. *Revista Colombiana de Educación*, (74), 177-195.

Balda, P. (2018). *Una epistemología de usos en torno a lo proporcional: Un estudio socioepistemológico en el contexto de la huerta escolar*. [Tesis de doctorado]. Universidad Santo Tomás, Bogotá, D.C.

Caballero, M. A. (2018). *Causalidad y temporización entre jóvenes de Bachillerato. La construcción de la noción de Variación y el desarrollo del pensamiento y lenguaje Variacional*. (Tesis doctoral inédita). Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional: Ciudad de México.

Cantoral, R. (2013). *Desarrollo del pensamiento y lenguaje variacional*. México, Distrito Federal: Secretaría de Educación Media Superior.

Córdoba, L., Díaz, M., Haye, E. y Montenegro, F. (2013). Dificultades de los alumnos para articular representaciones gráficas y algebraicas de funciones lineales y cuadráticas. En Y, Morales y A, Ramírez (Eds.) *ICEMACYC Congreso de Educación Matemática de América Central y El Caribe.* (pp. 1-13). Santo Domingo, República Dominicana: CEMACYC. Recuperado de http://www.centroedumatematica.com/memorias-icemacyc/373-401-2-DR-C.pdf

Cruz, F. y Butto, C. (Noviembre de 2013). Conocimientos de alumnos indígenas de educación primaria sobre dos sistemas de numeración: aportes para la educación bilingüe. En M. Barrón (Presidencia), *XII Congreso Nacional de Investigación Educativa.* Congreso llevado a cabo en Guanajuato, México.

D'Alessandro, Renzo, & González, Alma Amalia. (2017). La práctica de la milpa, el ch'ulel y el maíz como elementos articuladores de la cosmovisión sobre la naturaleza entre los tzeltales de Tenejapa en los Altos de Chiapas. *Estudios de cultura maya*, 50, 271-297. https://doi.org/10.19130/iifl.ecm.2017.50.768

Dietz, G. (2017). Interculturalidad: una aproximación antropológica. *Perfiles educativos, 39* (156), 192-207. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0185269820170002001 92&lng=es&tlng=es

Geoenciclopedia. (2019). *Fases de la Luna*. https://www.geoenciclopedia.com/fases-de-la-luna/

Gómez, K. (2015). *El fenómeno de opacidad y la socialización del conocimiento. Lo matemático de la Ingeniería Agrónoma.* Tesis de doctorado no publicada. DME, Cinvestav-IPN, México

INALI. (2021). Agrupación lingüística: Tseltal

Familia lingüística: Maya. https://www.inali.gob.mx/clin-inali/html/l_tseltal.html

Lehmann, C. (1989). *Geometría Analítica*. México D.F., México: Limusa

López, Y. y Victoria, D.A. (2015). La enseñanza de las matemáticas en un contexto multicultural hacia un currículum intercultural. *Revista de Investigaciones UCM, 15*(26), 44-55. http://dx.doi.org/10.22383/ri.v15i2.43.

Mendoza, E. y Cordero, F. (2015). *Matemática funcional en una comunidad de conocimiento. El caso de la estabilidad*. http://www.matedu.cinvestav.mx/~tercercoloquiodoctorado/memorias/art/035.pdf

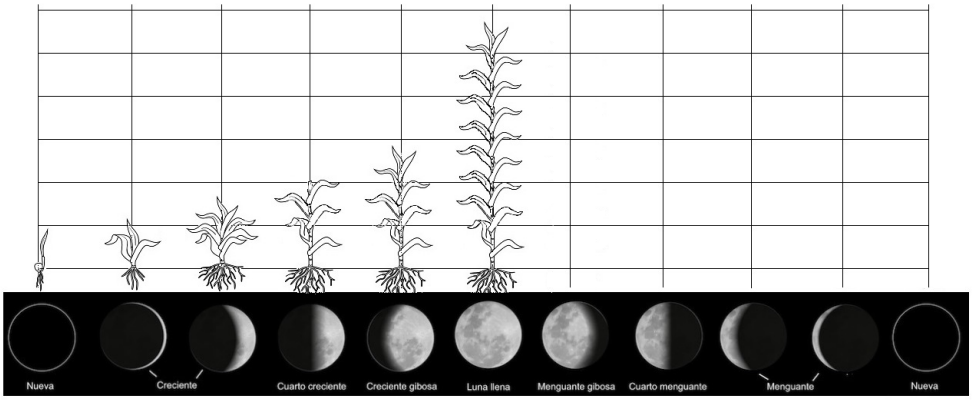
Micalco, M. (Septiembre de 2009). Los usos del sistema numérico vigesimal y su interrelación con el sistema numérico decimal en las prácticas comunitaria de los jóvenes mayas: un estudio etnográfico ubicado en la región Tseltal de los altos de Chiapas. En R. López (Presidencia), *X Congreso Nacional de Investigación Educativa*. Congreso llevado a cabo en Veracruz, México.

Peña -Rincón, P.A. y Blanco-Álvarez, H. (2015). Reflexiones sobre cultura, currículo y Etnomatemáticas, en Regina Cortina y Katy de la Garza (compiladoras). *Educación, pueblos indígenas e interculturalidad en América Latina* (pp. 213-245)., Quito-Ecuador: Ediciones Abya-Yala

Polian, G. (2015). *Diccionario Multidialectal del tseltal*. https://tseltaltokal.org/wp-content/uploads/2018/09/Polian_Diccionario-multidialectal-del-tseltal-enero2015-2.pdf

ANNEX A

PART 1. - The height of a corn plant at the full moon is as shown in the figure.

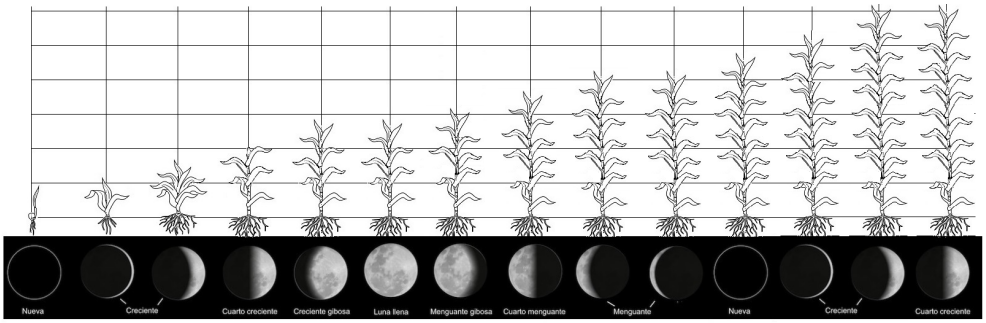


a) Is that height what the plant should be? If yes, why?

b) If no, what should the height be?

c) How did you know what the height should be? What calculations did you make? Post your procedure. Draw pictures to explain how you calculated the height.

PART 2. – A corn plant grows as shown in the following image.



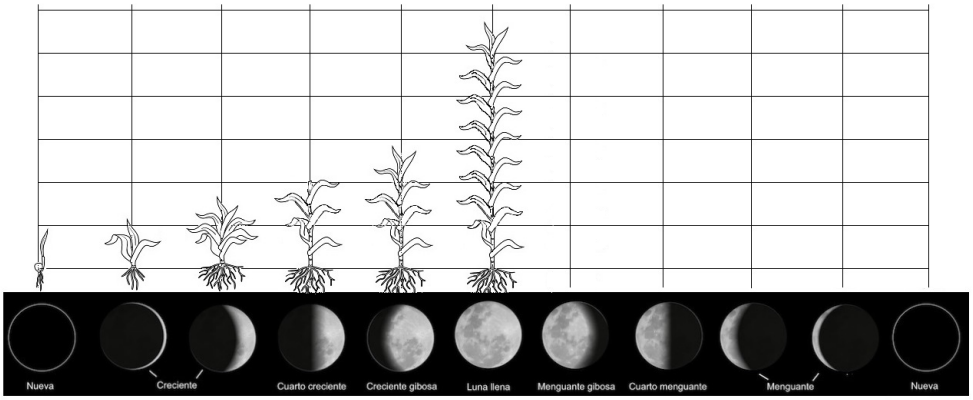
a) What would be the height of the plant at the next full moon?

b) How did you know what the height should be? What calculations did you make? Post your procedure. Draw pictures to explain how you calculated the height.

c) Why does the plant behave like this? (Make drawings to explain your answer if you think words are not enough to explain it).

ANNEX B

PARTE 1.- Ja’ te stoyolil te ixim-ej ta syijil uj aj’ te yax chiknaj te ta lok’ombaj.

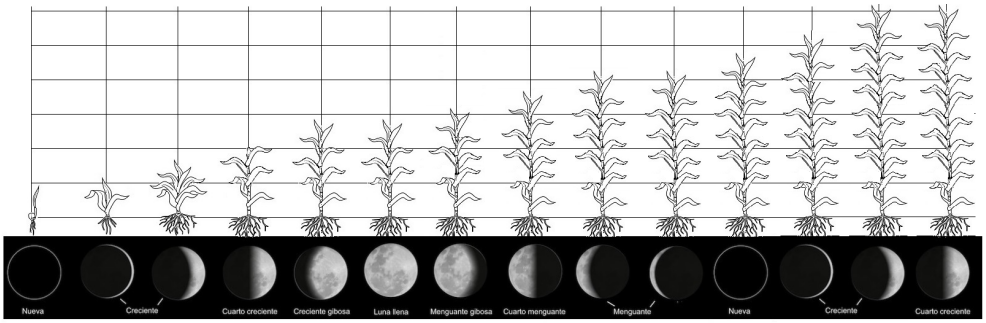


a) ¿jich bal stoyoyil xch’ijyel ixim-aj? Te me melel-ej, ¿biun?

b) Te me mauk-ej, ¿bin yilel wan xch’iyel aj

c) bit’il ya ka na’ bin smuk’ul xch’iyel aj?, ¿bin kalculo la ja pas?, Te me ya xu’ awu’une pas-aj slok’ombal te bit’il la ja pas kalcular te smuk’ul xch’iyel te ixim-ej.

PARTE 2.- Ja’ te xch’iyel te ixim-ej ja’ te ya xchiknaj te ta lok’ombaj.



a) ¿Bin wan smuk’ul xch’ijyel ixim-aj te ta syijil uj?

b) ¿bit’il la ja na’ bin smuk’ul xch’ijyel aj?, ¿bin kalculo la ja pas?, Te me ya xu’ awu’une pas-aj slok’ombal te bit’il la ja pas kalcular te smuk’ul xch’iyel te ixim-ej.

c) ¿Bin swenta te Jich ya ch'ijybal te ts'umbal ej?(te me ma' ka na' yalel o xcholel ta k'optik, pasbeya slok'ombaj ta lejchel Jun te bin ta jok'obeyelat ej)