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Dialogic Educational Practices in STEAM Non-Formal Contexts of Education in Monterrey, Mexico

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Lay-Wah Carolina Ching Chiang

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Dialogic Educational Practices in STEAM Non-Formal Contexts of Education in Monterrey, Mexico

Thesis to obtain the degree of

PhD in Educational Innovation

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Dedication

To my ancestors

for their love, hard work,

and strong family connections.

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Abstract

While STEM education is seen as a universal driving force for global economic development, there is also a complex nexus with social, political, and cultural inequalities, with gender issues, and with the education of Indigenous populations. The visible signs of these gaps are inequalities and increased marginality within a society and between societies. On many occasions, STEAM pedagogy, even with the recent inclusion of Arts in the formula, has fallen short in its promise of building knowledge located in real contexts of application, as well as in its capacity to transform the learning trajectories of the participants. As an alternative, the implementation of a dialogic perspective on learning processes in interactive experiences in STEAM projects could genuinely allow participants to reflect on their contributions at the local and global level. This research project has a clear objective to contribute to the reduction of marginality in Mexico and improve inclusion through the implementation of dialogic scientific-technological education for technical vocational students in marginalized situations. Thus, contribute to the plan of the United Nations General Assembly (2015) through SDG 4, quality education. To accomplish that research question leading this study is: To what extent dialogic educational practices in STEAM sessions have an impact in the critical thinking skills of participants of non-formal contexts of education? To answer the question a pilot study was done with families in a marginalized community in Monterrey, Mexico. The main study was done in the framework of the High STEAM project with 3 CBTIS and 3 CETIS in Monterrey. The participants were 124 high school students, 10 high school teachers and 19 high school students participated. The main study research implemented a mixed method study with a convergent parallel design. Even though the quantitative results did not proof a significant impact of the STEAM sessions, the qualitative results showed that the value of dialogic practices from a Latin American perspective is that they have a clear emphasis on social participation and reflect a sense of social justice in which dialogue is capable of transforming people's realities. A clear contribution from the dialogic educational practices in STEAM non-formal contexts is the purposeful design of educational experiences that combine the STEAM approach with the dialogic educational practices. Moreover, accompaniment showed to be a key foundation for the dialogic STEAM sessions. It is extremely important to observe the socioeconomic reality of the region to generate a reflection on educational practice. A clear contribution to the knowledge of and from the region is that can inform and influence policies as well as interventions in educational systems and institutions in Latin America by creating purposefully designed educational experiences based on accompaniment.

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Chapter 1: Problem Statement

1.1 Introduction to the Chapter

The purpose of Chapter 1 is to present the problem that needs to be addressed for this research study. Figure 1.1 summarizes the approach taken to establish the problem statement.

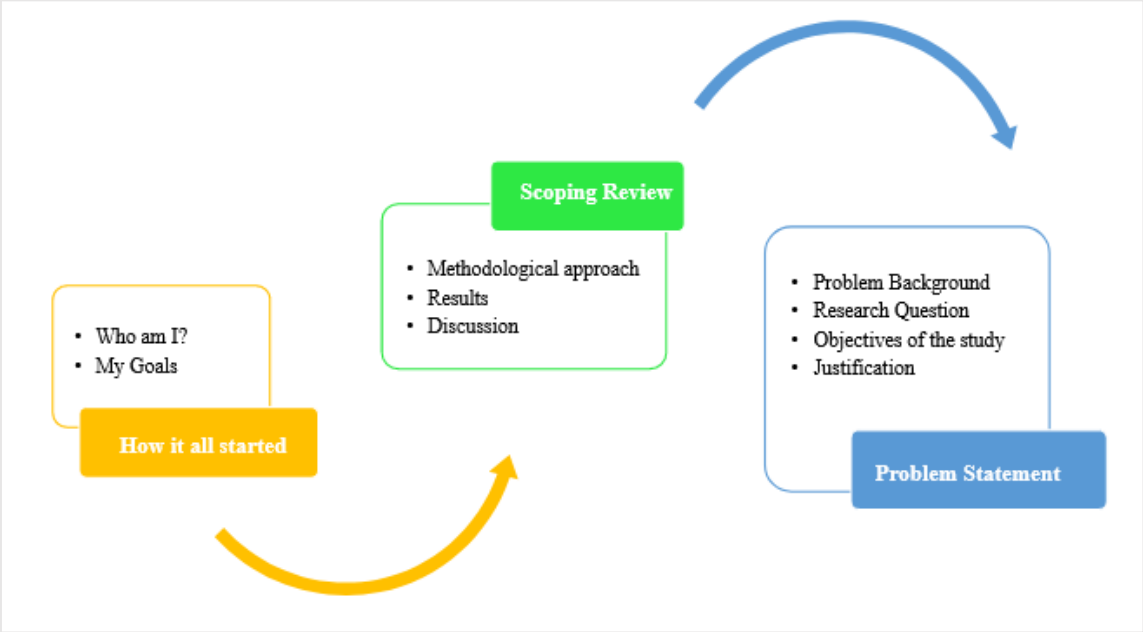


Figure 1.1 Establishing the Problem Statement Approach

In the diagram it is evident that, before establishing the problem statement, two previous steps were taken: “How it all started” and “Scoping review.” The purpose of the first step was to acknowledge “Who I am”, understanding how my experiences shaped my interests and declaring my researcher’s goals. The purpose of the Scoping Review was

to have an initial documentary research around the area of interest prior to the proposal and subsequent preparation of the dissertation. Having these two components, then it was possible to move forward to establish a problem statement that reflected the researcher's relevant context, as well as the niche in an academic field.

The three steps: How it all started, Scoping Review and Problem Statement are developed in sections 1.2, 1.3, and 1.4, respectively.

1.2 How it all started?

This thesis did not start with a Boolean formula to search in databases. It was the accumulation of a history of generations before me and my individual experiences which fuelled the thought of making this research. Thus, as a researcher, it was important for me to reflect upon those experiences so that I could clearly develop an understanding of my own research paradigms and motivations. The result of that moment of reflection is described in the first half "1.2.1 Who am I?" of this section. Upon understanding my previous experience, the next step was to establish goals that would guide my overall research and focus on a preliminary area of interest to explore. This was achieved in the second half "1.2.2 My goals" which established my personal, intellectual, and practical goals.

1.2.1 Who am I?

There are two main things that shaped who I am to pursue my PhD degree: My origins and three key learning processes from my educational and working life: my

educational and working life learnings, my experience with a STEM curriculum and when I became a teacher.

1.2.1.1 My origins

My name is Lay-Wah Carolina Ching Chiang, I was born and raised in Ecuador from a Chinese father and a Chinese-Ecuadorian mother. I am the oldest of four siblings and the only daughter. The first 20 years of my life I grew up in the duality of cultures. It can be summarized in this way: eating with fork and knife for lunch, and with chopsticks for dinner This duality of cultures had a series of implications that were not only influencing my eating habits, but also the way I developed my personality and actions based on the values and beliefs I was taught. I was taught to:

- Hear advice from my elders and treasure them
- Set the example for my brothers as the oldest sibling
- Be responsible with my studies because education is important to have a better future to support my family, youngsters, and elders
- Study and work hard to become a professional

As you may see, my core beliefs have always been based around family expectations. However, my education and working stories helped me to broaden my perspective and make more relevant to find my own purpose; one that according to the Japanese concept of Ikigai is based on four pillars: something that I loved, something that I am good at, something that I can be paid for, and something that the world needs.

1.2.1.2 My education and working life learnings

Following my parents set up, I had my elementary education in a catholic school and then moved to middle and high school to a science-based school. Their expectation was for me to study an engineering career or to become a doctor. My father wanted me to be a doctor because he had an open-heart surgery while I was one year old. Meanwhile, my mother wanted me to be an engineer because her brother who passed away when she was 13 years old was studying civil engineering. So, there I was with my origins on my shoulders.

1.2.1.2.1 My Experience with a STEAM Curriculum

In 2002, the Ecuadorian curriculum was organized in such a way that 10th graders would receive a combination of subjects in different areas of knowledge. On the other hand, 11th and 12th graders would receive subjects specialized in one area of knowledge that they would select among: Humanities, Engineering or Experimental Sciences. At school, each of the specializations was associated with traditional respected careers. Humanities will lead you to be an accountant, lawyer, economist, or entrepreneur. Engineering to anything related to civil, design, electrical, mechanical or software engineering. Lastly, Experimental sciences would lead you to become a doctor or pharmacist.

To make the decision of which specialization you would go, the school provided counsellors and a vocational test. Even though the counsellor recommended Engineering, and I had scored higher in aptitudes for Engineering, as desired by my mother, I chose to follow Humanities. I took deep into my heart my experience in 10th

grade with the combination of national and international STEAM curriculum that the school was running.

I had always been a top student during high school but that year in 10th grade I felt very frustrated. I had Math classes where I could make sense of it with the examples that the teacher gave, such as exercises related to interest rates. Computer class was interesting because we solved problems with programming. Electricity was fun because of the practical learning and repairing objects. However, Chemistry and Physics became a nightmare. They were subjects that I had to memorize things to pass my exams. I did not feel the connection with the real world, so it was hard to enjoy the class and learn. Moreover, my grades were not good and since I had associated grades with what I was good at, I concluded that I was not good enough for it. Having this fear with Chemistry and Physics, I decided not to choose Engineering and go for Humanities.

I knew it would disappoint my parents, but they did not take it so bad since I had proven that I was capable. I approved in 11th grade admission to the best engineering school in my city and for the Zamorano university in Honduras. In Humanities, the closest subject I had related to natural sciences was Environmental systems. The subject integrated skills from a STEAM curriculum and connected transdisciplinary curriculum which I really loved. This love for a STEAM curriculum followed me in the university.

In university, I always wondered if my life could have been different if I had made the choice of the specialization in Engineering. I had worked in my parents' hardware store and been involved in the building sector since childhood. While studying

my bachelor's in Business Administration, we talked about management, but it was based upon the things that could have been created by engineers. So, there were many times I wished I had taken an engineering career. However, years later, when I became a teacher, this wish to study, or not studying a STEAM curriculum kept following me and hit me in a unique way.

1.2.1.2.2 When I became a teacher

Becoming a teacher started with an opportunity to cover for the absence of a teacher that was leaving the last two months of the school year. I had just come back from China because my father had a medical issue with his heart, so I was supposed to oversee the family business that was a hardware store. It was expected that since I had studied Business Administration and had aptitudes for Engineering, I will inherit the leadership of the business. Plus, I was the most likely to do it since my brothers had not finished school at that time. But that changed when I went to give a conference to a brand-new authorized school to implement the Diploma Program of the International Baccalaureate. I met the English department teacher and we agreed upon some educational topics and my way to see education, given the three different educational backgrounds I had been in. One week later, she offered me a job in her department. I accepted thinking it was fine to have this experience for two months.

I was assigned to teach Business Management and Language Arts with the International Baccalaureate Diploma Program (IBDP), and Counselling students. It was in this space that I realized how important it was the role of a teacher in shaping the identity of students. I received training in the program implementation. One of the most

important came from the planning sessions that we had as a team. The IBDP has at its core three components: Theory of knowledge (TOK), the extended essay (EE) and the Creative, Action and Service (CAS), and six subjects depending on the school selection. It was while designing the relationship of our subjects towards TOK and between each other that I realized theoretically from a teacher perspective the need for connection between subjects in the curriculum, something that I had experienced as a student. I felt a strong need to make this happen for my students, so I started working on it.

One shocking experience came to place when I was teaching unit three financial ratios to my students. The aim for this unit targeted the ability of evaluating companies based on their financial ratios. So, it was not so important knowing the formula to calculate the ratios. The IBDP would even allow students to have a cheat sheet with the formulas. My students were able to input the numbers but failed when asked to analyze and justify the answers, thus, I had to change the teaching strategy. I went to visit the Math teacher class, since between the IBDP teachers we had the facility to visit other teachers. I realized that he was just working on calculations and making no connections with real life examples that could take students to the next level.

I realized three things here: (1) making an interdisciplinary work requires having all teachers involved, trained, and prepared to develop critical thinking of students (2) the importance of STEAM curriculum abilities for life, and (3) the impact that teachers could have in students' identity. As a result, I started having this dialogue with my co-workers and implementing changes in classes such as more opportunities to democratize

participations to hear more their voices as a sign of knowledge construction and taking advantage of the STEAM curriculum.

1.2.1.2.3 My experience with Community Service Programs

As a student and teacher of the IBDP, I experienced a component of the program called Creativity, Action, and Service (CAS) which called students to be part of a community service program. As a student, I chose to be part of a project that supported women of a rural community to learn abilities and set up a business. The project was twice a week to plan and reflect upon the activities, and every Saturday we would go to the community. We taught them how to make handcrafts and at the end of the project we got funding to buy sewing machines for them and to make a business.

The community service program was one of the most relevant activities in my life because in this process I was able to develop acknowledgement of a community. The community was in a marginalized area dependent on the rice harvest which was different from the set up I was living. However, hearing and interacting with the women in the community became a crucial part to break down barriers. I felt like through dialogue we were able to know each other and respect each other by having this process. Through this, I learned about their life in the community and roles.

Even though, at the beginning we had designed activities to teach them skills for making different crafts, it was by hearing their needs that we came with a final project to deliver to the community. It was their social dream and aspiration to form an association to sell clothes. So, in a team effort with different activities we got the funding and

delivered two Singer sewing machines to the women from the community to start their association.

Here, I realized how important it was to have this exchange of backgrounds and conversations to improve the lives of women in the community. We had an agenda of helping others with our own set of ideas and curriculum planning but having them involved in the process just empowered them on a more personal level. It was important that them, as the main actors, were heard and their own reasoning was fundamental for social transformation while developing their own identity.

1.2.2 My goals in this research

My personal experiences have become a cornerstone of my thesis because they are the driving forces behind the goals I have set for my overall project. Hence, following the recommendation of Maxwell (2012) it seems relevant for me as a researcher to acknowledge my own personal, intellectual, and practical goal leading this research. Table 1.1 summarizes the connections between the Who I am (my experiences) with my goals in this research.

Table 1.1

Matching who I am and my Goals in the research

My Experience	Goal
I loved being a teacher and my community service	(Personal goal) Innovate through dialogic practices the relationships in STEAM education
The world needs community service programs	(Intellectual goal) Understand STEAM education in shaping participants' identity and for social justice
I can be good at bringing STEAM subjects together	(Practical goal) Achieve a dialogic method to train teachers for better educational practices

In Table 1.1 each personal experience (my STEAM curriculum, becoming a teacher, and my community service programs) represents a motivating force in my life which gives a sense to “what I love”, “what the world needs”, and “what I am good at, and I can be paid for”. Understanding who I am is relevant as it propels the origin of the personal, intellectual, and practical goals that I have established for this research.

1.2.2.1 Personal Goals

As stated in my personal experience of becoming a teacher, I realized how important it was to discuss with other teachers’ educational practices and to democratize opportunities to hear students’ voices in their learning process. Similarly, in my community service program, it was relevant to acknowledge women in the community’s perspective to achieve an educational process that was relevant for them. In both cases, the transformation was experimented through dialogue, making me think that there is a field for innovation in education through the ways these discursive relationships are managed. Hence, I want to explore from a sociocultural standpoint the use of dialogue in educational practices, specifically in STEAM education, because developed nations seem to hold a relationship between scientific and technological knowledge with economic development (see Montgomery & Fernández-Cárdenas, 2018). Studying this in the context of the Latin American region could imply an opportunity to challenge the current methods of education and empower actors to make a significant difference taken from the very core of their social dream.

1.2.2.2 Intellectual Goals

It is impossible for me to think about my school life and not remembering my teachers. With their way of thinking and acting, they were a source of shaping my identity as a human being and the decisions I made throughout it. Teachers are responsible for student learning to a certain extent. Also, years later from the perspective of a teacher, I realized how dialogue opened opportunities to building knowledge in a transdisciplinary curriculum. Hence, my first intellectual goal is related to understanding how dialogic educational practices in STEAM education could shape the participants trajectory.

Rethinking about my community service program, it made me realize the marginalized conditions and access to educational opportunities they could have. They receive the same curriculum but their history repeats. Hence, my second intellectual goal has to do with understanding dialogic STEAM education as a matter of social justice. The world needs transformative learning opportunities that could take communities in marginalized situations to be empowered so they realize how much more they could achieve. In that way, I am looking forward also to reshape Latin American education by using local contexts instead of implementing foreign solutions or reinforcing elitism.

1.2.2.3 Practical Goals

I am motivated to create a tool that could support training participants in dialogic educational practices in STEAM trajectories of participants in non-formal contexts. I want participants to use dialogic educational practices to learn how to empower themselves and others. In this way, with an understanding of dialogic practices in

STEAM education settings, I am aiming to build bridges that better connect people with themselves and with others resulting in improving the learning and teaching experience.

1.2.3 Recapitulation

This section 1.2 “How it all started”, carried two purposes: (1) recognize my own baggage of beliefs and experiences, and (2) declare my goals in research. It is relevant to see how my own experiences shaped my research interests in STEAM education and with communities in marginalized situations because I acknowledged the genuine driving forces for this research. Moreover, when I declared my personal, intellectual, and practical goals, I can express an initial interest to innovate in the education field using *dialogic educational practices in STEAM education for transformation.*

1.3 Scoping Review

Having established my interests and goals in the previous section, the next step was to have an initial documentary exploration of the field of interest through a scoping review. Also known as scoping studies, they are useful to examine areas that are emerging, and identifying gaps (Munn et al., 2018; Peters et al., 2015). In other words, a scoping review purpose is to identify and map the available evidence (Arksey & O’Malley, 2005).

This scoping review aimed to survey the literature relating the terms STEAM education, dialogue, and identity. The main reason here to select a scoping review, was that in contrast to other methodologies, scoping reviews allow iteration of keywords in

the search process. This iteration was appropriate given that while studies related to dialogue are well established, at least in Europe, its relationship with STEAM education and identity is a new area as well as the wording and meaning use to refer to dialogic education. Moreover, the scoping review was used also for the purpose of making recommendations for future research (Peters et al., 2015).

This scoping review is reported in this thesis using three sections. The first section, Methodological Approach, gives a detail account of the methodological approach followed in making the scoping review (Section 1.3.1). The second section, Results, reports the main findings based on the scoping review research questions (See Section 1.3.2). Finally, there is a discussion focused on the research questions leading this scoping review

1.3.1 Methodological Approach

The methodological approach of this scoping review is informed by the frameworks proposed by Arksey & O'Malley (2005), Levac et al. (2010), and Major et al. (2018). Overall, from their work, it was established that a scoping review features at least five stages: (1) identifying the research questions, (2) identifying relevant studies, (3) study selection, (4) charting the data and (5) summarizing and reporting results.

My methodological approach was underpinned by this scoping review framework. The research questions that provided the roadmap for the subsequent stages were established using two thematic research questions (Section 1.3.1.1). Then, I declared a protocol for the search process to identify relevant studies (Section 1.3.1.2).

After that, I also established a data extraction process to select the studies (Section 1.3.1.3). To chart the data, I analyzed the data and synthesized the procedure carried (Section 1.3.1.4) as well as methodological considerations (Section 1.3.1.5). Furthermore, the main findings were summarized (Section 1.3.2) including a section considering the two research questions (Section 1.3.2.4 and Section 1.3.2.5). Finally, I proceeded to discuss the findings (Section 1.3.3).

1.3.1.1 Identifying Research Questions

For the scoping review two thematic Research Questions (RQ) were established:

- RQ1: In what ways does research suggest that use of dialogue enhances STEAM education?
- RQ2: What challenges are reported that may impact the dialogic STEAM education?

1.3.1.2 Search Process

The research protocol started with identifying relevant research with two digital databases: Web of Science and Scopus. Studies were screened based on their titles and abstracts using three sets of keywords: ‘dialogue’, ‘identity’ and ‘STEM’ (see Table 1.2)

Table 1.2

Sets of Keywords

Dialogue	Identity	STEM
dialog*; dialogic; dialogue: diálogo; dialogism; dialogismo; dialogic learning; dialogic teaching	identi*; identidad; identity	STEM; Science; technology; engineering; math; mathematics; technological; computational; robotic; maker; scientific;

A scoping review method is not a linear but instead is an iterative process that requires the researcher' reflection (Arksey & O'Malley, 2005) and at least two reviewers (Peters et al., 2015). Iterations were made using a keywording process around the terms dialogue, STEM, and identity. It is relevant to note that the use of the term STEM was used instead of STEAM because the inclusion of the A is recent. Four iterations were conducted where inclusion and exclusion criteria were applied to the potential studies. The reason behind this was that not all the studies portrayed relationship with the topic researched, and a consultant was used in between the iterations to have a second opinion to guarantee expertise on the results found.

The first iteration was limited to years 2016 to 2020 and to Spanish speaking Latin American countries, as well as Brazil, Spain and Portugal, an area sometimes called Iberic-America (see Fernández-Cárdenas & Reyes-Angona, 2019 for a similar geo-localized mapping on dialogic education). Documents were excluded if they did not belong to any of this subject area: Social Science, Arts or Psychology. The second iteration inclusion was limited to years 2015 to 2020 and to Latin American countries, Brazil, Spain and Portugal, India, Russia, China, and South Africa were added. Documents were excluded if they did not belong to Social Sciences or Arts. For this second iteration, one more year was added thinking that results could increase. India, Russia, China, and South Africa were added because together with Brazil they are known as the BRICS, a term coined by O'Neill (2001) who reported them as emerging economies because of their influence on regional affairs. The third iteration inclusion was limited to years 2015 to 2020. Documents were excluded if they did not belong to

any of this subject area: Social Sciences, Arts or Psychology. For this third iteration the considerations of country criteria were removed because it was seen that article production from these countries related to topic was limited. In the last iteration inclusion was limited to years 2015 to 2020 and articles in English or Spanish. In the last iteration, the subject area was removed and in Language Spanish was added; both decisions with the objective of enlarging the spectrum of articles.

1.3.1.3 Data Extraction

Data extracted about the studies included: type of study, type of article, number of citations in Google Scholar, country, educational context, topic in thesaurus. Information related to the research questions were extracted from the abstract, findings and conclusion sections of the included studies. Extracted data was stored in a Google Sheet.

1.3.1.4 Data Analysis and Synthesis

After all the iterations, potential articles were selected following two quality control questions: (1) Does the article contain a relationship between STEM education, dialogue, and identity? and (2) Is it a situated study with field work involving participants in their own circumstances (i.e., not an experimental study)? Depending on the answers, the articles were classified in a color-coding system. If the answer was positive for both they were classified with a green color, if the answer was positive for only one, they were assigned a yellow color, and if the answer was negative for both they were assigned red.

1.3.1.5 Methodological Considerations

In the database search process, there were certain considerations that deserve to be stated in this section. The choice of keywords used was based upon the goals on three concepts: dialogue, identity, and STEM but in the case of dialogue and identity the Boolean stated dialog* and identit* so it could bring the terms in English and Spanish. The selection of the digital databases was based upon the recognition that Scopus from Elsevier's Scopus, and Web of Science from Thomson Reuters have as peer-reviewed literature databases in the scholar field due to the quality and quantity of journals and articles found in them. The language of the articles was determined in the case of Spanish due to the interest to know what has been published by Spanish speaking authors and in English due to the general convention of publishing articles even if it is not your main language so that your articles could be published.

Between the iterations, it was methodologically relevant to have conversations with two senior researchers who worked in the field of studies to discuss the results in each iteration, and have their advice on the articles found, and the criteria applied. These conversations propitiated productive ideas. From those conversations, the issue of the place where the research study took place was made prominent. The initial idea was to search only Iberic-American countries, the search had few results, the same happened when Russia, India, China, and South Africa were added (BRIC Countries). So, the decision was to remove this as an inclusion criterion and allow all countries. However, the research found a larger proportion of articles coming from the United States. Hence, the cultural differences should be contemplated for the results interpretation.

1.3.2 Results

This section delivers the results of the scoping review divided in three segments. The first presents the search process results, the second is an overview of the core data obtained from the study, and the last one is a synthesis of the results based on the research questions presented above.

1.3.2.1 Overall Search Process

There were four iterations to search in the databases that took place between October 2019 - January 2020. The number of articles for each iteration were 64, 170, 56 and 106 articles making a total of 399 articles. The first step for each iteration was to remove duplicates from Scopus and Web of Science leaving the sample with 64, 104, 51, and 74 articles. The next step for each iteration was a process of classification in which three categories were established: green, yellow and red. The articles classified in green were the ones that contained the words dialogue, STEM, and identity, and were related to the purpose of this study, the one in yellow were the ones that contained two of the terms and were related, and finally in red the ones that were not related at all. That left a total of 11, 14, 10 and 19 green articles corresponding to the four iterations. When comparing the fifty-four green articles, it was found that twenty-two articles were duplicated between the iterations' searches. Hence, the final analysis was made of thirty-two studies (see Figure 1.2). Metadata of the thirty-two studies can be found in the following online database: https://bit.ly/3991lMr

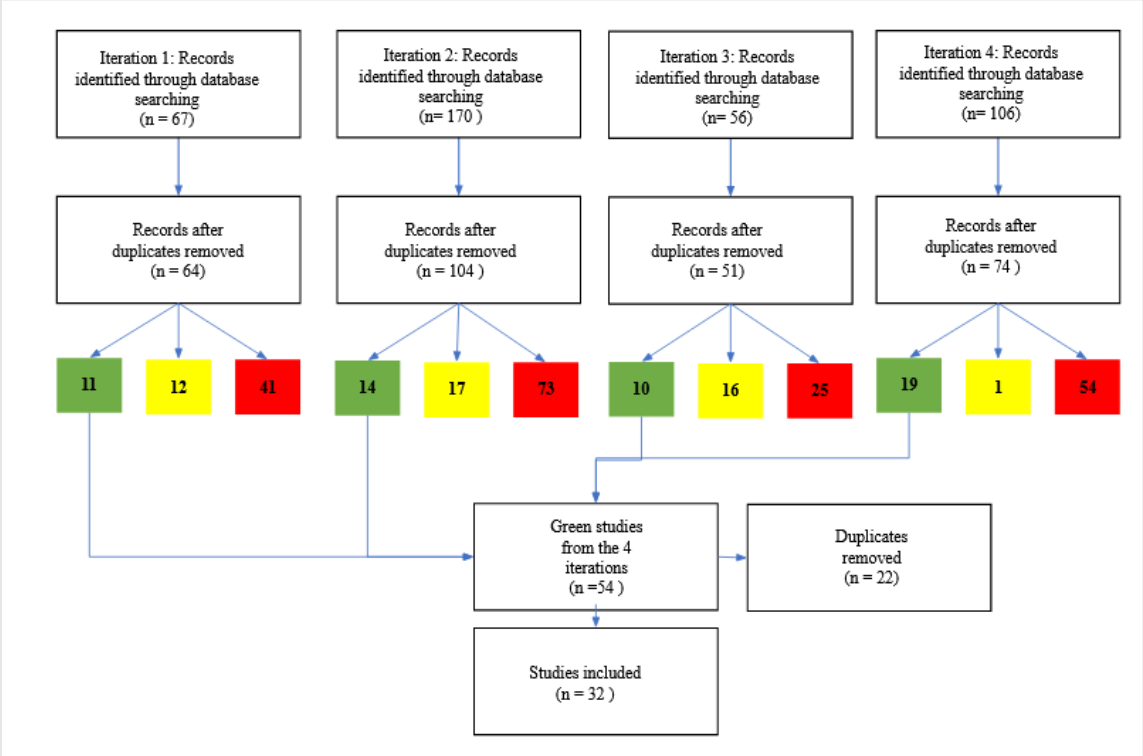


Figure 1.2 Search Process through iterations

1.3.2.2 Field Overview

This section presents a descriptive overview of characteristics of the thirty-two articles analyzed. The field overview starts with a general description of the articles, then moves to the most cited authors, geographical location of the authors, the journals with most publications in this research, the context of the studies, and main themes discussed in this line of research according to the research questions.

1.3.2.2.1 Educational Context of Participants

The thirty-two articles were classified according to the educational context where studies were developed as shown in Figure 1.3.

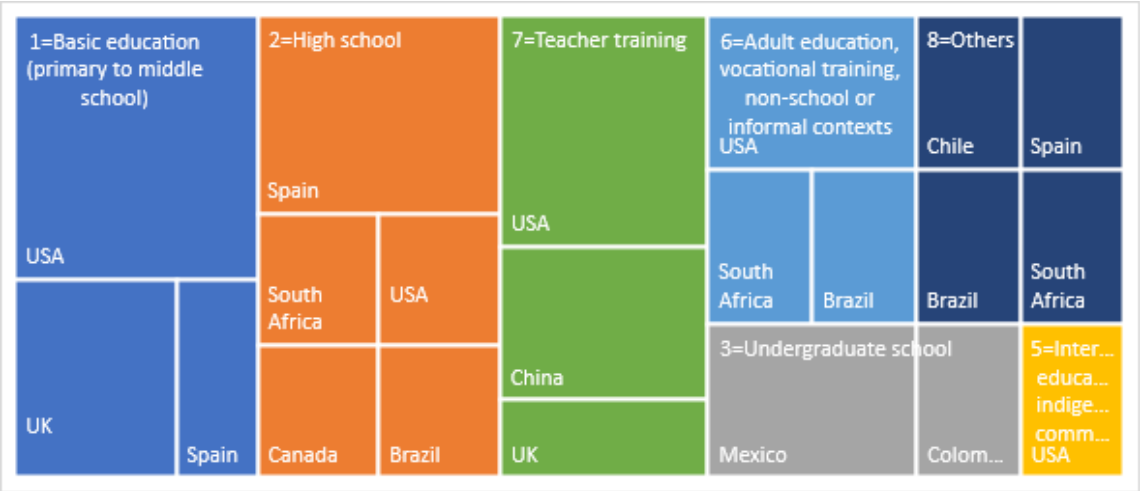


Figure 1.3 Educational context per country of the 32 Articles

For 'Basic education (primary to middle school)' there were seven articles; 'High school' had the highest frequency of studies with seven articles: half of them taking place in the United States; 'Undergraduate school' had three articles, all of them from Latin American countries. There was not a study developed in 'Graduate school.' There is one article in the context of 'Intercultural education, Indigenous communities, rural education' coming from the United States. There were four studies developed in 'Adult education, vocational training, non-school or informal contexts,' two of them came from the United States. Studies developed on 'Teacher training' had six articles: half of them from the United States. The last category 'Others,' had four articles.

Despite the fact the United States was recognized in the previous analysis as the country with the highest frequency of citations and journals, with eight out of the top 10 journals with the highest h index, highest geographical location, its educational contexts of studies were spread among the categories. This means that the studies in the United

States are taking in consideration a wide range of contexts where STEM education is happening and not limiting to formal educational contexts.

The proportion of studies for ‘Basic education’, ‘High school’, and ‘Teacher training’ was even among them, but higher, compared to other contexts, showing where the field is focusing its attention. The reasoning behind choosing basic education or high school was due to age, content, and skills, while for teacher training it was based on the impact it could have an impact on students and recognizing teacher’s humanity in their development process. They will be discussed next.

The reasons for choosing the basic education context are related to age, content, and skills. The age was related to cognition abilities (Cherniak et al., 2019; Kelley et al., 2015) and specific curriculum related to this educational level (Howe, Ilie, et al., 2015; Pierson et al., 2019). Another one was the specific issues related to the context of study such as the multilingual learners handling the language of mathematics and language of instruction (Planas, 2018), the likeliness for middle school young Latinx women to have STEM career aspirations (Nation & Durán, 2019). Finally, the consideration that this phase of schooling is the earliest one in which reform becomes possible (Chase et al., 2019) through working with relatively small cohorts of specialist teachers (Ruthven et al., 2017).

On the other hand, among the reasons for selecting the context of high school were testing specific abilities such as transferring knowledge and evaluating and designing scientific inquiries (Ferrés-Gurt, 2017a). The specific curriculum for this age

was also a reason (Lopez & Perez-Poch, 2018) as well as issues related to age such as the creative engagement that brings their voice expression (Rahm, 2016), and the vulnerability of adolescent institutionalization in academic failure (Gairal-Casadó et al., 2019). Finally, contextual factors such as females being minority choosing science electives (E. Oliveira et al., 2019) and the focusing of gifted students (Mhlolo, 2017) were also reasons to make research in the context of high school.

Making research in teacher training had two main purposes. Researchers chose teacher trainings because they acknowledged the importance of teachers in making reforms in the curriculum of students (Shadle et al., 2017), in helping students to develop into thoughtful and critical readers (McElhone, 2015), in offering experiences that create learning environments that challenge students to apply STEM knowledge to solve real life problems (Terrazas-Marín, 2018), and in networking with STEM professionals to demonstrate the benefits of scientific education (Aslam et al., 2018). The researchers also chose to study teacher training to explore how 'teacher knowledge communities' outside the teacher's school influence the teacher identities (Li & Craig, 2019), and other relevant connections between materials, design, society, as well as the natural environment, in order to critically engage with implicit and explicit aspects of disciplinary identity (Sochacka et al., 2016), and the potential factors influencing teachers' self-efficacy and engagement in STEM teaching (Dong et al., 2019) recognizing in this way the humanity of the teacher who is guiding the classrooms environments.

1.3.2.2.2 Research Design of the Examined Studies

According to the type of knowledge pursued by studies, it was found that there are twenty-seven articles that present empirical and five studies that are theoretical. As reported in Figure 1.4 the studies were mostly qualitative (27). In a lesser proportion quantitative (4) and mixed methods (1). A greater proportion of the qualitative studies took place in High schools and primary and middle schools; more quantitative studies took place in teacher development contexts.

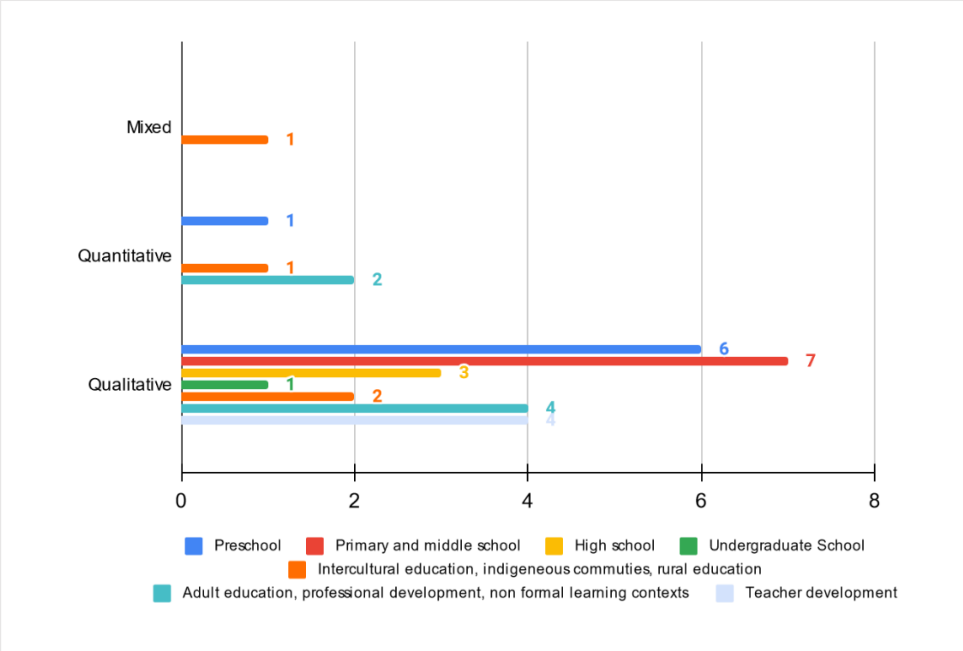


Figure 1.4 Research Design of examined studies

As seen in Figure 1.5, when analyzing deeper each type of study, it was found that qualitative studies mostly used case studies and general qualitative methodology approaches while quantitative approaches were experimental studies.

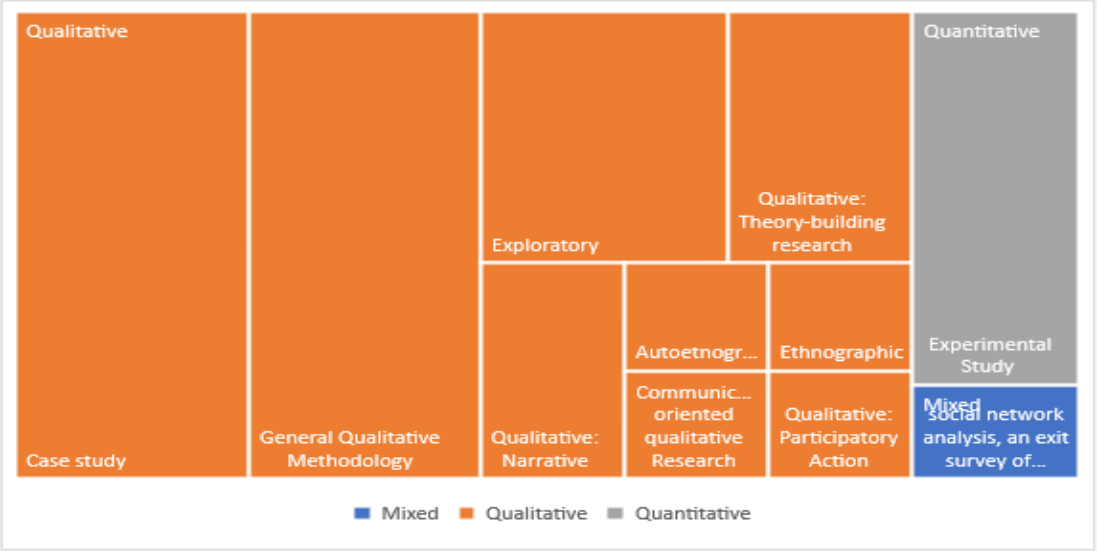


Figure 1.5 Type of Qualitative Approach

1.3.2.2.3 Implementation of STEM Education in Studies

Relevant to this study is the key term of STEM education so this section presents results on how STEM education was implemented throughout the studies. There are four options considered: (1) that only one area of STEM is used in the study, (2) that there is a combination of two STEM areas, for example Science and Technology, (3) that three areas are combined, for example Science, Technology and Mathematics, or (4) that all the four areas were used during the study.

It was found that even though the selection criteria made sure that the thirty-two articles selected contained the key term STEM, only nine studies integrated the four areas in STEM as seen in Figure 1.3. Sixteen studies used only one STEM area during their research while seven studies integrated two STE(A)M areas. Among the articles none pursued the integration of at least three STEM areas, but we have a jump in the integration from the use of two to the 4 STEM areas in the studies.

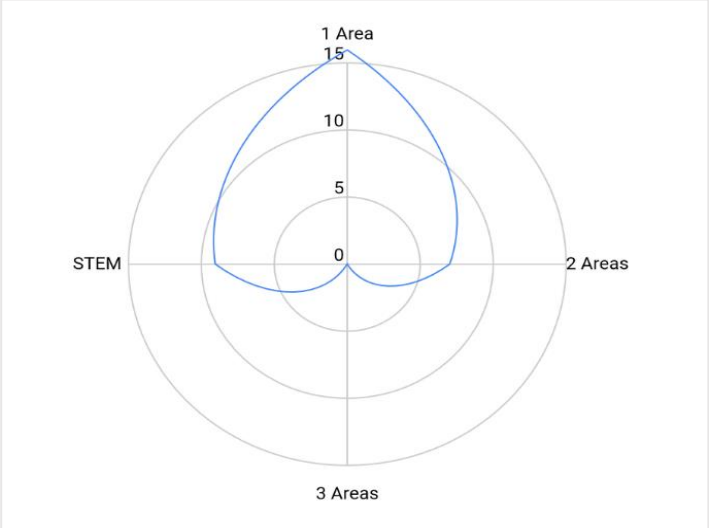


Figure 1.6 STEM Areas Involved in the studies

1.3.2.3 Metadata of Studies

This section supplies results over the metadata of the studies which will be relevant for further discussion about the details of the published works. The results presented here aim to show the top ten most cited articles among the thirty-two studies selected (Section 1.3.2.3.1), the geographical distribution of the authors (Section 1.3.2.3.2), and the journal rankings in which the studies were published (Section 1.3.2.3.3). This gives us a view of the context in which the articles are being issued and what voices are prevailing in the field of interest of this research.

1.3.2.3.1 Top ten most cited articles

Table 1.3 summarizes information of the top ten most cited articles.

Table 1.3

Top ten most cited articles

Citations	Author	T or E*	Country
49	Sochacka, N. W., Guyotte, Kelly. W., & Walther, J. (2016). Learning Together: A Collaborative Autoethnographic Exploration of STEAM (STEM + the Arts) Education: A Collaborative Autoethnographic Study of STEAM Education. Journal of Engineering Education, 105(1), 15–42. https://doi.org/10.1002/jee.20112	E	USA
31	Kelley, T. R., Capobianco, B. M., & Kaluf, K. J. (2015). Concurrent think-aloud protocols to assess elementary design students. INTERNATIONAL JOURNAL OF TECHNOLOGY AND DESIGN EDUCATION, 25(4), 521–540. https://doi.org/10.1007/s10798-014-9291-y	E	USA
30	Shadle, S. E., Marker, A., & Earl, B. (2017). Faculty drivers and barriers: Laying the groundwork for undergraduate STEM education reform in academic departments. International Journal of STEM Education, 4(1), 8. https://doi.org/10.1186/s40594-017-0062-7	E	USA
28	Ruthven, K., Mercer, N., Taber, K. S., Guardia, P., Hofmann, R., Ilie, S., Luthman, S., & Riga, F. (2017). A research-informed dialogic-teaching approach to early secondary school mathematics and science: The pedagogical design and field trial of the epiSTEMe intervention. RESEARCH PAPERS IN EDUCATION, 32(1), 18–40. https://doi.org/10.1080/02671522.2015.1129642	E	UK
26	Gutiérrez-García, E., Recalde, M., & Piñera-Camacho, A. (2015). Reinventing the wheel? A comparative overview of the concept of dialogue. Public Relations Review, 41(5), 744–753. Scopus. https://doi.org/10.1016/j.pubrev.2015.06.006	T	Spain
24	Planas, N. (2018). Language as resource: A key notion for understanding the complexity of mathematics learning. Educational Studies in Mathematics, 98(3), 215–229. https://doi.org/10.1007/s10649-018-9810-y	E	Spain
12	Mhlolo, M. K. (2017). Regular classroom teachers' recognition and support of the creative potential of mildly gifted mathematics learners. ZDM - Mathematics Education, 49(1), 81–94. Scopus. https://doi.org/10.1007/s11858-016-0824-6	E	South Africa
12	Aslam, F., Adefila, A., & Bagiya, Y. (2018). STEM outreach activities: An approach to teachers' professional development. Journal of Education for Teaching, 44(1), 58–70. https://doi.org/10.1080/02607476.2018.1422618	E	UK
11	Howe, C., Luthman, S., Ruthven, K., Mercer, N., Hofmann, R., Ilie, S., & Guardia, P. (2015). Rational number and proportional reasoning in early secondary school: Towards principled improvement in mathematics. RESEARCH IN MATHEMATICS EDUCATION, 17(1), 38–56. https://doi.org/10.1080/14794802.2015.1019914	E	UK
8	Archila, P. A. (2017). Using Drama to Promote Argumentation in Science Education: The Case of "Should've." Science & Education, 26(3–4), 345–375. https://doi.org/10.1007/s11191-017-9901-7	E	Colombia
8	Page-Reeves, J., Marin, A., Moffett, M., DeerInWater, K., & Medin, D. (2019). Wayfinding as a concept for understanding success among Native Americans in STEM: "Learning how to map through life." Cultural Studies of Science Education, 14(1), 177–197. https://doi.org/10.1007/s11422-017-9849-6	E	USA
5	McElhone, D. (2015). Using stems and supported inquiry to help an elementary teacher move toward dialogic reading instruction. Journal of Classroom Interaction, 50(2), 156–171.	E	USA

*T or E: T stands for Theoretical and E for Empirical

Note that since the seventh and nineth place have articles that are tied in the number of citations, two extra articles were included. The most cited article is from

Sochacka et al. (2016) with forty-nine citations. For the articles in seventh place the number of citations drops drastically to twelve. It was found that 41,67% of the articles were coming from the United States, 25% from the United Kingdom, 16,67% from Spain, 8,33% from South Africa, and 8,33% from Colombia. This proportion reflects precisely on the same issue when the first iteration of countries was conducted, and it was seen that production of articles from the United States and United Kingdom had a higher percentage compared to the rest of the countries. Some factors to consider are that most journals are published in English, the main language of these countries and that these countries were pioneers in STEM education.

From these articles, which are the most cited, seven of them have been published in a journal whose title has either STEM on their name or one of the STEM areas. From the top 10 most cited articles, comparing their citations and year of publication, it is clear that most of them are older compared to the article by Page-Reeves et al. (2019) which is more recent. Thus, the longer availability might influence the number of citations received.

1.3.2.3.2 Geographical distribution of the authors

The next characteristic deals with the location of the authors. Figure 1.4 shows the geographical distribution of the authors of the thirty-two articles which is attributed to ten countries. The two most represented countries are the United States with 37,5%, and Spain with 15.6% of the articles. The United Kingdom and South Africa are in third place with 9,4%. Brazil, China, and Mexico are in fourth place with 6,3%. Finally, Colombia and Canada with 3,1%.

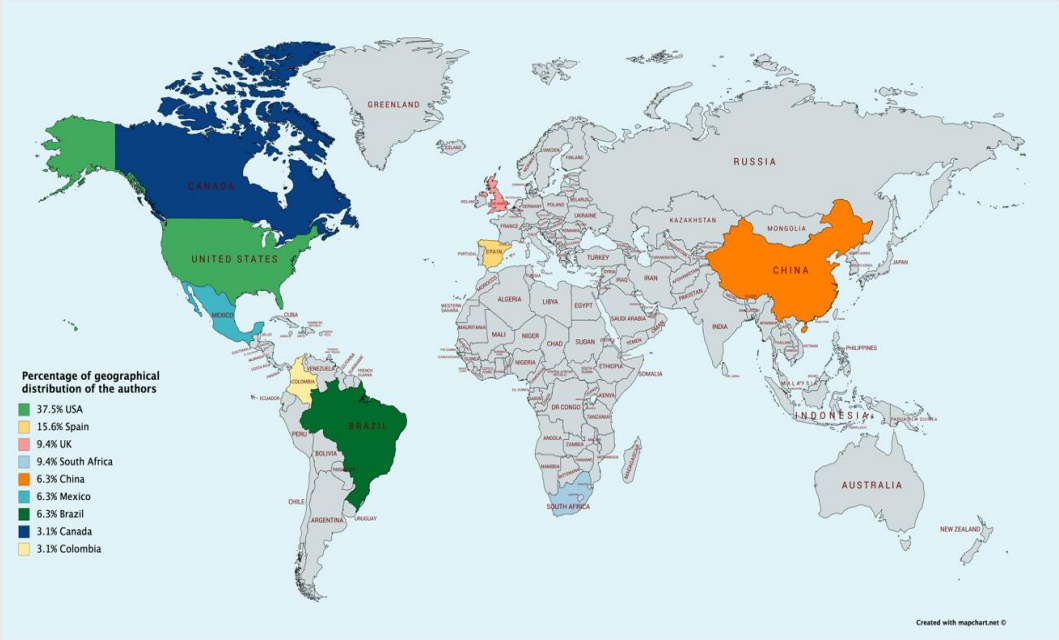


Figure 1.7 Geographical distribution of the authors

This disparity found in geographic distribution is not surprising if we tie it to certain factors in the education systems of those countries, such as the profile of scholars as well as their current level of economic development. Scholars drafting academic papers are usually postgraduate degree holders, this means those owning a master's or a Doctorate degree. The last available data from the World Bank (2018) shows that the educational attainment for master's degrees indicator for the United States was 13.05%, Spain 12.92%, United Kingdom 11.99%, Canada 7.10%, Colombia 3.57%, South Africa 1.79%, Mexico 1.57%, Chile 1.51%, Brazil 0.95%, and as for China it did not have records. A similar pattern is repeated in educational attainment for Doctoral degrees indicator. The rate for PhD holders in the United States was 2.03%, United Kingdom 1.00%, Canada 0.94%, Spain's 0.66%, Brazil's 0.25%, and Mexico's 0.08%, while for Chile, Colombia, China, South Africa did not present data.

The countries where most authors are coming from are also the countries with a higher gross domestic product (GDP) per capita as shown in Table 1.4.

Table 1.4

Key information of authors

Country	GDP per capita	Internet users	Education expenditure	Urbanization
United States	$59,800	76.20%	5%	82.70%
Canada	$48,400	89.80%	5.30%	81.60%
United Kingdom	$44,300	94.80%	5.50%	83.90%
Spain	$38,400	80.60%	º	80.80%
Chile	$24,600	66%	5.40%	87.70%
Mexico	$19,900	59.50%	4.90%	80.70%
China	$16,700	53.20%	NA	61.40%
Brazil	$15,600	59.70%	6.20%	87.10%
South Africa	$13,600	54%	6.20%	67.40%
Colombia	$14,400	58.10%	4.50%	81.40%

This means that are countries that have a higher economic reliance in tertiary and quaternary sectors, services, and knowledge sectors, rather than primary and secondary, agricultural, and manufacturing. Traditionally, this has had influence between the so-called developed and developing countries when measuring development. It also seems in accordance with the countries' priorities on research and their socio-economic background. In the same Table 1.4 we can see that the predominance of authors of articles coming from countries whose internet users and urbanization are high. The education expenditure presents an interesting data perspective because even though Brazil and South Africa have higher education expenditure as a percentage of their GDP, they are not the countries who has the most authors. However, this could be explained

given the fact that they are emerging economies. These two countries were part of the BRICS block.

The countries where the authors are coming from also show a relationship between geographical distribution with the h index. As seen in Table 1.5 the United States, the country where most of the articles are coming from, is also the top country for overall country h index and h index in the Social Science Education area. It is relevant to note that according to this SCImago (2020) ranking, there is a high relation between the h index of the overall country and the Social Science Education area. This means that the country with the highest overall country h index is also the country with highest production for social science education. It shows a prevalence of the works published and their citation. This means that there is not only strength on the number of articles published, but also on the articles that have been cited. In the Table the only atypical case that does not behave in the same way in the overall social science education country ranking is South Africa, which is higher than the one of Brazil, who had a higher overall country ranking than South Africa.

One more variable to consider in the analysis of geographical distribution of the authors is their language. Four out of the ten countries have English as their official language and added together 3892 social science journals. Four countries whose official language is Spanish control 338 social science journals. In Mandarin there are twenty-four social science journals, and in Portuguese 90 journals. This is another indicator of the disparity among the publications of this type.

Table 1.5

h Index per country and for Science Education

Country	Number of Journals from the study	Overall Country Ranking	Overall Social Science Education Country Ranking	Overall number of social science Journals from this country	Official language
United States	12	2222	398	1962	English
United Kingdom	3	1373	219	1836	English
Canada	1	1102	197	73	English
Spain	5	830	104	228	Spanish
China	2	794	84	24	Mandarin
Brazil	2	530	54	90	Portuguese
South Africa	3	423	76	21	Afrikaans, English
Mexico	2	411	42	37	Spanish
Chile	1	349	39	39	Spanish
Colombia	1	261	26	34	Spanish

*Data from SCImago

1.3.2.3.3 Journals Rankings

Table 1.6 shows the journals rankings. The impact profile of scientific journals was figured out using SCImago Journal Rank. There were twenty-seven journals for thirty-one articles and one book (Intersections of formal and Informal science - Routledge) for a book chapter. For two journals (Innovación Educativa - Mexico and International Journal of STEM Education) it was not possible to find their quartile and H index using the SCImago Journal Rank. The journals came from seven countries: Brazil, Germany, Italy, Mexico, Netherlands, Philippines, Spain, United Kingdom, and United States. Most journals came from the United States, with twelve, and the United Kingdom with eight. According to quartiles: fifteen journals belong to quartile one, eight to quartile 2, one to quartile 3, and one to article 4. The h index shows the journal's

number of articles (h) that have received at least h citations (SCImago Journal Rank, 2020), are in a range of 5 to 93. From the top ten journals according to h index, five belong to the United States, four to the United Kingdom and one to the Netherlands.

Table 1.6

Journal Rankings

h index	Journal	Country	Quartile	Subject area	Publisher
93	Journal of Engineering Education	United States	1	Engineering, Social Sciences	Wiley-Blackwell
77	Children and Youth Services Review	United Kingdom	1	Psychology, Social Sciences	Elsevier
69	Research in Mathematics Education	United States	1	Mathematics, Social Sciences	Routledge
67	Public Relations Review	United States	1	Business, Management and accounting, Social Sciences	JAI Press
54	Educational Studies in Mathematics	Netherlands	1	Mathematics, Social Sciences	Kluwer Academic Publishers
53	Culture, Health, and Sexuality	United Kingdom	1	Medicine, Social Sciences	Taylor & Francis
48	Journal of science education and technology	United States	1	Engineering, Social Sciences	Kluwer Academic/Plenum Publishers
48	Science Communication	United States	1	Social Sciences	SAGE Publications
44	Teachers and Teaching: Theory and Practice	United Kingdom	1	Art & Humanities, Social Sciences	Carfax Publishing
44	Mind, Culture, and Activity	United Kingdom	2	Art & Humanities, Social Sciences, Psychology, Neuroscience	Taylor & Francis
38	Science and Education	United States	1	Social Sciences	Kluwer Academic/Plenum Publishers
37	Research Papers in Education	United Kingdom	2	Social Sciences	Taylor & Francis
33	ZDM - Mathematics Education	Germany	1	Social Sciences	Springer Verlag
31	International Journal of Technology and Design Education	Netherlands	2	Engineering, Social Sciences	Kluwer Academic/Plenum Publishers
30	Journal of Education for Teaching	United Kingdom	1	Social Sciences	Carfax Publishing
24	Journal of Early	United	2	Psychology, Social	Sage Periodicals Press

	Childhood Research	States		Sciences	
23	Cultural Studies of Science Education	Germany	1	Social Sciences	Springer Verlag
20	Asia-Pacific Education Researcher	Philippines	2	Social Sciences	Springer Singapore
19	Equality Diversity and Inclusion	United Kingdom	1	Business, Management and accounting, Social Sciences	Emerald Group Publishing Ltd.
17	Engineering Studies	United Kingdom	2	Art & Humanities, Social Sciences, Engineering	Taylor & Francis
13	Journal of Science Communication	Italy	1	Social Sciences	Scuola Internazionale Superiore di Studi Avanzati (SISSA)
13	Cadernos de Pesquisa	Brazil	3	Social Sciences	Fundacao Carlos Chagas
10	Revista Complutense de Educación	Spain	2	Social Sciences	Universidad Complutense de Madrid
7	Revista Eureka	Spain	2	Social Sciences	Asociación de Profesores Amigos de la Ciencia
5	Journal of Classroom Interaction	United States	4	Psychology, Social Sciences	University of Houston
N/A	International Journal of STEM Education	United States	/A	Engineering, Social Sciences	Springer Open
N/A	Intersections of formal and Informal science - Routledge	United States	N/A	Social Sciences	Routledge
N/A	Innovación Educativa - México	México	N/A	Social Sciences	SEP- Instituto Politécnico Nacional

The results from the journal rankings follow the previous results found in the geographical distribution of the authors where there is a prevalence of the United States and United Kingdom. The main publishers holding journals for these articles were Taylor & Francis and Kluwer Academic Publishers both with four journals. Taylor & Francis is originally from the United Kingdom while Kluwer Academic Publishers was from Germany but recently merged with Springer Verlag from the United States, which would add two more journals to its count.

This data from the journal not only does support the prevalence from these two geographical regions, but it shows the language prevalence in which articles are published. From the thirty-two articles, thirty were published in English compared to two in Spanish. This is also reflecting on the h index. The only three journals from Spanish speaking countries have a lower h index meaning they are not being as cited as the others. It could be thought that language can also be a barrier that limits to a certain extent publication of articles from the Latin American region. From the 9 Spanish speaking countries, only two articles were published in the original language.

Another relevant data to see from Table 1.6 is the fact this STEM related topics are being published in journals that belong to Social Sciences. None of them is published in purely STEM journals. This gives us an idea on the type of audience that are reading the articles. The titles of the journals are also revealing this. All the engineering words appear either with the word education or studies, and there are fifteen journals that do not have any STEM subject on its title.

The next section supplies information about the contexts where the studies were developed so it will be important to note if the countries have a particular interest among a specific context.

1.3.2.4 RQ1: In what ways does research suggest that use of dialogue enhances STEM education?

In this section, I present the results of the thematic synthesis done to address RQ1: In what ways does research suggest that use of dialogue enhances STEM

education? I set up two high-level themes to portray ways in which research suggests how the use of dialogue by students or teachers enhances STEM education. The subthemes fit within the theme through association of the examined studies. All themes and sub-themes for RQ1 can be seen in Table 1.7.

Table 1.7

Thematic synthesis for RQ1

Themes	Sub-themes	Studies
Students	Supports new production of meanings	8
	Projection of identity	7
	Finding solutions	7
	Improving higher level abilities (critical thinking, argumentation)	4
	Disciplinary engagement	4
Teacher	Acknowledge others	6
	Build knowledge	6
	Reinforce teacher role	5
	Build better classroom activities	4
	Identity formation	4
	Improving inquiry	4
	Conversational peers	4
	Positive opinions of teachers	3
	Gender recognition	2
	Enhance non-formal competences	2

1.3.2.4.1 Students

The first theme analyzed is from the point of view of the students. This category brings together eight diverse ways in which dialogue enhanced their STEM education. Four studies identified how classroom activities set how dialogue was used to improve higher level abilities such as critical thinking and argumentation (Archila, 2017; Castellanos Ramirez & Alheli Nino, 2018; Chase et al., 2019; E. Oliveira et al., 2019) and improving inquiry (Ferrés-Gurt, 2017; Howe et al., 2015; López et al., 2018; Pierson

et al., 2019). The development of abilities caused by dialogue in STEM education included taking steps mediated by different dialogue stages (Archila, 2017) to have a scaffolding that allowed to rich the higher-level abilities such as dialogue, interpret, build, agree, propose, exchange, discuss, reach consensus, approve, review (Castellanos Ramirez & Alheli Nino, 2018). This is also causing that students have a positive opinion of teachers (Chase et al., 2019; Ferrés-Gurt, 2017b; Howe, Luthman, et al., 2015).

The activity of conversational peers (Cherniak et al., 2019; Pierson et al., 2019; Villalta Páucar et al., 2015) allowed them to develop disciplinary engagement (Castellanos Ramirez & Alheli Nino, 2018; Gairal-Casadó et al., 2019; Howe, Luthman, et al., 2015; Pierson et al., 2019). Moreover, seven studies reported that it also allowed them to find solutions (Chase et al., 2019; Cherniak et al., 2019; Howe, Luthman, et al., 2015; Kelley et al., 2015; Mhlolo, 2017; Terrazas-Marín, 2018; Villalta Páucar et al., 2015), and eight studies reported that dialogue supported the creation of meanings in STEM education (Chase et al., 2019; Ferrés-Gurt, 2017a; Mhlolo, 2017; Page-Reeves et al., 2019; Planas, 2018; Terrazas-Marín, 2018; Villalta Páucar et al., 2015). These findings are consistent with social constructivist theories.

Two sub themes reported that a sign that dialogue enhances STEM education is that students/participants can project their identity (Cherniak et al., 2019; Gairal-Casadó et al., 2019; Mhlolo, 2017; Nation & Durán, 2019; A. W. Oliveira, 2010; Page-Reeves et al., 2019; Pierson et al., 2019) and there is also gender recognition (Hardcastle et al., 2019; E. Oliveira et al., 2019). From the study of Page-Reeves et al. (2019) with Native science professionals it emerged that their STEM education intertwined both of their

realms (being Native and being a science professional) serving as a cultural tool to mediate social relations, create new possibilities, identity formation, connecting personal and professional real (serving a bridge for cultural identity and education). Stadler et al. (2018) found that the same happened when science and local knowledge were brought together for lyric writing about the experience as former trial participants for anti-HIV pharmaceutical agents. Open dialogue and conversation gave agency to the patients and shortened the barriers on conceptions about a public deficit of scientific literacy

1.3.2.4.2 Teachers

The second theme analyzes, from the point of view of the teachers, the ways in which dialogue enhanced STEM education. In this theme, five studies reported that dialogue reinforce the teachers' role (Chase et al., 2019; Dong et al., 2019; McElhone, 2015; Shadle et al., 2017; Sochacka et al., 2016) by creating better classroom activities (Aslam et al., 2018; Li & Craig, 2019; Shadle et al., 2017; Sochacka et al., 2016) and building knowledge (Aslam et al., 2018; Gutierrez & Vossoughi, 2010; Li & Craig, 2019; Shadle et al., 2017; Sochacka et al., 2016; York, 2018). Through a dialogic approach to STEM education, adopters were shown empathy towards the change in teaching and learning practices reinforcing their relevance in the implementation of a STEM curriculum (Sochacka et al., 2016a).

Four studies reported how identity formation (Aslam et al., 2018; Dong et al., 2019; McElhone, 2015; Shadle et al., 2017) was a result of dialogic STEM education. And this could be attributed to the fact that dialogism acknowledge others (Aslam et al., 2018; Gutiérrez-García et al., 2015; Shadle et al., 2017; Sochacka et al., 2016; York,

2018). For example, York (2018) collaboration with co-workers calling them for reflection opened the floor for participation to reimagine STEM spaces. Teachers looking for STEM outreach programs which consist of looking for STEM professionals, mentoring schemes, consultations, competitions, STEM placements, etc. (Aslam et al., 2018) can create a network for teachers' own development. Using social networks like WeChat to build a community and have their experiences heard on their own terms (Li & Craig, 2019) could become their own democratizing exercise and replicated in classes.

There were two studies that reported how dialogue was able to enhance non-formal competences from STEM education (Shadle et al., 2017; Sochacka et al., 2016). The exercise of challenging teachers to non-formal education strengthened critical reflection and dialogism of teachers while designing real life problems activities for students (Terrazas-Marín, 2018).

1.3.2.5 RQ2: What challenges are reported that may impact the dialogic STEM education?

In this section, I present the results of the thematic synthesis done to address RQ2. I set up two high-level themes relating challenges reported first by students and second by teachers. The subthemes fit within the theme through association of the examined studies. See Table 1.8 for all themes and sub-themes for RQ2.

Table 1.8

Thematic synthesis for RQ2

Themes	Sub-themes	Studies
Students	Real Tools knowledge limitations	3
	Assumptions of tools knowledge limitations	2
	Racial prejudice over the person	2
	Gender prejudice	2
Teacher	Pedagogical assumptions	4
	School Administration Barriers	4
	Lack of network support	4

1.3.2.5.1 Students

The first theme analyzed is from the point of view of the students. Among the studies, the challenges that students/participants reported were grouped in four categories. The first category of challenges was related to having a real tool knowledge limitation: lack of acknowledgement of possibilities of other possibilities due to cultural factors (Campos & Araújo, 2017), underserved populations (Nation & Durán, 2019), lack of models of dialogue to encourage deeper discussions (Castellanos Ramirez & Alheli Nino, 2018) and gap between political rhetoric and science communication practice that could threaten the credibility of science (Weingart & Joubert, 2019). The second category was that students/participants were treated under the assumption that they had knowledge limitation of the tools in the STEM space. That means that the relying on knowledge was solely given to the scientists/teachers (Stadler et al., 2018), so there is a tendency to demean local knowledge.

The last two categories of challenges from the point of view of the students/participants are related to the prejudices. Racial and gender prejudices are the third and fourth categories of challenges which are limiting the conversation and STEM identity. Page-Reeves et al. (2019) report that the Native science professionals are

redefining their participation in science by making their way, but a huge challenge is that metaphorical descriptions of the two worlds (Native and Non-Native culture) is disavowed. Meanwhile, Rosa (2018) exposes how prejudices based on race and gender limit the opportunities of STEM education because they are being reproduced in STEM spaces.

1.3.2.5.2 Teachers

The second groups of challenges are analyzed from the point of view of the teachers that impact the dialogic STEM education. The challenges faced by teachers were grouped in one of these three categories: pedagogical assumptions, school administration barriers, and lack of network support. Pedagogical assumptions are related to issues involving faculty switching to STEM education and making assumptions around how teaching and learning works (Li & Craig, 2019; Shadle et al., 2017; Sochacka et al., 2016; York, 2018) which can be detrimental for the implementation. For example, science teachers needed to be aware of the dialogic approach and combine it with significant activities that demand participation of students (Terrazas-Marín, 2018), instead of the conceptual work.

School Administration barriers, as a challenge found by STEM education teachers, refer to the lack of alignment of interests, goals, and implementation of methods to teach, which could hinder their performance. A teacher might not feel comfortable with testing systems (Li & Craig, 2019) because they do not reflect all the work they do, and it might seem like lack of administration support (Dong et al., 2019).

The third challenge from the point of view of the teachers is a lack of supporting network. For Aslam et al. (2018) teachers are managing multiple professional identities such as being a STEM teacher and going out to outreach programs for their students which brings more complexity to their work thus discouraging their performance. Shadle et al. (2017) named some barriers that could hinder their performance such as loss of autonomy and conflict with institutional rewards and priorities.

1.3.3 Discussion

The data obtained through the scoping review supply relevant insights about the current knowledge in dialogic educational practices in STEM related to the methodology and the metadata of studies, and the improvements and challenges of dialogue in STEM education. Therefore, this section aims to discuss the main findings in the field of Dialogic STEM education from the data selected.

Starting with the search process, a key issue to discuss is about the **term dialogic education,** which involves a semantic aspect. It was found that depending on who the subject of study is the term assigned could be dialogic learning or dialogic teaching**.** In the case of dialogic learning, the emphasis is set on the student while in dialogic teaching is set on the teacher. This finding made relevant the use of a scoping review so that a keyword iteration process could make possible to include studies that might otherwise be left out of the field study. Moreover, this differentiation in understanding dialogic education influenced the use of a thematic analysis of the research questions dealing with the dialogic improvements and challenges in STEM education. It is of

interest to redefine dialogic education, so that it can contemplate the learning and teaching processes.

The field overview supplied data about the participants, **contexts, research design methods and the use of STEM education in the studies.** The data reveals a focus on basic education, high school and teacher training leaving out other educational contexts and levels. This seems following some efforts commonly made by governmental organizations to disseminate STEM education through public education policies, programs, partnerships, and funds to these audiences to incentivize the interest in STEM careers. However, Dierking & Falk (2016) assert that STEM learning is not confined to classrooms but rather taking place in informal settings. They suggest that there is a growing awareness in the field that frameworks in STEM research need to contemplate these new contexts in which STEM education is taking place. They highlight the fact that in STEM education the learning and teaching roles can be swapped, and that STEM education has transcended classrooms. Their affirmations are supported by the Do-it-yourself movement, makerspaces and fabrication laboratories networks which have supported themselves in open-source resources to empower citizens to experience STEM education. This contradiction is a niche in the academic research that portrays the lack of academic production related to informal settings of education where STEM education is occurring.

The type of research design implemented in those contexts are qualitative, which involves an interest for understanding how experiences are occurring. There is an emphasis in the understanding of the scenarios through words and meanings that

qualitative approach can supply successfully. More specifically, the two types of **qualitative approach that are mostly used are general qualitative method and case studies**. The reason for the use of a general qualitative method is that it brings a variety of qualitative instruments without compromising to one specific approach. On the other hand, the main reason for using case studies is to present issues or specific situations (Creswell & Poth, 2018). In STEM education, the use of case studies allows the authors to have in place parameters under the specific socio-cultural context in which the studies are taking place.

Concerning STEM education, data points out a disagreement in what counts as STEM. Not even half of the studies integrated the four areas of knowledge in STEM but one or two. To add to this conversation, it seems also interesting to point that none of the studies integrated three areas of knowledge. The question remains, what is understood by STEM education? Is it only science or there should be an integration of all the areas of knowledge? What type of education has been implied with the STEM acronyms?

The academic conversation in dialogic educational practices in STEM communities is being done in other contexts that are not precisely in Latin America. In a conversation with experts for the iterations process, the dialogic field seems to be developing in areas such as the United Kingdom represented by Sinclair & Coulthard (1975, 1992), (Barnes & Todd (1977), Neil Mercer & Rupert Wegerif (Mercer et al., 2009, 2019; Mercer & Howe, 2012; Wegerif et al., 1999). In the USA, the topic is linked with classroom talks by Courtney Cazden. In Spain, the work of Ramón Flecha is

associated with dialogic spaces. In Latin America, dialogic education has its origins with Paulo Freire, and it even linked to popular education. In more recent years, the field has been amplified with the works of Sylvia Rojas-Drummond, Juan Manuel Fernández-Cárdenas, and Antonia Candela. The view of the expert was confirmed with data obtained in the scoping review. The data showed a dominance of the United States regarding top authors cited, language used in the studies, h index, and being a country that performs well in economic indicators. Unfortunately, the other side of the coin is few productions of studies involving STEM dialogic educational practices in the Latin American context which represent a limited understanding of the region.

The students and the teachers presented differences in the impact (enhancement and challenges) they experience with dialogue in STEM education depending on their role in the dialogic educational process. Comparing the ways in which dialogue enhances and challenges STEM education for students and teachers, considerable research has focused on finding out that impact for students but little research on teachers. The studies have failed to account deeply for the role of the teacher in designing and implementing dialogic activities and the impact this causes in STEM education from their perspective. Hence, additional studies that give voice to teachers are needed to understand dialogic education as whole rather than dialogic learning or dialogic teaching as discussed above.

As seen with the earlier paragraphs, the scoping review provided with valuable information to understand the field of dialogic educational practices in STEM settings

and to identify gaps. The next section, research problem statement, will supply a positioning for the overall research.

1.4 Research Problem Statement

1.4.1 Problem Background

STEAM education without a critical perspective becomes contradictory for communities in marginalized situation. If we scale it, we could also analyze comparisons in terms of country to country and region to region where the scientific and technology development race has created wider gaps leading to inequalities. So, it seems like some regions, countries and people are controlling more resources with that. For that reason, it becomes interesting to adopt a critical perspective in STEAM education. This allows us to question the knowledge that students are getting and to motivate students to generate the opposite of oppressive responses. As a result, it is expected that students could empower themselves to challenge current practices and beliefs. In that sense, this thesis sees in dialogic educational practices a way to assume a critical perspective in STEAM education that could transform the story of those participants in marginalized situations.

Even though, the scoping review informed that the academia has produced some works in dialogic educational practices in STEAM contexts these studies seem dominated by the United States, Spain, and the United Kingdom. In those countries, the focus of dialogic educational practices has been set in terms of classroom talk and discourse analysis. This situation leaves a niche for research in the global south where

there is still a lack of studies in dialogic educational practices in STEM settings with a critical perspective. In that sense, I want to occupy the niche through this dissertation looking into dialogic educational practices in STEM settings found in marginalized contexts in Mexico. Moreover, I am interested in non-formal STEM contexts because the current public system reinforces a globalizing type of knowledge. As a result, the local knowledge relevance is diluted.

The interest of this research is to study the Latin American region through the case of Mexico. The region holds a long history oppression and perpetuated political, social, economic, and cultural imbalances (UNESCO, 2009). The result is that the region portrays cultural differences, heterogenous views of life and a series of crisis (economic, financial, democratic, demographic, migratory, labor, environmental). Mexico is not an exception to this phenomenon, especially because of national and international migrations. This mobility transforms societies and cultures, creating diasporas and developing transnational identities (UNESCO, 2009). Hence, the region does not just need STEAM education, but a critical perspective applied through dialogic educational practices.

Dialogic educational practices for Latin America represent a new paradigm in STEAM education that challenges traditional practices. A critical perspective challenges the view of education, that authors like Foucault (2004) and Weber (2009) have identified, in which education serves the State and its purpose of organizing society through the transmission of culture and knowledge and maintaining legitimacy of its power. Rather, in a critical perspective, education challenges any form of oppression of

dominant culture values. It focuses on different forms of power in the school, and the social construction of knowledge based on dialogue and reflection (Freire, 2005; Rousseau, 2010).

Having a critical perspective in STEM education is necessary to keep relevant the promises of STEM education to provide all students with critical thinking skills and making them creative problem solvers resulting in a better prepared workforce and citizens (Bybee, 2013; White, 2014). The critical perspective supports these promises through dialogic educational practices because they make each individual count in the learning process and propel liberating responses that modify individual and social changes.

Dialogic educational practices in non-formal STEM settings are an opportunity to target the phenomenon of educational exclusion. Despite the benefits of schooled systems, they could bring negative consequences such as exclusion of those who cannot have access to schooled systems (Merton, 1992). So, one might think that STEM education is limited to those who have access to formal contexts of education. However, STEM education has transcended the school borders challenging where, when, how, why and with whom STEM education is occurring (National Research Council, 2015). The informal contexts are rising new STEM educational paradigms (Dierking & Falk, 2016) including opportunities for vulnerable contexts to experience STEM education which reduces the gap of educational exclusion.

I could summarize the problem background in Figure 1.8 where the economic situation and STEAM education show the gaps. The niche led to the research question and is the one that I intend to occupy with the research.

Figure 1.8 Research problem summary

1.4.2 Research Question

This study aims to answer the following research question:

To what extent dialogic educational practices in STEAM sessions have an impact in the critical thinking skills of participants of non-formal contexts of education?

For this study, the term critical thinking skills is seen as a cognitive process for education, and on the other hand is seen as a sociocultural skill related to being critical about oneself circumstances. Even though, authors like Sensoy & DiAngelo (2017) differentiate between critical thinking and critical theory making it clear that critical thinking deals with the reasoning system while the critical theory attempts to a moral

critique of culture, for this thesis the aim is that the critical thinking skill combine the critical in the reasoning and social spheres.

1.4.3 Objectives of the Study

(1) Implement a social design experience based on dialogic educational practices in STEM education for marginalized contexts to fuel discursive relationships and empower actors for social transformation and multicultural coexistence.
(2) Illustrate the impact of dialogic educational practices in non-formal context for STEAM educators and learners of marginalized areas.
(3) Compare and contrast high school students' thinking skills before and after the implementation of the social design experiment.
(4) Analyze the impact for higher education students of designing dialogic educational STEAM activities.

1.4.4 Justification

This research in dialogic educational practices in non-formal STEM settings found in marginalized contexts in Latin America represents my contribution to the efforts towards the solution of the phenomenon of social and economic exclusion. This research is justified by five criteria: **social relevance, practical relevance, theoretical value, methodological value, and viability**:

The study of dialogic educational practices in marginalized contexts in Latin America is socially relevant because of the region's historical condition on inequality and difficulty to access resources traditionally dominated by an elite. It goes beyond the expected benefits of the STEM experience and knowledge because it aims to become a space for participants reflections of own practices, realities, and overall trajectories.

Hence, the expectation is that participants of the study discover their own conditions and historicity process leading to solutions to the problematics of poverty and improving lives *from* them rather than solutions *for* them.

The theoretical value of this study is that the field of STEM education demands a change in paradigm that engages citizens in dialogue for multicultural coexistence and planet interdependence solutions for the common good of present and future generation. The theoretical value is the addition of the critical perspective through dialogic educational practices. Hence, the theoretical value of dialogic educational practices in STEM settings is rooted in the relational, interactional, and ethical components that make participants realize that there is value in what each of them generate.

The practical implications of this project are aiming directly to develop higher level abilities in participants including a critical view of their own realities, and an invitation to reflect and hopefully transform their trajectories based on a social justice agenda. Even though, I am aware that a transformation might require a longitudinal study to see impact over the years and that there is a time limitation of this dissertation, indicators of transformation can be obtained through narratives of life and exercises of thinking the future that point to a process of historization in which they reflect on their position as human beings in the world. Other sociological and quantitative studies could also give as a more detailed view of their trajectory.

The theoretical value of the dialogic practices in marginalized contexts in Latin America is that serves the academia to appreciate dialogue under a more complex

paradigm that go beyond the discursive interactions among participants. It offers the possibility to open the floor to show a critical theory view. This serves a greater purpose of having a local theory on dialogic educational practices instead of foreign theories that could impose a perspective that reinforces elitisms and inequities in the region, including those found in research production.

The methodological value of the dialogic practices in marginalized contexts in Latin America is to improve participants practices not only in the types of talk but on the coexistence and critical reflection. Having this study in non-formal settings could result not only in a framework for dialogic educational practices rooted in Latin American marginalized contexts but for formal education places which deal with their own oppressive systems.

This project viability is supported by an earlier experience with the CBTIS99 and Fab Lab La Campana in Mexico (González-Nieto et al., 2020), and the work in schools in Ecuador (Ching-Chiang & Fernández-Cárdenas, 2020). Working previously with these formal and non-formal settings mentioned gave me the experience to conduct research including the design and application of research instruments, data collection analysis, time and project management, soft skills needed to interact with participants and academic networks. Precisely, this academic network made it possible to have access to Hyperlocal Learning Network La Campana-Altamira for a pilot study, and the main study have been guaranteed with funds granted by the U.S. Consulate of Monterrey.

Chapter 2: Theoretical Framework

2.1 Introduction to the Chapter

"How wonderful it would be if the growth of scientific and technological innovation could come with more equality and social inclusion"

Francis (2020).

These words from Pope Francis (2020) echoed loudly in my mind. As I meditated them during the whole encyclical letter, Francis's words set an aspiration to let scientific and technological innovation to develop, having at the same time a demand for human dignity based on fraternity and social friendship. Francis does not deny the possibility for development to occur but makes a clear emphasis on the need for human relationships to become the priority when taking decisions related to the development of nations.

Francis (2020) himself proposes a solution to his aspiration. He sets the need for dialogue, which appears forty-nine times across the encyclical letter and has the whole chapter six dedicated to it, as a transversal topic in his manuscript. He proposes dialogue as the mediating tool to pull development and human dignity together because "Approaching, speaking, listening, looking at, coming to know and understand one another, and to find common ground: all these things are summed up in the one-word dialogue" (Francis, 2020, p. 50).

His emphasis on the dialogic strengthen my personal inner call for this whole study that I am proposing and reinforces my view of the relevance of the dialogic for transformation.

I was inspired by Francis's quote and by Byrne's (2017) assertion that the purpose of a theoretical framework is to create awareness of what others have written in the general area of our research to organize the content of this second chapter. Figure 2.1 proposes the route to conduct the objective of this chapter, which is to create a critique on the current state of STEM education implementation and point to dialogic education as the component that can bring a genuine interdisciplinary education that fulfils the promises of an education that prepares the future labor force and world citizens.

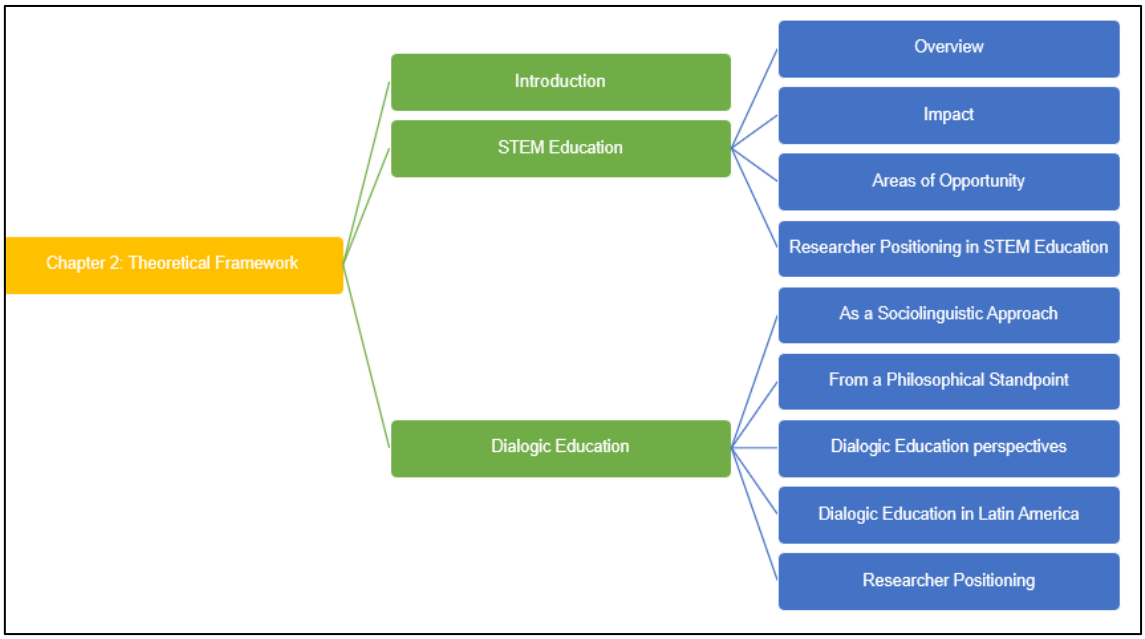


Figure 2.1 Chapter 2 Route

Chapter 2: theoretical framework has three sections. Section 2.1 presents a brief introduction and layout of the chapter. Section 2.2, as mentioned before, deals with STEM Education. The purpose is to give an overview (Section 2.2.1), impact (Section 2.2.2), areas of opportunities (Section 2.2.3), and research positioning (Section 2.2.4) on current STEM education status that strengthen the problem statement developed in chapter 1 about Latin American dialogic STEM education. Section 2.3 approaches theorization and explanation of dialogic education divided in four subsections. First an analysis of the dialogic as a sociolinguistic approach, starting with the sociocultural context that the philosophers lived in as a factor to consider in shaping their conception of the dialogic; then explores the different approaches to the sociolinguistic analysis field and finally assess specific philosophical concepts that contribute to the definition of a dialogic approach (Section 2.3.1). Next, a description of the conception of dialogic education, inspecting it in lieu of the current practices for which they have been grouped in four main conceptions: communicative relationship, constructivist pedagogy, instructional design, and critical consciousness, affording to see that dialogic education could be approached depending on these emphases given by the authors (Section 2.3.2). Third, it manages dialogic education in Latin America, as the region of interest in this study, through contextualizing colonization as a major factor influencing education in the region and reviewing dialogic education efforts as a response to inequalities, traditional teaching, and classroom talk pedagogy (Section 2.3.3). Finally, the last subsection presents my own view on dialogic education that leads to a genuine interdisciplinary education (Section 2.3.4).

2.2 STEM Education

Even though in chapter 1, a niche for dialogic STEM education was found through a scoping review, the purpose of this section is to further strengthen this understanding and deepen into the problem statement established, by highlighting the use of key theoretical concepts for this endeavor.

For that matter, this section presents first an overview of how STEM education was established, second presenting its benefits, third its areas of opportunities, and fourth a researcher positioning on the status of STEM education.

2.2.1 Overview

The STEM acronym, standing for Science, Technology, Engineering and Mathematics (STEM) was first introduced in 2001 by scientific administrators at the U.S. National Science Foundation (Hallinen, 2019), which makes it relatively new. STEM education is the intentional and explicit integration of various disciplines directed towards increasing students' understanding of how things work and solving real-world problems (Bybee, 2010; Sanders, 2009). The birth of STEM goes back to the United States during and post-World War II, which set in motion the creation of the U.S. National Science Foundation itself. Its purpose was to support basic research and education in sciences, mathematics, and engineering (Britannica, 2014; Sutori, 2020).

Despite the large interest, initiatives, approaches and discourse around STEM education, there are different definitions on STEM education. Holmlund et al. (2018) states that the fact that there is not a single worldwide definition of STEM education is not critical since there is a variety of institutionalized practices and school contexts within which STEM education is enacted. In other words, the proposal of STEM

education as interdisciplinary education seems to be educationally valuable; it is widely agreed that STEM, as an interdisciplinary education, involves a sense of integration of the four disciplines rather that isolated from one another (Park et al., 2020; STEM Task Force Report, 2014) because of its effective response to building world-class university systems (Wei et al., 2020). Interdisciplinarity seeks to go beyond the limits of school disciplines and of the many areas of knowledge, to promote more effective learning. STEM education calls for interdisciplinarity also seems to become key to solving current world problems that increasingly has our society, with the need to provide a qualified labor force able to draw solutions from different areas of knowledge.

Currently, the conception of interdisciplinary in STEM education has broadened due to the integration with other subject areas. Taking a renewed interdisciplinary stance, science education constructs new educational meanings for the acronym STEM, seeking to foster students' literacy in the various constituent disciplines (Bybee, 2010). For example, it has made integrations with other academic disciplines such as arts (Allina, 2018; Belardo et al., 2017; Coelho & Contreras, 2020; Conradty et al., 2020; Costantino, 2018; de la Garza, 2019; Faulconer et al., 2020; MacDonald et al., 2019; Muldrow, 2019; Sochacka et al., 2016) entrepreneurship (Eltanahy et al., 2020), Environmental science (Birney & Cronin, 2019; Cole, 2019; Geidel & Winner, 2016; Juškevičienė et al., 2020; Muldrow, 2019; Suh & Han, 2019), History (Hughes & Cosbey, 2016), and Literature (S. Hsu et al., 2020).

The STEM-focused curriculum has transcended the borders of the United States waking up interest in developed and developing countries. The aspiration of many countries is to use STEM as an education strategy to advance the economy and

technology aiming to build a society that is advanced (Freeman et al., 2015; Marginson et al., 2013; Mildenhall et al., 2019; Türk et al., 2018) and, more recently, to respond to fundamental challenges that humanity is faced with (Park et al., 2020). As a result, the STEM objectives are closely shaping our daily lives.

In fact, STEM education is a dominant discourse in our political, economic, and educational spheres. Although STEM would appear in principle as a simple list of four disciplines, it has built into a much more complex construct that links education, employment, and productivity (US National Science Foundation, 2010). That view is based on how STEM knowledge and skills are essential to a diverse field such as health care and biotechnology, manufacturing and product development, transportation, and energy and utilities (STEM Task Force Report, 2014). For that reason, it makes sense that STEM is used by a wide variety of interest groups with different agendas, which leads to different goals and implementation methodologies (Siekmann, 2016).

Stakeholders such as governments and private businesses have led specific STEM initiatives directed towards promoting awareness, training, and career aspirations into the field. Several initiatives such as STEM Education strategic plans (Hong, 2017; U.S. Department of Education, 2020), develop and test commercially viable educational technology products (Australian Government Department of Education, 2020; Office of Science and Technology Policy, 2019), and apprenticeship programs (Science and Engineering Apprenticeship Program, 2020), which are led by governments and business, so that the overall development of countries propel. These initiatives are inherently targeting to create opportunities for further countries development through the alliance of public and private efforts.

Following a STEM agenda there are many impacts of STEM education. The impact of these efforts will be explored in the next section.

2.2.2 Impact

Led by the socio-economic interests, countries have established different measures to account for the STEM education's impact. The works of Freeman et al., (2015) and Marginson et al. (2013) have presented reports based on country, regional and special interest on: STEM education, attitudes towards STEM, perceived relevance of STEM education, current patterns in STEM schooling, the role of STEM disciplines in education and training programs, factors affecting student motivation in STEM programs, access of STEM graduates to the labor markets, strategies, policies and programs, and issues of indigenous students with STEM education.

Even though this strategy could propel a benchmark based on the comparison among countries, the fact that STEM education has embedded an interdisciplinary conception makes it more relevant to analyze the impact it has from the viewpoint of the stakeholders who have a role in bringing together multiple disciplines. This impact is not limited to schools but it has rather extended the school borders (Dierking & Falk, 2016) so with this perspective the following two sections will comment on impact not only in school but informal settings too.

2.2.2.1 Formal contexts of education

STEM education, by calling for an integration of multiple related subjects, has unfolded changes in the school praxis. There is a vast research on the implementation of STEM planning, rolling out exciting lessons, units or modules involving green building education (Cole, 2019), electronic textiles (Nugent et al., 2019), programming robots

(Smyrnova-Trybulska et al., 2017), chemical kinetics (Parra Cordova & González Peña, 2020), bioengineering curriculum (Strawhacker et al., 2020), and computational thinking integration elements (Lee & Malyn-Smith, 2020), as a few examples named with this interdisciplinary agenda in formal contexts of education.

The implementation of STEM education has replaced traditional pedagogical approaches. STEM education evokes inquiry-based, activity oriented, interdisciplinary Project-Based Learning, and experiential learning. Examples of the implementation of these new pedagogies can be seen in the works of different authors (Eltanahy et al., 2020; Jho et al., 2016; Johnston et al., 2020; Kuo et al., 2019; Wilson, 2020).

As a result, some identified benefits include the potential for children's learning of STEM education for increasing adults' understanding of environmental issues (Mildenhall et al., 2019), improvement of students' critical thinking during argumentative interactions (Convertini, 2020), and entrepreneurial competencies (Eltanahy et al., 2020). These changes in the praxis are aligned to the development of interdisciplinary skills needed to prepare the future labor force.

STEM education provides students with interdisciplinary skills preparing them for real world demands. Students gain in creativity, critical thinking, high-level thinking skills, problem-solving skills, and become active collaborators of the STEM community of practices (Kubat, 2018; Kubat & Guray, 2018; Sivaraj et al., 2020; Slavinec et al., 2019). Moreover, STEM education leads to positive changes in children's attitudes of learning (Ching-Chiang & Fernández-Cárdenas, 2020; Nugent et al., 2019), community engagement (Burrows et al., 2018), emotional engagement (Ching-Chiang & Fernández-Cárdenas, 2020; Ni, 2019), educational attainment (Jiang et al., 2019), and

even awakens interest in ways that social justice is manifested in their lives (Kozan et al., 2017). Developing STEM skills are appropriate to become part of the accelerating economic and technological changes of our times, making STEM education impact positively on students' development.

STEM education has also proven to positively impact preservice and in-service teachers' educational practices and identity. Studies have currently shown that STEM education, as an interdisciplinary hands-on approach, is leading teachers to get involved in community-based practices (Jho et al., 2016), promoting problem solving and analytical thinking skills (Hussin et al., 2019), as well as continuous reflection and dynamic learning transactions (Gardner & Tillotson, 2019). Moreover, the addition of student-centered instructional materials have a positive impact on both the teaching practices and beliefs of college faculty (D. Bell et al., 2017). The implementation of programs such as Water-Energy education supports preservice teacher confidence and growth (Schneider et al., 2020), while the use of static scaffolding cohort (SSC) and adaptive scaffolding cohort (ASC) has resulted in process-oriented and result-oriented design-thinking patterns respectively, enhancing STEM learning design practice (Wu et al., 2019).

2.2.2.2 Non-Formal contexts of education

STEM education is happening in non-formal contexts of education. According to Dierking & Falk (2016) STEM education has transcended the borders of classrooms, finding itself "in settings like museums, science centers, zoos and aquariums, when children and adults are at home, participate in community-based activities and after school programs and across a wide range of digital media". In that sense, the

collaborations taking place in museums (Havice et al., 2018; Parker et al., 2018), after school programs (Hsu et al., 2019), and makerspaces (Falloon et al., 2020; González-Nieto et al., 2018; Lotz et al., 2019) have made possible to reduce the gap between history and science, formal science and playful qualities, literature and science, among others, making science more accessible and part of the daily life of citizens.

STEM education in non-formal contexts is creating opportunities for learners to lead their own educational process. According to Kim & Bastani (2017) learners determine the knowledge and skills needed creating a complex set of meanings. As a result, learners engage in active learning, critical thinking and complex problem solving and decision-making. As a result, STEM education in non-formal contexts allows to exchange the teaching and learning roles more often. In that sense, Gutierrez (Gutiérrez, 2008; Gutiérrez et al., 1995) would agree that Third Spaces emerge "creating the potential for authentic interaction and a shift in the social organization of learning and what counts as knowledge".

2.2.3 Areas of Opportunity

Despite the benefits of STEM education that I discussed in the previous section (see 2.2.2 Impact), studies have also revealed areas of opportunity for STEM education.

STEM education faces some challenges from the school standpoint. Even though the educational system's target is to make knowledge and experience useful and functional for students' life, it prevails the conventional educational systems' practices that dictate students to learn specific topics separately (Kubat, 2018). Moreover, the current design of curriculum has often been fragmented because of overspecialization, also attributed to the fact that teachers are traditionally trained to teach domain-specific

knowledge (Wang et al., 2020). Thus, these issues represent a call for a genuine interdisciplinary STEM education. It calls schools firstly to connect teaching methodology and STEM content courses taught in isolation (Nowikowski, 2017; Ramli et al., 2017; Ryu et al., 2019); secondly, it is needed to highlight the potential value of multi-dimensional assessments to allow students to demonstrate STEM proficiency through novel forms of evidence (Wilson, 2020); and thirdly, to partner school teachers with universities and industries to enact a STEM integrated model (EL-Deghaidy et al., 2017). For STEM teachers some areas of opportunity include the possibility to strengthening design-thinking competences (Wu et al., 2019), advanced technical skills, materials, and time (S. Hsu et al., 2020; Juškevičienė et al., 2020), strategies for drawing on a professional orientation that encourages collaboration (Yip, 2020) risk-taking (Ryu et al., 2019), and understanding of scientific modelling instruction and experience teaching with coding (Vasconcelos & Kim, 2020).

2.2.4 Researcher Positioning in STEM Education

As seen in this 2.2 section, different stakeholders including governments and businesses are aiming for economic and technological advances. Hence, this has created a high demand for a labor force that possesses not only the knowledge but also the set of skills to solve real world problems. The world economies have been in a career for development in which the rankings are given through productivity indicators generated by the technological advances they could own and develop. Thus, that has traditionally turned the eyes to academia in search for curricular practices that prepare citizens to achieve economic objectives making STEM education one of the most promising educational interventions to reduce poverty.

The governments have placed in the education sector the responsibility that STEM education successfully works. Aligning to pursue that goal, governments have pushed policies leading schools to prepare citizens for a knowledge-based society with 21st century skills (communication, collaboration, creativity, critical thinking) for problem solving. In that sense, we have already seen some of the positive impact that STEM education has caused (section 2.2.2), but also some areas of opportunity (section 2.2.3).

However, considering the interest of this thesis, the biggest niche found is that it seems that STEM education, as it is, is still far from that messianic promise. According to the OECD (2015), growth has disproportionally benefited higher income groups while lower income households have been left behind making the economic gap wider. This inequality can be seen in terms of region-to-region, country-to-country and among citizens of a country. When comparing by regions we can think about it terms of the concept of the Global North-South, where the northern regions are refereed to countries with greater economic and political power (Butler, 2021). When comparing countries, it might be termed as the developed and the developing countries. In terms of citizens comparison is termed as the poor and the upper classes. In any of these three cases, the situation of marginalized regions, countries and citizens denotes the fact that STEM education is becoming the root for inequalities where there are increasing and persisting symptoms of job polarizations, gender gaps and wealth concentrations.

The lack of fulfilment in the STEM education promise leads me to question the STEM education that is received by those in marginalized positions. Is STEM education only preparing those in marginalized countries to be in a modern form of slavery? Are

they bounded to stay in a poverty cycle? What could be the twist in STEM education needed in the case of those in Latin America and Mexico, specifically those marginalized citizens?

Under a critical framework view, this thesis aims to offer genuine interdisciplinary STEM education with dialogic educational practices. By this I mean that for those marginalized citizens in a Latin American context, it is necessary to bring together the disciplinary knowledge with a social justice flag given by dialogic practices, so that interdisciplinary STEM education could reduce inequalities among citizens.

In other words, the proposal is to bring this genuine transformative interdisciplinary STEM education through the conception of dialogic education that inherently calls for a greater interdisciplinary communication too. I want to pursue an interdisciplinary agenda that integrates the four areas of knowledge through dialogic practices instead of the dissociation or partial integration very often found in scientific education.

A genuine interdisciplinary dialogic STEM education opens a gateway to challenge current structural problems in the educational systems of Latin America. That means that it cannot only help to prepare Latin American students to face scientific and technological problems challenging content-based and isolated knowledge, but it also presents itself as an opportunity to manage core social issues in the region. Interdisciplinary STEM education with a dialogic practice brings an opportunity for marginalized participants to have a voice in the discourse of STEM knowledge and actions.

Moreover, the proposal of a dialogic education calls for human dignity and fraternal relationship acknowledging humanity as a whole community, aiming to emphasize the interdependence among individuals. In other words, an interdisciplinary STEM education will target fundamentally the integration of people through shaping first the recognition between individuals, the social construction of knowledge, and an embedded agenda for socio political justice.

This component of the dialogic education will be explored deeper to its foundation in the next section of this theoretical framework so that a diachronic view is offered.

2.3 Dialogic Education

Several waves of conception of dialogism have been in place since the last century, including sociocultural theories from Vygotsky (1978) which have propelled an increasing interest in the role of language. The socially constructed knowledge theories proposed by Vygotsky accentuated studies on how students participate in classroom discourse.

Considering theorizing and explaining dialogic education, this section presents five subsections. The first three subsections deal with an analysis of dialogic education as a sociolinguistic approach and from a philosophical standpoint. Then, I review some dialogic education perspectives and provide a view of dialogic education in Latin America in a diachronic view to see where the discussion is standing. Finally, I evaluate the previous positions resulting in my own positioning about dialogic education.

2.3.1 Analysis of the Dialogic as a Sociolinguistic Approach

2.3.1.1 Context of the 20th Century

Even though dialogism can be traced back to philosophers like Socrates, who lived in the fifth century BC, and many interpretations have been offered around his ideas, the intent of this thesis is to keep building up over the shoulders of these giants. Hence, this subsection makes a review from a more contemporary perspective set in the 20th century. The purpose is to accomplish a view of the philosophical grounds where the current dialogism notions stand in terms of the seminal work of Ludwig Wittgenstein (1889-1951), Mikhail Mikhailovich Bakhtin (1895-1975), Emmanuel Levinas (1906-1995) and Jurgen Habermas (1929-present).

From a sociocultural perspective, it is relevant to pay attention to the time and place where philosophers developed their work. As Vygotsky (1978) proposed, the social context affects how learning takes place and is responsible for higher-order functions. Thus, to understand the work of these philosophers of the 20th century, it is imperative to point briefly to some of this era's political and social events that they went through and impacted their worldview.

Overall, the 20th century has been an era of great transformation for humanity. During the first half, the changes in relationships between the world powers propelled two World Wars and one Cold War. Meanwhile, the second half replaced the hegemony of the European state systems for a world system (McDougall, 2020). Due to the world wars and regimes during the first half of the 20th century philosophers were driven to adopt political stances and surf through them in their sociocultural contexts. Ludwig Wittgenstein Austrian-born British philosopher, enlisted in the Austrian army and in

1916 at his own request, and he was sent to a fighting unit at the Russian border (Monk, 2006). Bakhtin from Russian origins was confronted in this period with the Stalinist regime which made him go through exile in 1929 when he was sent to Kazakh (Britannica, 2006). Emmanuel Levinas from Lithuanian origins was imprisoned in a concentration camp in Germany, as well as other philosophers of the time such as Jean Paul Sartre (Wolin, 2006). On the opposite ideological spectrum, Habermas from German origins was part of the Hitler Youth groups when he was 15 years old, but later in his life he joined movements where he sought to protect democracy, avoid wars and genocides, and even the dangers of German nationalism posed by Germany's reunification in 1989–90 (Matustik, 2009b, 2009a).

The 20th Century was grounded on a different philosophical view for humanity. The discoveries of Charles Darwin, Albert Einstein and Sigmund Freud settled traditional issues such as reflection on the existence of nature or the Universe, and philosophers began to concern themselves with questions of political and moral philosophy, or with more concrete issues such as linguistic analysis (Ventura, 2016). The interest in linguistic analysis seems relevant among philosophers, given that it is the primary semiotic tool for human communication and necessary in all spheres of their lives to negotiate reality. However, the 20th century shows a linguistic turn in the second half having a particular social component. This linguistic turn will be explored through the different sociolinguistic and discourse analysis approaches field in the next section.

2.3.1.2 The sociolinguistic and Discourse Analysis Approaches Field

To give a brief background on the sociolinguistics field, this section presents, as seen in Figure 2.3, the linguistic turn in the 20th century through the lens of Fernández-

Cárdenas (2009). He makes a detailed diachronic review of five sociolinguistic and discourse analysis approaches: 1) ethnomethodology, 2) social semiotics, 3) ethnography of communication, 4) critical discourse analysis, and 5) interactional sociolinguistics. These five approaches share in their core that they study the social phenomena from the perspective of the participants causing a linguistic turn in philosophy. With these approaches it becomes clearer the role of language in the social construction of knowledge.

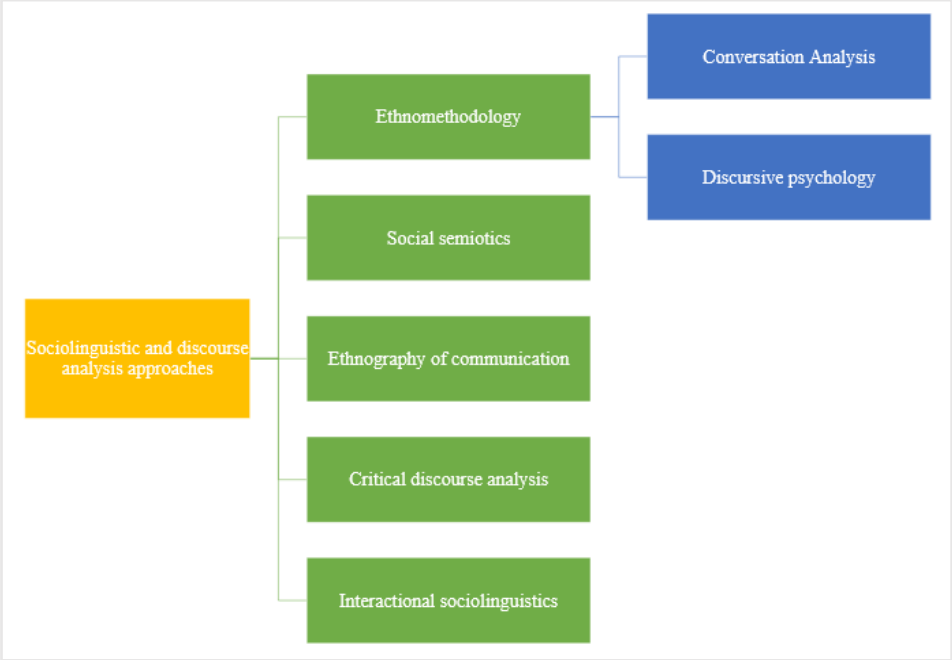


Figure 2.2 Sociolinguistic and discourse analysis approaches

Fernández-Cárdenas (2009)'s review of the approaches takes us to explore how each of them carried the proponents' interest about the concepts and methodological tools in the study of language shaping the discussion on the way in which meaning is constructed in the social interaction. From ethnomethodology the emphasis is related to the rules and methods that participants create to make deductions about the world and

themselves in relation to that world. It emerges from ethnomethodology the conversation analysis and discursive psychology from which we obtain tools and methodologies to analyze speech and in the second one the role of language creating psychological categories. According to Fernández-Cárdenas (2009) social semiotics focused on how the language as a set of semantic resources are structured and organize the context. Then, he moves to Ethnography of Communication which is particularly attracted to understanding how culture shapes the way we talk. Fernández-Cárdenas (2009) points in the Critical Discourse analysis how discourse is a historic phenomenon with authors like Foucault, Habermas, Bourdieu, and Fairclough. Finally, in his review of Interactional sociolinguistics, the emphasis is in studying the way that participants use discourse to co-create knowledge and achieve common goals.

As you can see through Fernández-Cárdenas (2009)'s review of the approaches, the sociolinguistic approaches have evolved from rules and methodologies to a more cultural sense where the notions of power and intersubjectivity become essential. They also appeal to embedded meanings and personal agendas of individuals in the communication process. However, Fernández-Cárdenas work leaves room to add to the sociolinguistic approaches the analysis of the dialogic in which the priority is the plurality of voices.

2.3.2 Analysis of the Dialogic from a Philosophical Standpoint

Figure 2.4 presents is a synthesis of what will be presented in this section. The objective is to put together the specific philosophical contributions of Ludwig Wittgenstein, Mikhail Mikhailovich Bakhtin, Emmanuel Levinas, and Jürgen Habermas to this analysis of the dialogic approach. I build the dialogic analysis approach with (1)

Wittgenstein awareness of categories not been sufficient to comprehend human thinking; (2) the concepts of voice, polyphony, heteroglossia, and carnivalesque from Bakhtin; (3) Levinas' emphasis in the importance of the recognition of the other in the dialogue; and (4) Habermas' socio-political agenda in language from the intersubjectivity.

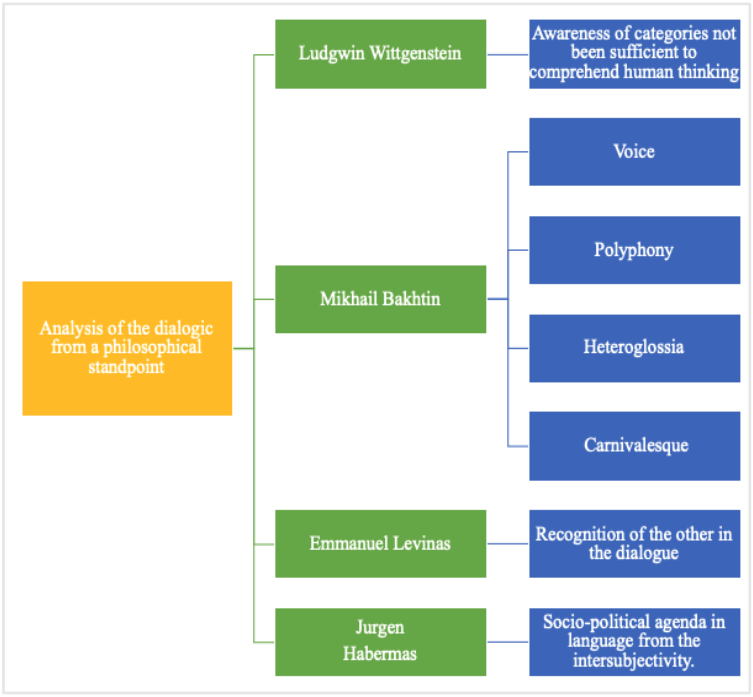


Figure 2.3 Analysis of the Dialogic from a philosophical standpoint

2.3.2.1 Ludwig Wittgenstein

When we talk about dialogic education it is necessary to have a philosophical foundation on the primary vehicle: language. Hence, it is necessary to recall Ludwig Wittgenstein' work because it gave a linguistic turn to the way that philosophy was done (Glock & Kalhat, 2018). Wittgenstein' work immediately evokes, what many have already called, the myth of the two Wittgenstein, which refer to his two major philosophical works "Tractates" and "Philosophical Investigations". The work on the

two books seem to contradict themselves in the terms of philosophical thinking but I would say they rather complement the way that language can be studied.

The focus of the Tractus is in language based on propositions and logic. These two were used to picture reality (Britannica, 1998), and portrait a more descriptive use of language (Karam, 2007). More so the central idea of the Tractatus is that all languages have a uniform logical structure and so logic Tables give account to propositions and meaning of language (Tamayo-Valencia, 2005). Sometime after finishing this book, Wittgenstein was disappointed because the list of categories was not able to understand the nature of understanding in humans (Fernández-Cárdenas, 2009). This led us to explore Wittgenstein's "Philosophical Investigations".

In this second phase of philosophical thinking as specified by Wittgenstein the main proposal is that language has multiple functions and unaccountable usages (Karam, 2007). That opens to a broader consideration the usage of language for which contexts are important in shaping the meanings. In this regard, it becomes essential seeing the way in which people use language to perform tasks where the concepts are included and ineffably it points out that human actions are building meanings.

Wittgenstein's two main contributions leave us with these two philosophical views of language. Both are necessary to give us a framework of two cosmovision of seeing language. In particular, the second Wittgenstein for whom human actions are relevant in the language, thinking and knowledge creation is fundamental in this analysis of the dialogic approach that I am building.

2.3.2.2 Mikhail Bakhtin

Bakhtin's work in linguistics points to the dialogic nature of language. For Bakhtin (1981) every word participates in a history of rich intertextual relations in which it is related to all other utterances. By that relationship, he acknowledges that humans engage in a dialogic process in multiple ways, which have a broad possibility of viewpoints and positions. That also points to the recognition of others located outside with their own time, space, and culture. To better understand that dialogue, Bakhtin refers to the terms of voice, polyphony, heteroglossia, and the carnivalesque, as fundamental.

2.3.2.2.1 Voice

A voice is more than a sound. For Bakhtin (1976), a voice has intonation, accentuation, abstract concepts, and judgements from living words (p. 147). Voice then reflects the values behind the consciousness which speaks (Roberts, 1994, p. 251). According to Sturrock (1982) Bakhtin, through the study of novels, realized that there were a variety of voices establishing three elements: the individual, the discursive and the ideological. These elements of heteroglossia call to stop seeing language as a mere theoretical structure. It is the space where the elements converge in dialogue between the characters and entrench at the same time a complex dialogue through various levels of abstraction. This conception of voice is further developed in the term polyphony, which Bakhtin (1999) Bakhtin raised in his work Problems of Dostoevsky's Poetics.

2.3.2.2.2 Polyphony

The term polyphonic opposes one of monophonic. While in a monophonic chant you could hear many singers singing in one voice, in a polyphonic chant there are many

singers from you could hear their different voices they were singing in harmony. This last part of harmony in the voices is what Bakhtin (1929) points in Problems of Dostoevsky's Creation. He identifies the conception of polyphony as a new type of thinking in the narrative where not only converge the utterances of several voices, but the capacity to embody each other's utterance creating a dialogic relationship. That meant in the novel the opportunity to insert, besides the voice of the narrator, the voice of the characters, undramatized voices, and even the stratification of the narrator's voice into two distinct voices.

Even though polyphony was an assertion referring to a new type of novel based on Dostoevsky 'work and a metaphor borrowed from music it builds on his conception of voice previously discussed and becomes fundamental for Bakhtin's work on dialogism. It recognizes the possibility of acknowledging others and a space to form a relationship through talking and listening.

2.3.2.2.3 Heteroglossia

Bakhtin (1981) coined as heteroglossia the idea of other-languagedness. Compared to polyphony previously presented, heteroglossia is a broader concept. It is a complex mixture of languages, not limited to a national language but to any utterances, and world views that are always dialogized, as each language is viewed from the perspective of the others (Dimitriadis & Kamberelis, 2006, p. 51). Sisto (2015) explains that a complex dialogue is established not only with the immediate interlocutor, but with everything, the rest of foreign words through which it connects and positions itself, with the rest of its socio-historical context (p. 12). That implies that there is an inherent consciousness formed by the social, cultural, and political nature of the speakers.

Heteroglossia in language has a social character. Bakhtin (1981) himself pointed to it as a social phenomenon (p. 291). That means that language is the product of collective human activity, which reflects in all its elements, both the economic and socio-political organization of the society that has generated it (Bakhtin, 1929, p. 227). That process of collective activity is characterized by a response of the other rather than a passive understanding, which only reproduces your idea in someone else's head, but wants an answer, consent, participation, objection, compliance. The social character implies a dialogic space for relationships explored by Bakhtin with the next concept of the carnivalesque.

2.3.2.2.4 The carnivalesque

Carnivals are an opportunity to open the floor for genuine dialogues. According to Bakhtin (1965, p. 199) in a carnival there is a temporary suspension of hierarchical rank that allows a special type of communication impossible in everyday life that breaks the distance and creates special forms of marketplace speech and gesture, frank and free. It is an opportunity for positioning language in the context of a relationship, and the ethics of creating a dialogic space in which two or more voices can express themselves without trying to silence themselves (Fernández-Cárdenas & Piña-Gómez, 2014).

Carnivals are also an opportunity for a relationship with oneself. Owning to the fact that "one cannot determine one's own position without correlating it with that of others" (Bakhtin, 1981); that implies that one acknowledges oneself relationship considering the interactions with others through this dialogic space. In carnivals, as claimed by Bakhtin, laughter destroyed epic distance; it began to investigate man freely

and familiarly, to turn him inside out, expose the disparity between his surface and his center, between his potential and his reality (1981, p. 35). Carnivals loosen at least temporarily the current normative of social behavior given by law and tradition, allowing speakers to explore new relationships with others and oneself.

If Wittgenstein's work opened the door to consider human actions in the meaning creation for language, Bakhtin puts together the concepts of voice, polyphony, heteroglossia and the carnivalesque. He further emphasizes Wittgenstein's social relation in terms of recognizing the oneself voice as a reflection of consciousness, the encounter of voices that can have a harmonious encounter through the recognition of the other and opening a more sincere space to express themselves.

2.3.2.3 Emmanuel Levinas

Levinas's work in linguistics points to the philosophy of otherness. Unlike Heidegger, for Levinas (1977) the relationship with the other displaces the existence of a self-centered position. In this sense, the image of encounter in Levinas is one in which each human being is responsible for the other, offering hospitality and welcome (Viveros-Chavarría & Vergara-Medina, 2014, p. 63). This philosophy of otherness has a couple of features discussed below.

The philosophy of otherness is rooted in a new self-identification. The other not only could give a new meaning - which Heidegger totally ignores - but also gives a new identity (Begrich, 2007, p. 75). The Self and its identity reached a crisis, but for Levinas the crisis of subjectivity is not the end of humanism, but the beginning of a new humanism based on the others. This humanism of the other man brings a new identity, which comes from the responsibility for the other (Begrich, 2007, p. 80).

The philosophy of otherness features an altruistic construction of dialogue. Contrary to constituting an expression of egology, the encounter with others transcends the self and offers a space for the dialogic relationship. Levinas (1977) based on this, his criticism of Heidegger, proposed a human being who acts from an ethic in which the other is first than the self, that is, an ethic of the encounter. Heidegger conception of the self as the main source of philosophical reflexivity as the ultimate foundation is challenged by Levinas (Viveros-Chavarría & Vergara-Medina, 2014, p. 63) to give room to a dialogic relationship in which the speakers come to acknowledge themselves as responsible for others.

The philosophy of otherness also features an altruistic being. In that encounter with the face of the other, as Levinas (2001) puts it, there is a radical inversion in which the self is replaced by a self that is willing to put himself at stake and undresses to show others a sincere and honest human relationship. That implies an ability to hear while being there for the other. For Viveros-Chavarría & Vergara-Medina (2014), Levinas calls for a subject who does not cower in the presence of the other but decides to open his dwelling place and risk the encounter, which is a work aimed at the singularity of the one who is close and who little by little approaches and becomes present (p. 68). The responsibility for others features somehow a detachment of oneself that finds a new form of meaning that goes beyond the time of a single life (Begrich, 2007, p. 75).

The philosophy of otherness rejects reciprocity. For Begrich, 2007, p. 55), Levinas' otherness does not imply a commitment but a sacrifice without pays in which the self is not related to you as the you with the self. For Levinas (2001, p. 213) once the relationship is in the hope of reciprocity, the relation arises from a commercial

relation rather than a generous relationship. My responsibility for the other, far from being a reciprocal responsibility, is an inevitable choice (Begrich, 2007, p. 59).

The concept developed by Levinas about otherness becomes relevant in the analysis of the dialogic. It adds to Bakhtin's work recognizing not only the plurality of voices in a conversation but as a responsibility of the self towards oneself and social construction.

2.3.2.4 Jurgen Habermas

The final philosophical stone for this analysis of the dialogic is the work of Jurgen Habermas. To understand Habermas's contribution to dialogism is imperative to trace back his work in Critical Theory. His theory can be considered critical to the extent that it seeks human emancipation and acts as a liberating influence (Horkheimer & Adorno, 1972, p. 246). However, critical theory aspects differ in different historical phases. Habermas himself rejected the radical democracy as an expressive and rational ideal as presented by his predecessors of critical theory and rather focuses on the attempt to determine the nature and limits of "real democracy" in complex, pluralistic, and globalizing societies (Bohman, 2019). In that search, his interests turn to human competences as speaking, understanding, judging, and acting giving life to Habermas's theory of communicative action. According to Maceratini (2019), in Habermas' theory of discourse, the investigation on the link between democracy and language refers to a broader question on the relationship between public space, discourse and reason.

Habermas, as Bakhtin, sees the dialogic nature of language, but also recognizes a communicative action for the goodness of a deliberative democracy. Communicative action is individual action designed to promote collective understanding in a group and

to promote cooperation, as opposed to strategic action designed simply to achieve one's personal goals (Habermas, 1984). Two words are relevant to point in his definition: understanding and cooperation. First, note that the communicative action is motivated to obtain mutual understanding rather than focusing on the self. This differs from Levinas description in his philosophy of otherness in which he points more to a selfless version of one of the parties in the dialogic communication. Second, note that by promoting cooperation, it aims for a subjective and social self-clarification, resulting in understanding as emancipation from communicative conditioning.

Habermas's theory of communicative action was questioned in terms of the premises that it is built on. Baxter (1987) mentions the cases where there is an open strategic action in the communicative action. By that he meant that the speaker openly declares an intent to manipulate the communication. Thus, Baxter (1987) claimed that Habermas needs another criterion to exclude from communicative action cases of open strategic action. A second questioning is the ideal communication community that regulates itself to support the claims and obtain a mutual understanding (Matustik, 2009a). It is questioned the fact that there is always this ideal community as described.

Habermas points to validity in communication. He demands that communication is comprehensible, verifiable, it shows appropriateness, and have a sincere component in the intersubjectivity but Alexy goes further in the argument adding more specific rules such as no contradictions in the talking, an intrinsic trust in the other saying what he really believes in and a recognition of the other to express himself (Fernandez-Cardenas, 2009).

2.3.2.5 Recapitulation

Through section 2.1, it has been relevant to make an analysis of the dialogic as a socio linguistic approach so we can situate the topic in the broader academic field it is coming from. Through the briefing on the socio-cultural context that the philosophers of the 20th century, I was able to point out some socio-political and socio-economical situations that give us light about the world cosmovision and required a turn in linguistics. That shift was analyzed through the work of Fernández-Cárdenas pointing five approaches of sociolinguistic analysis. Lastly, I went through this approach of analysis of the dialogic for which I used Ludwig Wittgenstein, Mikhail Mikhailovich Bakhtin, Emmanuel Levinas, and Jürgen Habermas philosophical contributions. The use of these philosophical foundations helps not only to show awareness of the construction of knowledge through language but will also set a view on why dialogic education is approach different in the praxis.

2.3.3 Dialogic Education Perspectives

In the same way that cosmovision and social contexts impacted philosophers in shaping the analysis of the dialogic, dialogic education also presents a diverse conception in the praxis. Several teaching and learning practices are labelled as dialogic pedagogy including discourse patterns, epistemologies, relationships, power, and an inquiry stance (Alexander, 2018; Asterhan et al., 2020; Lefstein & Snell, 2011; Segal & Lefstein, 2016). Hence, this subsection explores the multiple perspectives in the field and analyzes the conceptual instruments from which dialogism is conceptualized.

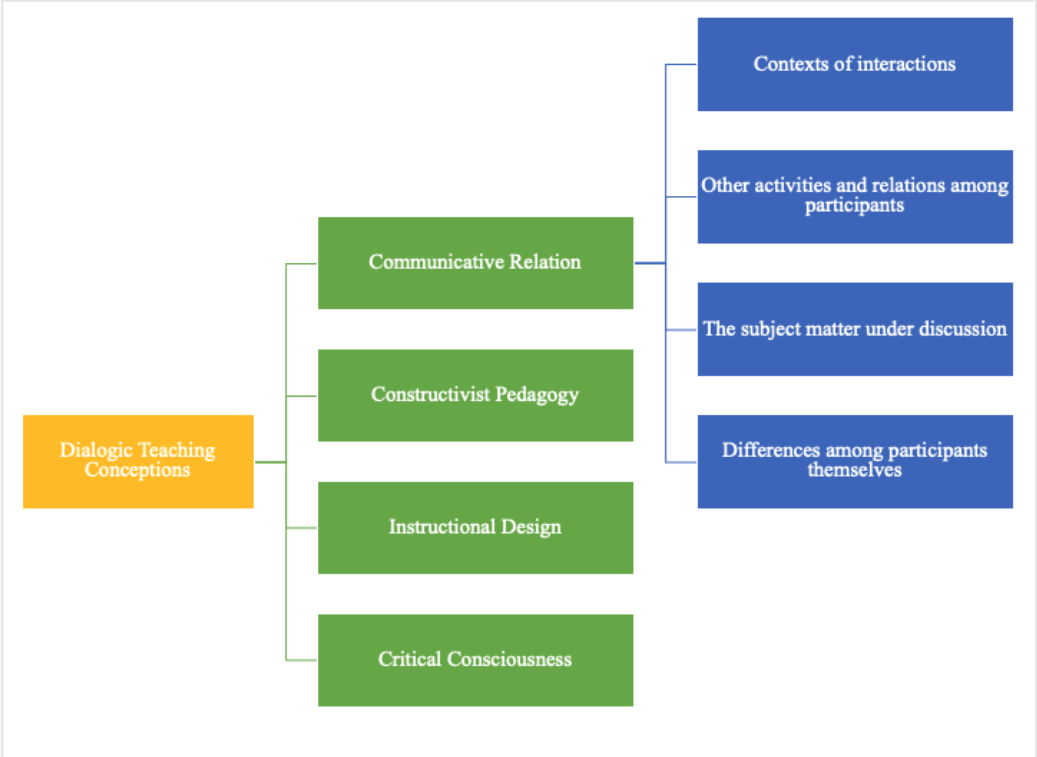


Figure 2.4 Dialogic education Conception

As seen in Figure 2.5 the different perspectives emphasis was grouped in four categories: (1) as a communicative relationship; (2) as a collaborative construction pedagogy; (3) as an instructional design methodology; and (4) as critical consciousness. Each one will be explored below.

2.3.3.1 Communicative Relation

As stated by some philosophers reviewed in the previous section, dialogue was portrayed as a communicative relationship. The importance of seeing dialogic education as a communicative relationship is that it recognizes the voice of oneself and the voices of others in the teaching-learning process. However, the understanding of that communicative relationship differs among authors due to the emphasis of the feature that each takes side. In words of Burbules et al. (2001), the features are in terms of the

relation between forms of communicative interaction and (1) the contexts of such interaction; (2) other activities and relations among participants; (3) the subject matter under discussion; and (4) the varied differences among those participants themselves.

2.3.3.1.1 Contexts of Interactions

The communicative interaction shapes the contexts of such interactions and vice versa. For Mortimer & Scott (2003) language plays a role in the social construction of meaning, and to develop a sound research methodology for examining the diverse interactions of science classrooms, as well as applying sociocultural theory to classroom contexts. This emphasizes the role of communicative interaction over contexts. On the other hand, Burbules et al. (2001) asserted that the conceptions of dialogue need to be rethought within the changing institutional and demographic circumstances of teaching and learning, and within the changing educational needs and aims of society. That points to the idea of contexts shaping the communicative interaction

2.3.3.1.2 Other Activities and Relations among Participants

The communicative interaction depends on other activities and the relations among participants in three aspects: authority and roles. In terms of authority, Mortimer & Scott (2003) see classroom discourse in two dimensions: dialogic-authoritative dimension and interactive-non interactive dimension. By dialogic-authoritative dimension they point out the role of the teacher in paying attention to more than one point of view, because the more available the teacher presents him/herself and offers this opportunity, students will have higher possibilities to lay down their own point of view. This leads to the second point of interactive-non interactive dimension which refers, besides the teacher role, to the activity of the student, which is relevant and

allows the student to decide whether participate in the communication. As we can see, these authors are recognizing, first, a dimension of relationship talking about roles and functions and, in a second stance, the inner willingness of the learner to respond and interact. For Reznitskaya & Gregory (2013, p. 116), in dialogic education power relations are flexible, and responsibilities for the form and content of talk are shared among group members.

The relationship among participants demands a switch of conventional roles played by students. Authors like Burbules et al. (2001) place a role of responsibility on the student demanding him/her to be a more active partner in the teaching-learning process. Precisely because there will be a transformation in the character of the student making them become richer in argumentation (Sedova, 2017, p. 23). As a result, the role of the student and capabilities demand a higher level of thinking processes that will be expressed in a range of communicative acts, gestures, or facial expressions, and not only or always spoken word.

The relationship among participants demands a switch of the assumed role played by teachers. Sedova et al. (2016) challenge the role of the teacher and emphasizes a teacher who is willing to make room for students to speak more and must attribute greater epistemic weight to student talk. Snell & Lefstein (2018) go beyond saying that, in a dialogic pedagogy, teachers are expected to encourage all pupils to participate actively and subject their ideas to critical examination, pushing pupils to justify their arguments (p. 46). To achieve that Matusov & Marjanovic-Shane (2018, p. 22) proposed that teachers enter an improvisational performance in which they improvise to help students discover and construct the curricular endpoint presented by

the society. Moreover, letting the students' voices be involved implies an opportunity to speak, to expressing one's own ideas, on one's own terms, and being heeded by others (Segal & Lefstein, 2016, p. 3).

The views for students and teachers' roles in dialogic interactions completely challenge the classic transmissive mode of instruction. For Lefstein & Snell (2013) in these new roles, students and teachers will face problems and play an active and agentive role in the joint construction of knowledge and negotiation of meaning. This evokes a socio constructivist approach in education and the creation of a community characterized by respectful, supportive, and caring relationships instead of what Freire (2006) coined as banking education.

2.3.3.1.3 The Subject Matter under Discussion

The communicative interaction is shaped by the subject matter under discussion. For example, Mortimer & Scott (2003) argued that learning science involves acquiring a new social language—a language unique to the scientific community. That implies the necessity to have a mutual understanding of how the tools and practices work which need a communicative relationship among participants. Moreover, this same subject matter under discussion could propel what Burbules (1993) identified as four types of dialogue: inquiry, instruction, conversation, and debate. Similarly, the study of Ching-Chiang & Fernández-Cárdenas (2020) pointed to class topic influenced dialogue. When the classes required mathematical calculations, dialogue was directed towards instruction but when they did not, the topics elicited a more elaborate dialogue where students could see a context and create a sequence for conversation and debate.

The subject matter under discussion does not necessarily imply that all parties must reach a consensus about it. Matusov & Marjanovic-Shane (2018, p. 20) view the communicative interaction as an opportunity to develop a critical dialogue about the subject matter under discussion. For them, it is helpful that there are disagreements as a permanent moving force of the dialogue. So, the subject matter is an excuse to promote informed authorial judgments Matusov & Marjanovic-Shane (2018, p. 21). Moreover, it is also an excuse to provoke thoughtful answers, and these answers are supposed to provoke further new questions (Sedova, 2017).

2.3.3.1.4 Difference among Participants themselves

The communicative interaction depends on the differences among participants. Burbules & Bruce (2001) bring to the Table the fact that participants carry in dialogue different forms to express, often implicitly, their own assumptions on the nature of knowledge, the nature of inquiry, the nature of communication, the roles of teacher and learner, and the mutual ethical obligations. However, they believe that dialogue plays a significant role because it is a medium through which they bring those different points and share them. This then implies for participants to acknowledge the position of the other and recognize the uniqueness of the participants even if they are coming from the same culture.

The uniqueness among participants determines the type of communicative interaction. This retakes Mortimer & Scott (2003)’s point of view related to interactive-non-interactive dimension, where it depends on the participants' own self to choose to interact. Sedlacek & Sedova (2017) made a claim that there is a danger in dialogic education in which it could increase the differences in learning opportunities for

individual students given that the most encouraged students to participate will do so (p. 101). However, communication cannot be seen as just talking, but rather focus on students' different capabilities to manage their own learning interests and can express and living them in their school activities (Matusov & Smith, 2012), which would make them interact by taking control of their learning in their own hands. In fact, their choices of discourse manifested through a range of kinds of texts and other mediating objects, which establish daily communicative practices (Burbules et al., 2001).

2.3.3.2 Constructive Pedagogy

There are some authors that view dialogic education developing hand to hand with a constructivist pedagogy. A constructivist pedagogy contrasts with the behaviorist paradigm, which is drawn from empiricism, in which the focus is the reproduction of objectivist knowledge passively transmitted by the instructor (Bell, 2020, p. 1695). The same happens with dialogic teaching that goes against traditional monologic classrooms. Dialogic teaching and learning have been presented as the antidote to the prevailing recitative discourse that plagues so many classrooms (Boyd & Markarian, 2015, p. 272). That means that both leave behind the teacher as the main source of knowledge and as the focus in the learning process. Hence, dialogic teaching as constructivist pedagogy advocates for a role of all participants in the construction of knowledge.

Dialogic teaching as a constructivist pedagogy promotes the creation of space for knowledge creation from participants' own meaning. In terms of dialogic communication, Burbules (2006) calls this a third space in which the semantic frames meet, conflict, and get attached with meanings, where there is not a compromise to get

to a middle ground. However, this third space is bounded to time, space and circumstances making them untransferable, acting as actual border zones or specific practices. Reznitskaya & Gregory (2013, p. 116) supports the fact in this third space participants meet on terms of equality and take on key roles in navigating class communication but also adds that this space of knowledge creation is transformed into learning communities.

Dialogic teaching as a constructivist pedagogy is an opportunity for inquiry to take the stellar role. Wells (1999) introduced the concept of dialogic inquiry in which all participants are engaged in knowledge building. That inquiry process is possible because of the interactional structures and discursive actions (Boyd & Markarian, 2015; Wells & Arauz, 2006). Moreover, in that space for dialogic inquiry, conditions such as reciprocity between participants, and a positive classroom climate that supports safe personal and joint exploration (Boyd & Markarian, 2015; Haneda & Wells, 2008, 2010). One more consideration for dialogic inquiry is that the open-ended questions can inspire meaningful inquiry in contrast with questions that demand memorization (Reznitskaya & Gregory, 2013, p. 117).

Dialogic teaching as a constructivist pedagogy opens the space for intersubjectivity. As learners take an active part in the projects they participate, this opens an opportunity to share consciousness and knowledge. Research over the last four decades has focused on how classroom dialogue allows teachers and students - and students working together -to co-construct knowledge and meanings and develop intersubjectivity (Howe & Abedin, 2013). Through dialogic teaching, participants are called to make a persistent attempt to understand each other's perspectives for which

they need to become active listeners and acknowledge that participants interpret and speak from different perspectives (Wells & Arauz, 2006, p. 382). Despite that there is no perfect communication and ambiguity can arise, a dialogic teaching activates willingness and consciousness of the other, creating intersubjectivity.

Dialogic teaching as a constructivist pedagogy shapes a new social space. Guerrero-Arias (2002) argues that culture is the result of a social construction that is given in a dialogic process that allows the interaction and making of a collective (p. 51). Culture in dialogic teaching comes into place because we are "beings of transformation and not of adaptation" (Freire, 1997, p. 26). So, the contact with others makes us enter a new process of meaning where we appropriate various cultural tools (Wells, 1999) reshaping us constantly both in the cultural and psychological functions.

Dialogic teaching as a constructivist pedagogy develops transferable capacities to daily life. Wegerif et al. (1999) found out that studies that examined transfer performance in dialogic settings generally report positive results, including improved reasoning. Reznitskaya & Gregory (2013, p. 129). see in dialogic teaching an opportunity to develop the capacity to acknowledge own beliefs about the nature of knowledge as well as from others, and willingness to reshape beliefs based on the encounters with others. Those are beneficial to academic life, but most important as citizens part of a community.

2.3.3.3 Part of the Instructional Design

Dialogic teaching can also be conceived from the very moment that there is a purposeful intention embedded in the instructional design of class. Dialogic teaching can serve purposes such as stimulate student thinking and advance their learning

(Sedlacek & Sedova, 2017, p. 101), encourage children to meet and explore others' positions and reflect on their own positions at the same time (van der Veen et al., 2018), engage and shape children's thinking and learning (Alexander, 2008, p. 32), and for the co-construction of guided knowledge between teachers and students (Hardman & Hardman, 2017) among others. Having set one or more of these purposes in the instructional design, dialogic teaching takes part of the objectives, activities designed, and opportunities to participate.

Dialogic teaching as part of the instructional design calls for a shift in the traditional accepted roles of teachers and students. Resnick et al. (2018) consider it a double pedagogical shift in which teachers forget to get the right answer from students and value the participation as well as the possibilities that students bring, and from students to engage actively with content, rather than passively (p. 337). Instructional design implies "having purposely practices that provide students with opportunities to engage in learning talk across not only the lesson but through the whole program in a sustained manner" (Juzwik et al., 2013, p. 5). Dialogic teaching places considerable demands on teacher knowledge and flexibility (Alexander, 2015) calling the teacher to listen, lead, follow, respond, and direct (Boyd & Markarian, 2015, p. 273).

Some authors propose tools to further develop dialogic teaching as part of the instructional design. Alexander's dialogic teaching (2008) is characterized and exemplifies productive forms of dialogue in the classroom along five core principles: collective, reciprocal, supportive, cumulative, and purposeful. More so his work contemplates a dialogic teaching framework with four main components: justifications, principles, repertoires, and indicators (Alexander, 2018).

Dialogic teaching as part of the instructional design supports achieving educational goals. According to Resnick et al. (2018, p. 325), students who had opportunities to debate their ideas with classmates have better initial learning, retention, far transfer and general intelligence than students who experienced traditional teaching. Nussbaum & Asterhan (2016) have proposed that participation in classroom argumentation strengthens an even more basic set of capacities. The student is prompted to re-evaluate and possibly further self-explain or elaborate on his or her proposition (Resnick et al., 2018, p. 338). It focuses on the potential of student and teacher ideas to promote learning and inquiry (Boyd & Markarian, 2015, p. 273).

2.3.3.4 Critical Consciousness

In the previous subsections we analyzed perspectives of dialogic teaching considering its function for human interaction in language, pedagogy, and instruction. In this section, dialogic teaching is conceived as a critical consciousness perspective developed by Paulo Freire. Critical consciousness describes how oppressed or marginalized people learn to critically analyze their social conditions and act to change themselves (Watts et al., 2011). They become fully conscious, develop their full capacities, and fulfil their own needs in communion with the needs and aspirations of others (Orellana, 2016, p. 48).

The stance for a critical consciousness in dialogic teaching reflects a socio critical paradigm. In the previous review of philosophical foundations from the 20th century, we touched upon Habermas' work on critical theory and how this pointed to human liberation from their oppressors, implying a search that instigated a critical consciousness. One of Freire's main premises is that people are fully human when they

are free, meaning when they can choose out of their own will and can express themselves (Abdul Razzak, 2020, p. 1003). That has an implication to give a voice to all people as part of oneself development. Conscious of those different authors have addressed these issues of social class, inequity and accessibility in the linguistic research field reflecting a socio critical paradigm (Asterhan et al., 2020; Matusov et al., 2019; Snell & Lefstein, 2018).

The political and social context of the 20th century left humanity with clear examples of situations of disparity where the voice of many were silenced for which a dialogic teaching practice that developed critical consciousness was particularly relevant. In the Latin American context, Paulo Freire himself saw that in his native Brazil which prompted him to develop a Pedagogy of the oppressed (Gerhardtl, 1993). (Boyd & Markarian, 2011) Freire (1959, p. 15) was looking to achieve a "real democratization in Brazil" and his ideas also evoked the development of critical consciousness as one of education's objectives. The dialogic stance represented an opportunity to listen and provide space for student voices and build upon students' everyday knowledge to make lessons relevant to their contexts (Boyd & Markarian, 2011, p. 7).

Dialogic teaching seen in the eyes of critical consciousness carries a flag of emancipation. Dialogic teaching would prompt the ability to recognize and analyze systems of inequality and the commitment to act against these systems (El-Amin et al., 2017). Critical consciousness becomes particularly relevant for the Latin America context where the silenced groups are benefited by dialogic teaching. The emancipation

through dialogic teaching is rooted in the deconstruction of hierarchies and structures that are oppressive.

Social justice finds in education an opportunity to develop critical consciousness. It is through an education referred as liberation education that emancipation of the oppressed starts (Burbules & Berk, 1999). Here the oppressed become conscious of their situation and the practices that oppress them so it can emerge new structures. The education for critical consciousness is based on also challenging the traditional banking system in which those who hold themselves as wise donate knowledge (Freire, 2006, p. 79). As a result, critical consciousness points to a development of reflection and action that leads to creating a just and democratic society.

2.3.3.5 Recapitulation

In this subsection of dialogic teaching conception, we reviewed different perspectives. It is relevant to note that different research traditions are portrayed in how dialogic education has been approached showing that a dialogic pedagogy is transverse to multiple disciplines. Particularly, dialogic education as a (1) as a communicative relationship; (2) as a collaborative construction pedagogy; (3) as an instructional design methodology; and (4) as critical consciousness shows connections to philosophy, linguistics, and pedagogy.

2.3.4 Dialogic Education in Latin America

As shown in Figure 2.6, the purpose of this section is to narrow down the work of dialogic education in the context of Latin America. For that, this section is divided in two: the first one reflects on the socio-cultural background of the region; and the second one on current views of dialogic education for Latin American researchers.

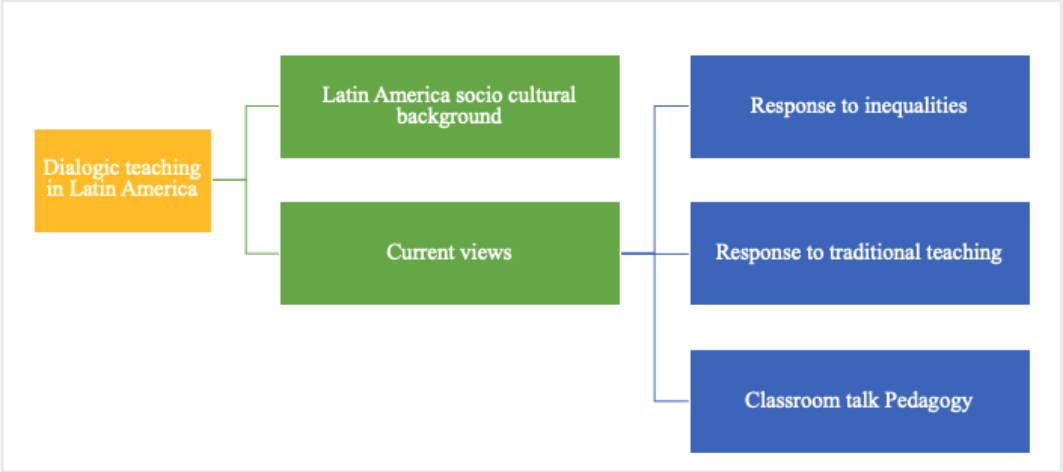


Figure 2.5 Dialogic education in Latin America

2.3.4.1 Latin America Socio Cultural Background

To be able to understand dialogism in Latin America it is necessary to point out its sociocultural aspects from the past which evokes its colonization history (1492-1810). Latin America was colonized by the Spanish, but the Portuguese and the French had also major influences. The colonization period represented the elimination of cultures and the appearance of others that are still struggling to find an identity umbrella that could cover them all.

The conquerors set their traditions and rules all over whipping the natives' culture and establishing their own power structures. The society structure was a mixture of the: peninsular, creoles (a new class emerged known as the Creoles (from the Spanish parentage, born in America), native (original people in Latin America), Africans (brought under slavery) and mestizos (from Spanish and native descent). The peninsular and creoles enjoyed the privileges of wealth, political power, and social status. The rest of the classes were left behind and traditionally struggled to have some social mobility and are often associated with marginalized contexts.

The colonization process was reinforced through education. The purpose of the colonial education for natives and Africans involved the assimilation of culture and traditions of the colonizers. For example, during the colonization period the Catholic church became an educational institution that searched to convert them to the faith. The orders of the Franciscans, Dominicans, Augustinians, and Jesuits had a major impact in this task. The effect of the imposing colonial education was the annihilation of the self.

The colonized lost their voice, language, beliefs, practices, history, and customs in the process. The educational systems prevailing reinforce to educate the masses accommodating to the elite's own beliefs. Recognizing the colonial character of Latin American societies leads us to intuit the equally colonial character of their knowledge systems, of their knowledge (López Rozo, 2007).

Even after Latin America independence movements that began in the 1800's the region was left with political uncertainty and structural impediments leading to resources dominated by elites. Quijano (2007)'s view is that coloniality persists as one of the most generalized forms of world domination because once formal European colonialism was destroyed there was a regime of global coloniality. Khilnani, (1967) makes it clearer stating that Latin America achieved statehood thanks to independence but not nationhood and self-government. It becomes evident that the creole aristocracy was neither ready to rule nor to control the territorial extent but there was desire to permeate in power.

There was a need to control. It is easy to understand that in a stratified society, in which there are social class, ethnic, gender and generational differences, is difficult

for those sectors that hold power to seek social participation and democratize decisions in aspects so fundamental to the social future (Isch Lopez, 2015, p. 45).

2.3.4.2 Dialogic Education in Latin America

Reviewing Latin America researchers and their work in dialogic education, their educational intervention is a response to inequalities, as a response to traditional teaching, or as a classroom talk pedagogy.

2.3.4.2.1 A Response to Inequalities

The 528 years history of inequality in Latin America is still visible in the contemporary world. Latin America entered the 20th century with prominent levels of inequality due to the persistence pattern of institutions that favored the elites and provided the bulk of population with limited access to economic opportunities (Sokoloff & Robinson, 2003, p. 176). From a critical theory perspective, it becomes evident the need to search for a liberation of the elites making the Figure of Paulo Freire still relevant.

Paulo Freire is still in our days a source of inspiration to challenge the current social order through education. Fernández-Cárdenas & Reyes-Angona (2019) reported that the Brazilian pedagogist and philosopher continues to be the main representative in the region, inspiring educational proposals based on an equal relationship with the other. Freire's notion of dialogue's nature and purpose is human and social empowerment (Alexander, 2018, p. 3). According to many researchers, Freire's influence on contemporary education is obvious (e.g., Bell Jiménez, 2017; Shih, 2018). This influence springs mainly from his concept and approach of critical and dialogic pedagogy (Abdul Razzak, 2020, p. 999).

Freire's work has a high sense against oppression. The oppression Freire saw was what he called the anti-dialogic action theory characterized by conquest, division, manipulation, and cultural invasion (Freire, 2006, p. 159). For that reason, he considered that it was a farce to talk about democracy and keeping the people silent (p. 111). In the educational field, Freire called this the banking model which presumes "that learners are ignorant and must therefore receive the greater wisdom of the enlightened" (Orellana, 2016, p. 51).

Freire's proposal to inequalities is centered in dialogue. "Dialogue is this encounter of men, mediated by the world, to pronounce it not exhausting, therefore, in the mere I-you relationship" (Freire, 2006, p. 10). In that encounter, Freire sees the opportunity for reflection and action towards transforming and humanizing the world. A social transformation, which would lead to greater justice and better life conditions for all because the individual transforms its socially achieved status for themselves. That means that dialogue becomes the essence of the revolutionary action.

2.3.4.2.2 A Response to Traditional Teaching

Dialogic education is a response to traditional teaching pedagogies. In the eyes of Freire (2006). there is a consistent critique towards an education that imposes itself in the minds of the learners and instead sees dialogism as the coherent solution. In traditional schooling, there is a tendency for the teacher to monopolize speech. Therefore, there are few opportunities for the construction of a position of the students, with few initiations of speaking turns by the student (Rojas-Drummond, 2000).

Dialogic education then is a call to transform the traditional teaching practices. Reznitskaya & Gregory (2013) call for a shift from traditional school practices to more

dialogic pedagogy in which participants reshape their views on knowledge, authority, and learning. For Freire (2006) the dialogic is “organized, systematized, and increased to the people of those elements that it delivered in an unstructured way” (p. 113). This implies a complete opposition to educational practices of donation or imposition. Teachers with a dialogic stance will try to listen better and seek out more appropriate foreknowledge in their students to offer more meaningful and lasting connections between what a student knows and what he or she is coming to know (Boyd & Markarian, 2011, p. 7).

Dialogic education proposes to transform and improve the education situation of oppression. The liberating and non-banking education transforms education by acknowledging others' thinking, allowing them to discuss their thinking, their own vision of the world, manifested, implicitly or explicitly, in their suggestions and those of their colleagues (Freire, 2006) Dialogic education contributes to equivalent shift taking, clear and inclusive positions, recognition of the history and culture of a community and an assessment of plurality (Fernández-Cárdenas, 2014) which decreases barriers implemented by oppressive systems.

Dialogic education reshapes the features of education. Matusov & Marjanovic-Shane (2018) would call it a genuine education in the pursuit of a critical examination of life, self, world, and society (p 24). For Rantalo (2016) in dialogic education the concept of collective reflection breaks through holding an emancipatory potential providing opportunities to make visible social and cultural premises of a particular context that are often taken for granted (Rantalo & Karp, 2016). That same collective reflection comes in multiple forms such as anticipatory, deliberative, organizing, and

critical (Keevers & Treleaven, 2011). In the eyes of Fernández-Cárdenas (2014) dialogic education bets on the construction of horizontal relationships in which as teachers allow students to talk more and express themselves more frequently, students will be favored building their own knowledge (p. 200).

2.3.4.2.3 A Classroom Talk Pedagogy

Dialogic education as a classroom talk pedagogy has been explored by different Latin American authors exploring different angles. Contemporary works can be found in the hands of Fernandez-Cardenas, Silvia Rojas-Drummond, and Nestor Daniel Roselli, who are explored to reveal their perspectives.

2.3.4.2.3.1 Juan Manuel Fernández-Cárdenas

Juan Manuel Fernandez-Cardenas is from Mexico, holds a PhD in Education and Language Studies and currently working at Tecnológico de Monterrey. His work on dialogic education is particularly focused on academic writing activities (Fernández-Cárdenas, 2014; 2015; Reyes-Angona & Fernández-Cárdenas, 2015), STEM education (Fernández-Limón et al., 2018; Lotz et al., 2019; Montgomery & Fernández-Cárdenas, 2018; Reynaga-Peña & Fernández-Cárdenas, 2019) and the use of technological education (Ramírez-Ramírez & Fernández-Cárdenas, 2018; Reynaga-Pena et al., 2020; Salinas et al., 2016). His work also portraits a social justice agenda given that he has been addressing problems in traditionally marginalized groups, given their economic situation (Ching-Chiang & Fernandez-Cardenas, 2020), abilities (Reynaga-Peña & Fernández-Cárdenas, 2019) and migratory status (González-Nieto et al., 2018).

Fernández-Cárdenas (2014) sees dialogism as an alternative to analyze educational practice, but also to promote interactions that are more symmetrical,

relationships with more authenticity and openness to express themselves. He values the concepts of sequentiality, positioning, plurality, and historicity as dialogic features. There is also an appreciation for different voices to build one's own discourse (Reyes-Angona et al., 2020).

2.3.4.2.3.2 Sylvia Rojas-Drummond

Sylvia Rojas-Drummond is also from Mexico, and currently working at Universidad Nacional Autónoma de Mexico. Her work on dialogic education is carried out in literacy and writing contexts (Guzmán-Tinajero & Rojas-Drummond, 2012; Rojas-Drummond et al., 2008, 2010, 2016, 2017, 2020b), in coding schemes for analyzing classroom dialogue (Hennessy et al., 2016), teaching-learning strategies (Rojas-Drummond et al., 2020) and collaborative learning (Rojas-Drummond et al., 1998, 2006, 2013, 2014; Rojas-Drummond & Mercer, 2003)

Rojas-Drummond's efforts have been leading to the construction of a coding scheme for analyzing classroom dialogue across educational contexts named Scheme for Educational Dialogue Analysis, SEDA, (Hennessy et al., 2016), which may be perceive as encapsulating dialogue under a framework and risking the richness of each particular social and cultural contexts. However, other Rojas-Drummond's findings are relevant for dialogic teaching in the sociocultural perspective following this study. For example, her findings around dialogic teaching as a classroom talk pedagogy contribute to teacher professionalization and to increase student's participation, impacting beyond the school community (Rojas-Drummond et al., 2020a, 2020b). Another relevant finding is that collaborative learning propels the development of self-regulated skills (Guzman-Tinajero & Rojas-Drummond, 2012).

2.3.4.2.3.3 Nestor Daniel Roselli

Nestor Daniel Roselli is from Argentina, holds a Doctorate degree in Psychology and currently works at the Research Center on Psychology and Psychopedagogy of the Catholic University of Argentina and at IRICE (Instituto Rosario de Investigación en Ciencias de la Educación) of the National Scientific and Technical Research Council. His work focuses on analyzing verbal interactions in collaborative settings (Borgobello et al., 2013; Castellaro & Roselli, 2015; Peralta & Roselli, 2016), analyzing the relationship between collaborative peer interaction and its cognitive effects (Castellaro & Roselli, 2015; Castellaro & Roselli, 2018, 2019, 2020) and collaborative learning strategies for university teaching (Roselli, 2017).

His main findings that are relevant for dialogic teaching as a classroom talk pedagogy are that teachers who have more experience lead lessons with more conceptual opening, in contrast to teachers with less experience, who would fit to a more predetermined screenplay for education (Borgobello et al., 2013). That is, didactic strategies and styles are highly dependent on the teacher who can choose between collaborative, guided-participative or expository class (Peralta & Roselli, 2016). Similarly, socioeconomic contexts play a key role in the transmission and use of linguistic symbols and basic socio-relational modes (Castellaro & Roselli, 2015).

2.3.4.3 Recapitulation

The Latin American context as a region presents a history of colonization that shaped the region's memory, self-perception, and character. Therefore, the region presents the need for an educational intervention that acts as a response to inequalities,

as a response to traditional teaching, and as a pedagogy that defies traditional banking systems.

Dialogic education is a tool to enact critical consciousness and actions to transform the Latin American socio-political and economic situation. However, there is a need in the region for a dialogic education that carries a social justice agenda based on contemporary strategies. The strategies should emphasize the concept of the other in the dialogue, collaboration in the construction of knowledge and a focus on teacher training and professional development.

Even though the researchers reviewed above carry this dialogic education agenda, they have not fully developed this agenda. Hence, there is a niche to position myself in the STEM dialogic education with a transformative agenda.

2.3.5 Researcher Positioning in Dialogic Education

Across the "Dialogic education" section, I reviewed some philosophical foundations in which dialogism was grounded, describing the main conceptions of dialogic education and the actual debate in Latin America. The purpose of dedicating space to develop these topics was that they help me to build the case of the dialogic component for a genuine interdisciplinary STEM education.

The reason behind making a special emphasis in dialogic education for interdisciplinary STEM education is that it brings to the table a dialogue among the disciplines and stakeholders. The current educational system in Latin America as a region is still carrying colonization marks that reinforce social structures and limit mobility which are contradictory to the purpose of education to get better opportunities

and a better future. As a result, it is important to retrieve a conception of education for social justice under a critical and transformative theory mediated by dialogic education.

Similarly, sociolinguistic and discourse analysis approaches have evolved as a field to take into consideration more social approaches in the construction of knowledge. This brings an opportunity for an analysis of the dialogic on the foundation of, what I would want to adhere, a critical and transformative theory appropriate to the context of Latin America.

To portray this type of analysis of the dialogic approach for a critical and transformative theory in an educational context, it would be important to consider a framework that features:

1 Dialogic education is seen as social construction of knowledge where the key is the relationship between teachers and students. Dialogic education by nature presents a relationship with others, but it is in the recognition of others and how we manage to give out a voice to others that dialogue is formed. The student and teacher dialogic relationship demands a role from teachers as facilitators of the dialogic education approach. Therefore, in the attempt to recognize others, in particular students, it also demands from teachers a process of self-reflection on how to give opportunities to students to voice out their opinions and questions, how to open a safe space for different perspectives to be voiced and how to make students independent thinkers and active citizens. For these demands to be fulfilled, then it is necessary to put in brackets the traditional hierarchy in which the teacher has been the source of knowledge, so that nobody could question his/her authority over a topic. It is key to let flourish relationships in which horizontal communication is cultivated. In that

way, through a diversity of voices, a dialogic space could come to build knowledge where it is not necessary to agree, but to coordinate various positions.

2 Dialogue embedded with the inner idea and practice of respect towards the other and can generate a critical reflection about reality. The communicative or dialogic action features the participation of different social agents, which is contrary to imposition, features the subject's freedom to build knowledge based on his own meanings, perceptions, and reflections, learning to have a voice, and to be a good receiver.

3 Dialogic education as an opportunity to carry socio political agendas that have repercussions in the life of citizens. By no means, this does not imply to use dialogic education as a brainwashing process, but to open a space to develop critical thinking in citizens that would allow them to solve issues locally, and fully aware of the repercussions it can have globally. It also considers fraternal caring for others. In that sense dialogic education is not limited to empathy but an ethics of caring for other which includes responsibility, solidarity, and commitment to the circumstances of the others.

The framework here does not intend to portray the whole picture but become pieces in the puzzle of creating a comprehensive framework for dialogic education that could help Latin American schools in marginalized contexts fuel discursive relationships that empower educational actors for social transformation

Chapter 3: Methodology

3.1 Introduction to the Chapter

While in the first chapter I shared my personal agenda through previous experiences, and in the second chapter I presented formal academic research through a scoping review about my interest in dialogic STEAM education, the purpose of this third chapter is to present the methodology used for this research.

The strategy I followed to assemble the methodology was first to conduct a pilot study (Section 3.2) before establishing the main study methodology (Section 3.3). which aimed to analyze how theory and praxis interact in terms of dialogic educational practices in non-formal contexts. From the pilot the study, I reflected upon the research interest, procedure, and my trajectory as a researcher which led to establishing a series of lessons learned (Section 3.2.13). They became an input that shaped the methodology design of the main study (Section 3.3).

It is relevant to clarify at this point that the pilot study was done to have a previous experience in designing and implementing a dialogic experience in a non-formal context as well as in the researcher's ability to design a complete research procedure in a different context of the main study. However, the main study is not an extension of the pilot study. Table 3.1 purpose is an overview of the main methodological frameworks between the two studies in which I participated as a research student. Additionally, in High STEAM, I also participated doing administrative and academic tasks such as creating the academic plan with the topics and activities for

the five modules, preparing a detailed budget with the materials needed for each session, and working the design of the experience of the social service students, teachers, and high school students.

The data I have used for my thesis is only a sample of the data collected as a whole in the projects *"Hyperlocal Learning Network La Campana-Altamira: Supporting digitally enhanced maker education for low resourced communities during a pandemic"*, led by Dr. Nicole Lotz (The Open University), and *"HIGH STEAM: Transformative education through science, technology, and art in marginalized communities in Monterrey"*, led by Professor Juan Manuel Fernández-Cardenas (Tecnológico de Monterrey). With the data available in each project, Doctor Lotz and Professor Fernández-Cárdenas, the academic and legal responsible of these projects, are producing official technical reports for the corresponding funding bodies, developing analyzes with other research purposes, and writing manuscripts for publications with other colleagues. My research is just a parcel of the academic work led by these scholars and other contributors and partners in each of these projects. In each of these projects, I have also collected data which are reported originally as part of this dissertation, in a subsequent personal effort doing my own fieldwork.

Table 3.1 Summary of Pilot study and Main study

	Pilot Study Hyperlocal Learning Network La Campana-Altamira: Supporting digitally enhanced maker education for low resourced communities during a pandemic	**Main Study** High STEAM: Transformative education through science, technology, and art in marginalized communities in Monterrey
Funded by	The Open University	United States Consulate of Monterrey
Academic, financial, and legal representative	Dr. Nicole Lotz (The Open University)	Prof. Juan Manuel Fernández-Cárdenas (Tecnológico de Monterrey)
Participating institutions	2 Higher education institutions, 2 Non-profit institutions	2 governmental institutions, 1 higher education institution, 6 public vocational high schools
Location	Campana Altamira district in Monterrey, Mexico	Monterrey, San Pedro, Apodaca, Escobedo, Montemorelos, Guadalupe located in Nuevo León, Mexico
Period of research	January to June 2021	June 2021 to June 2022
Participants	11 Families, 12 Higher Education Students, 9 Scholars from different countries	10 High School teachers, 124 High School Students, 19 Higher Education Students
Instruments	Semi-structured Interviews, field notes, artifacts	Semi-structured Interviews, ethnographic field notes, artifacts, focus group, Educate Insight Thinking Mindset test
Research Paradigm	General Qualitative	Mixed Methods
Research Procedure	Design and implement social design experiment: Hyperlocal Learning Network La Campana-Altamira. Collect and analyze data	Design and implement social design experiment: High STEAM. Collect and analyze data
Social design experiment	4 STEAM dialogic sessions	20 STEAM dialogic sessions
Analysis strategy approach	General qualitative strategy	Mixed Methods (convergent parallel design)

The relevant connection between the two studies with the main objective of this thesis is that both were social design experiments implemented in non-formal contexts. From the lessons learned in the pilot study, the research paradigm and analysis approach were modified in the main study, as presented in section.

3.2 Pilot Study

3.2.1 Introduction

For this dissertation, I implemented a pilot study before the main study, due to the benefits associated with it. A pilot study is a feasibility study which purpose is the improvement of the quality and efficiency of the main study (In, 2017; Y. Kim, 2011). In that way, it was expected that running a pilot study would increase the likelihood of success in the main study (van Teijlingen & Hundley, 2002).

For my pilot study, I had the opportunity to be part of the "Hyperlocal Learning Network La Campana-Altamira", a research project led by Dr. Nicole Lotz, from The Open University. My participation in the project was possible thanks to an academic relationship previously established between researchers of The Open University and Tecnológico de Monterrey, as led by Prof. Juan Manuel Fernández Cárdenas, in the design, implementation and operation of the Fab Lab Campana (see González-Nieto et al., 2020; Lotz et al., 2019).

In the pilot study, I conducted research under a qualitative perspective that included a case study and a participatory research approach (Section 3.2.2) to answer inductively the proposed initial research questions (Section 3.2.3). The pilot study was

done in the context of a traditionally marginalized area in Monterrey, Mexico (Section 3.2.4) where the participants were selected responding to the research objective and included the project team, undergraduate students, and families (Section 3.2.5). Among the instruments that were assessed in the field study were field notes from the participatory observations, semi-structured interviews, as well as documents, photos and videos produced in the project by the participants (Section 3.2.6). The research procedure I followed was divided in three phases: Designing the intervention, Implementing the intervention, and Data collection (Section 3.2.7). Next, I specify ethical considerations taken during the research (Section 3.2.8) Then, it follows an explanation of the analysis strategy (Section 3.2.9), and a summary of the data collected (Section 3.2.10). The results were organized according to the domains established from the pilot study questions (Section 3.2.11), and then a discussion is provided (Section 3.2.12). Finally, lessons learned for the pilot study were established (3.2.13) to serve in adjustments of the methodology for the main study.

3.2.2 Methodology

Considering the interest of this research, and the proposed research questions for the pilot study (section 3.2), the methodology was based on a qualitative tradition paradigm. As described by Denzin & Lincoln (2011) qualitative research is a situated activity that locates the observer in the world involving an interpretive, naturalistic approach to the world where there is an attempt to make sense of or interpret phenomena in terms of the meanings people bring to them.

As a site of multiple interpretative practices, qualitative research is pertinent to understand how dialogic educational practices look like in non-formal educational

contexts. Creswell (2013, p. 44) asserted that qualitative research works under an interpretative/theoretical framework that addresses the meaning that individuals or groups ascribe to a social or human problem. This is useful because rather than aiming to quantify dialogic educational practices, it is the richness of the participants' meanings and context that I aiming to understand. Moreover, other reasons to use qualitative research is that they allow flexible and inductive design rather than a fixed, and deductive one (Maxwell, 2012; Robson, 2011). The benefit of being flexible and inductive is that, during the study, the design can respond to new developments.

In a qualitative research design, Creswell & Poth (2018) consider that it is relevant to consider the philosophical assumptions and interpretative frameworks underlining the overall research. In my case, the use of a **theoretical-critical perspective** in the pilot responded to my personal experience before this dissertation and the goals set for the future. According to Horkheimer (1982) the theoretical-critical perspective aims for human emancipation from the circumstances that oppress them. In that sense, my personal agenda with dialogic educational practices is precisely to comprehend how they can impact communities in marginalized situations and give an opportunity to hear voices that are traditionally silenced.

There is a **social justice agenda** that I am also aiming to operationalize. This agenda is based on the ideas of solidarity, inclusion, and equity, which are described by Jara (2010) as pillars for social change in education in Latin America. The notions of social change for the region were strongly shaped by movements searching for an education that could be of its own. This search took names such as Popular Education, Liberating Education, Pedagogy of the Oppressed, Emancipatory Education, Critical-

Social Pedagogies, and Community Pedagogies. Gaviria & Holguin (2017) identified four major milestones that contributed to take a view of education for and from Latin America. First, the ideas of Rodríguez (1979) for whom education in America should make Americans and not Europeans, and should enable those educated to make a living. Second, building popular education universities, especially successful in Peru, El Salvador, and Mexico, which granted a consciousness of the place and role in history to learners. Third, the recognition of native Indigenous knowledge and culture in the construction of educational practices and pedagogy. Fourth, the movement "Fe y Alegría" which pushed forward an education that break the chains of oppression through education. Undoubtedly, the work of Freire (2005) had a strong impact in the region placing learners at the center of education and teachers as guides of the learning process in order to avoid the banking education system. In the 1980's this proposal was connected to sociocultural movements propelling spaces for debate and dialogic methodologies proper for the region.

In the qualitative design, I conducted the research using **ethnographic and case study tools** because they provide a deeper view of the ways of collecting data for complex dialogic practices.

The use of ethnographic tools for the pilot study are rooted on the benefits that ethnography presents as a qualitative research approach. Ethnographic tools (see J. Greene & Bloome, 2004) allow ethnographers to examine shared patterns among members of families. I chose three **ethnographic tools**: participant observation, ethnographic field notes, and interviews. According to Maxwell (2012), through ethnographic tools the researcher can study the meaning of the behavior, the language,

and the interaction and the members of the culture group. This was important because of my role as designer, and researcher in the project team of the Hyperlocal Learning Network La Campana Altamira where I interacted with the participants too. Creswell & Poth (2018) described it as the act of noting a phenomenon in the field setting trough the five senses. In that respect, participant observation allowed me to be immersed in the lives of participants and produce ethnographic field notes that were triangulated later with interviews too.

I chose **case study tools** because of its holistic, dynamic, and in-depth exploration qualities. The first reason, holistic, is explained by Yin (2011) who sees the value of a case study in the fact that this research examines the context, and other complex conditions related to the case being studied as integral parts that serve to understand the case. In that sense, the socio-cultural, economic, and political conditions are fundamental to understand participants of the Altamira hill, a marginalized community in Monterrey, in their dialogic educational practices. Another reason to select a case study is the dynamic quality that Mills et al. (2010) recognized. They consider that with this case study approach, researchers are not bound to a defined set of questions which allow them to expose different patterns after the interviews. In that sense, the case study could allow to inquire not only about critical thinking and transformation but also observe other patterns. Finally, the in-depth exploration is explained by Simons (2009) as the capacity to explore the subject from multiple perspectives of the complexity and uniqueness in a “real life” context. These holistic, dynamic, and in-depth exploration qualities are appropriate to explore a non-formal educational context for the particularities that arise due to the social, economic,

political, and historical components of La Campana-Altamira, where the pilot study took place. The case studies tools also include interviews and participant observations as in ethnography, but in addition, I analyzed documents and physical artifacts tools. According to Creswell & Poth (2018) using documents and physical artifacts are useful as supplemental materials of interviews and observations. A more detailed account of the instruments selected is provided in section 3.2.6.

3.2.3 Research Questions

The Hyperlocal Learning Network La Campana-Altamira project had its own goals and research question, but for the purpose of this pilot study in the framework of this dissertation, I established my own research questions:

1. What do dialogic educational practices look like in a non-formal context of education?
2. How non-formal STEM activities in vulnerable communities are a source of critical thinking in the Hyperlocal Learning Network La Campana-Altamira?
3. How non-formal STEM activities in vulnerable communities are a source of critical consideration of their own circumstances in life for the transformation of participants in the Hyperlocal Learning Network La Campana-Altamira?
4. How the process of designing the Hyperlocal Learning Network La Campana-Altamira project shaped my own learning trajectory in terms of: (1) designing an intervention study with a multicultural team and (2) research methodology?

3.2.4 Context of the pilot study

The purpose of this section is to give a comprehensive context in which the pilot study was developed. To achieve that, it is relevant to present first a geographical description, and historical background of La Campana-Altamira (section 3.2.4.1) as the context where the study took place. After that, I give a background for the Hyperlocal

Learning Network La Campana-Altamira (section 3.2.4.2) as well as the phases of the project (3.2.4.3) and the tools (3.2.4.4) used during the implementation which portrays.

3.2.4.1 La Campana Altamira

The city of Monterrey is the capital city of Nuevo León, one of the 32 Mexican states which generates 7.6% of the gross domestic product (GDP) of Mexico, holds a population of 5.75 million people and has a GDP per capita of $18,912USD (Data Nuevo León, 2021). Monterrey is a flourishing and culturally diverse city in the state of Nuevo León, which population represents 21.7% of the overall state population. It is a city that has attracted internal and international migration due to is economic dynamics based on manufacturing, commerce, and construction. According to the 2015-2016 Census, Monterrey has a density of 3,414.5 habitants/population, 96.7% has access to water, 99,9% to electricity, 59.6% access to internet, 54.1% to computers and 86.2% to the Internet (INEGI, 2016). Despite the economic development in Monterrey, there is an economic gap that has a tendency to be more and more inequitable (Aparicio Moreno et al., 2015; Sandoval-Hernández, 2005) which can be seen in the marginalized areas neighboring more developed districts. One of the marginalized areas is La Campana-Altamira district, where this pilot study was conducted.

La Campana-Altamira district is in the south-central part of the city of Monterrey, and it is paradoxically located in front of the municipality of San Pedro Garza, one of the richest economic areas not only in Mexico but in Latin America. The polygon that delimits the Campana Altamira District has an area of 1.68 km2 and is made up of two hills separated by a stream. The district has fifteen estates which include La Campana and Altamira hills. La Campana-Altamira's location have access to

relevant points of the city through Lazaro Cárdenas Ave., Rio Nazas St., and Alfredo Garza Ríos Ave.

The urbanization process that the district has experienced presents risks due to the lack of planning and adequate urbanization (IMPLANMTY, 2017) (See Figure 3.1). There are settlements at the crest of the two hills, La Campana and Altamira, making it inaccessible to motorized vehicles. As a result, a person at the upper part of the district would have to walk an average of 35 minutes from their home to the nearest bus stop. This also means the inhabitants do not have access to many of the basic services to which the rest of the citizens have access. Another problem derived from the accessibility issue is that people end up paying higher prices for food because they must add up mobilization costs. There are two main markets that operate in the area: one on Wednesdays located in the Campo Los Pinos, which is an open field, and the second one during the weekends around a vocational public school. Both require people to go down the hills to stock up on food.

Figure 3.1 Housing and street infrastructure in la Campana-Altamira

The people in La Campana-Altamira have jobs characterized by low income and precarious working conditions including informal working situations where inhabitants do not have benefits or written contracts. They usually engage in jobs as factory

workers, domestic workers, cleaning services, customer service in restaurants, hotels, laundry, and ironing (IMPLANMTY, 2017).

The Municipality of Monterrey through the state Law of Human Settlements, Land Management and Urban Development established the Partial Urban Development Program of the Campana-Altamira District 2020-2040. The purpose of this program was that through a co-creation planning the habitants could develop skills, knowledge, and participation to contribute to the projects and actions that would be established in the district. In that same line, since 2013, Tecnológico de Monterrey, a private higher education institution neighboring the district, has implemented social program initiatives to develop the socio-economic aspects, as well as access to the hills.

During the pandemic, the living conditions worsened including the access to educational opportunities. The unequal access to ICT impacted the continuity of education because families had to prioritize the use of money for food and health. In La Campana-Altamira very few students had a permanent Internet connection and devices to attend online classes. Students were faced with two options to either completely dropping out of schooling or having poorer quality education in a formal learning setting. The government established a distance education strategy through a TV program series called *"Aprende en casa"* ["Learn at home"] for primary and secondary schools so they could reach more students. The dynamic was that students would receive the class explanation on TV and then complete their homework in physical notebooks. Then, they would use their limited Internet access to send schoolwork through applications like Facebook, WhatsApp, Google Classroom or Microsoft Teams. The lack of access to technology widened educational disparities and hindered

development opportunities for people in marginalized situations (see also González-Nieto & Fernández-Cárdenas, 2021). It is under these circumstances that the Hyperlocal Learning Network La Campana-Altamira was born in July 2020.

3.2.4.2 Hyperlocal Learning Network La Campana Altamira

3.2.4.2.1 Background

Hyperlocal Learning Network La Campana-Altamira was a project organized by researchers in the United Kingdom and Mexico and supported by La Campana-Altamira Initiative led by Distrito TEC, a non-profit organization who works for the urban development in the marginalized community of La Campana-Altamira. The academics had established a previous relationship through the work done in the creation of FabLab Campana, a fabrication laboratory located in the facilities of a local vocational high school in La Campana-Altamira (González-Nieto et al., 2020; Lotz et al., 2019) in 2018-2019.

The researchers had two specific concerns related to Covid-19 pandemic. The first one was that the lockdown caused the FabLab Campana closedown which meant shutting down the opportunities to quality educational experiences, especially in the field of STEAM education, for the community which promoted active learning and critical thinking (Hernández-de-Menéndez et al., 2019). The second concern was that even though, some schools adopted different strategies to move to online education, the socio-economic conditions of families in La Campana-Altamira did not allow this strategy to work for all because there is unequal access to ICT due to having permanent Internet connection or even devices to attend online classes as explained in the previous section.

Hyperlocal Learning Network La Campana-Altamira purpose was to create equitable access to quality education and socio-economic development opportunities through hyperlocal and creative learning networks. It aimed for La Campana Altamira community to engage in informal, creative, maker-based learning in a social setting. In that way, it was expected that during the pandemic they could continue developing relevant skills and sustain the motivation to learn and change. The Hyperlocal Learning Network La Campana-Altamira research was led by the question: How can hyperlocal networks support digitally disadvantaged families in a marginalized community to learn together from their homes through creative making?

3.2.4.2.2 Phases of the Project

The Hyperlocal Learning Network La Campana-Altamira project had a timeline of one year, from July 2020 to June 2021. The main phases during the Hyperlocal Learning Network La Campana-Altamira project are described in Figure 3.2

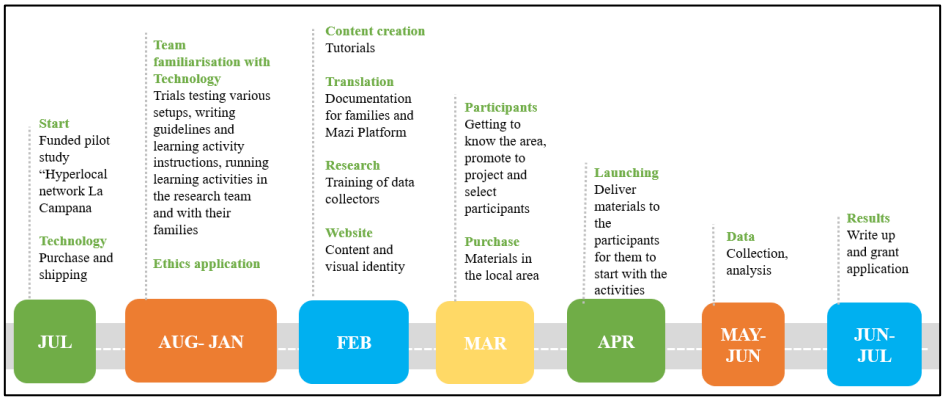


Figure 3.2 Hyperlocal Learning Network La Campana-Altamira timeline

In July 2020, the project started with a seed fund to make the feasibility study of the hyperlocal networks. From August to January, the short-range local and closed Wi-Fi networks were assessed by the project team in their own houses. At the same time, it

was a period to write up guidelines on the use and assess the four STEM activities proposed to the families: decoder, soap making, mask making and drawing robot. During February 2021, the undergraduate students came on board, and they collaborated with the content creation, translation, and data collection instruments. In March, participants were invited through two informative sessions to be part of the project. In April, the families were given a box with materials for the activities as well as the phone, sim card, and the corresponding raspberries were placed. The last two weeks of April and beginning of May served to collect data. June and July were used to analyze data and dissemination of the information. The Hyperlocal network La Campana project was also a pilot study for researchers aiming to establish a scalable process to be in a better position to acquire external funding for a larger project in the Campana-Altamira project. That larger project envisioned that hyperlocal informal learning networks can function as a bridge to formal learning and reinforce connections to wider education networks.

3.2.4.2.3 Tools

Based on previous successfully used activities in the community, the team proposed four creative activities: a decoder wheel, a drawbot (a robot that draws), making soap, and making face masks; that could be conducted at the families' homes. To conduct those activities two tools were given to the families: the Craft Kit and the MAZI platform.

The families were given a craft Kit as seen in Figure 3.3.

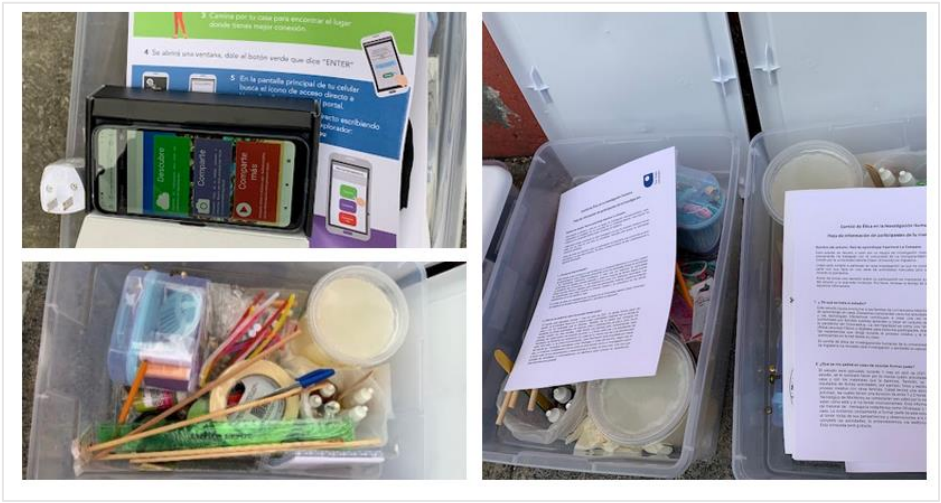


Figure 3.3 Craft Kit for the families

The kit included a copy of the information sheet, consent form, starting guide, and materials such as motor, markers, wires, tape, ruler, sewing kits, fabrics, papers, glycerin, scented essential oil, and a cell phone with phone line, among others. The Open University provided the funding to purchase materials and technologies to enable the participants to engage them in learning opportunities during the pandemic lockdown and social distancing regulations.

The use of hyperlocal networks was suitable for the project due to the low-cost networking technologies where internet or cell phone networks are not suitable. The project used MAZI, an open-source digital platform to create the hyperlocal networks. MAZI empowers local communities to participate and communicate in a more local level. The phones connect to the digital platform MAZI through the wireless network without the need of cell phone data. MAZI had three sections *Descubre, Comparte and Comparte Más* [Discover, Share and Share more] as seen in Figure 3.4.

Figure 3.4 MAZI Digital Platform

Through the *Descubre* section, the Hyperlocal learning network enabled the community to learn through four videos of the Decoder, Soap, Face Mask, and Drawboat. The instructional design of the videos is described in Appendix A.1 to A.4. Meanwhile, the *Comparte* and *Comparte Más* sections allowed them to communicate with other members. The difference between the *Comparte* and *Comparte Más* section was that in the *Comparte* section participants were able to share pictures and messages while the *Comparte Más* section they could upload other type of files such as mp4, docx, etc. From the safety of their homes, families in a marginalized community could still engage in STEAM learning activities to develop digital and creative skills.

The Raspberry Pi is a “tiny, dual-display, desktop computer and robot brains, smart home hub, media center, networked AI core, factory controller, and much more” (Raspberry Pi, 2021). In Figure 3.5 you can see how this tiny computer looks like. In

the Hyperlocal Learning Network La Campana-Altamira project, the Raspberry Pi functioned as the cloud where participants could pull out content from the *Descubre* section, and upload the pictures, videos, and comments through the *Comparte* and *Comparte más* sections. Five Raspberry Pi were given to the selected families which location best suited connectivity.

Figure 3.5 Raspberry Pi

3.2.5 Participants of the project

The participants who took part in the pilot study were classified in one of the following groups: project team, undergraduate students, and families. The names used below are pseudonyms to protect their real identities

3.2.5.1 Project Team

The project team was responsible for the design, implementation, monitoring, evaluation, and dissemination of the project. The project team consisted of nine people, including myself, as seen in Table 3.2.

Table 3.2

Pilot Study: Project team

Project team	Occupation	Project title
Nancy	Senior Lecturer	Project leader, translation team leader
Daniel	Senior Lecturer	MAZI Expert, translation team leader
Mathew	Lecturer	MAZI Expert, translation team leader
Amanda	PhD student in	Project leader Mexico, Content team leader
Renato	Architect and project designer	Researcher, Content team leader
Valentino	Community linker	Link with the community
Nicolás	Lecturer and Researcher	Researcher, Research team leader
José	Lecturer and Researcher	Researcher
Lay	PhD student in Educational Innovation	Researcher, Research team leader

The team was selected by invitation of Nancy, the project leader, who used her previous academic relationships with the team in Mexico and the UK to put together this team. Three of the members were physically located in the United Kingdom, while for the team in Mexico: one was in Mexico City, and five were in Monterrey. The Mexico team had previously collaborated with Nancy in setting up the FabLab La Campana. Meanwhile, Nancy with the UK team were united in their interest in Design Thinking, and by previous experience as lecturers in the same university.

My role in the Hyperlocal Learning Network La Campana-Altamira was as member of this group and co-leading the research team of the undergraduate students. I also took part in the data collection with the research team with two of the families.

3.2.5.2 Undergraduate Students

The undergraduate students were the ones responsible for translation, content creation, and data collection from families. They were twelve students from Tecnológico de Monterrey community service program. As part of the graduation requirements, undergraduate students must complete 480 hours of community service. Every semester, they choose to join a community project that best suits their interest.

The Hyperlocal Learning Network La Campana-Altamira set itself as a community service program and was opened for twelve students to join the project in one of the three teams: Translation, Content creators, or Research team.

The students were selected through an interview process that included questions such as their career, the reasons why the wanted to join the program, and their previous community service programs. After the interview process, the selected students were assigned to a group based on their interests as described in Table 3.3. We had four female students and eight male students between 20-22 years old.

Table 3.3

Pilot study: Undergraduate Students

Team	Student	Career	Team Leaders
Translation	René	Mechatronics	Nancy, Mathew, and Daniel
	Christian	Computer Science	
	Hector	Physics	
	Abigail	Mechatronics	
Content	Fátima	Chemistry	Amanda and Renato
creators	Abraham	Chemistry	
	Roman	Animation	
	Sara	Law	
Research Team	Omar	Economics	Nicolás, Lay, and José
	Lucas	Mechanics	
	José	Communication	
	Leonor	Biomedicine	

Table 3.4 is a calendar of the activities stating the activities each team had. The translation team job included to translate from English to Spanish the MAZI digital platform, the information sheet, and consent form, and from Spanish to English the data collected from the research team. The content creators' team was responsible for making video tutorials for the family and for the project's website. Finally, the research team received training on participatory action research, design of instruments, and

interview protocols, so that they could collect data from the participants through an initial interview, follow up and final interview.

Table 3.4

Calendar of Activities

Week	Activity	Undergraduate Students		
		T	C	R
1	Kick off Session / Weekly Meeting with students	x	x	x
2-3	Welcome videos		x	
	Literature Review			x
	Introduction to research	x		
4-5	MAZI Platform Translation	x		
	Welcome videos		x	
	Literature Review			x
	Ethics letter translation	x		
6-7	MAZI Setup Document translation	x		
	Ethics letter for kids		x	
	Video tutorial Introduction and instructible		x	
	Instruments to collect data			x
	Ethics letter translation	x		
	MAZI Setup Document translation	x		
8-9	Video tutorial Introduction and instructible		x	
	Video tutorial Soap Making, Masks, drawbot, decoder		x	
	Instructible Soap Making, Masks, drawbot, decoder		x	
	Instruments to collect data			x
	MAZI Setup Document translation	x		
10-13	Video tutorial Soap Making, Masks, drawbot, decoder		x	
	Instructible Soap Making, Masks, drawbot, decoder		x	
	Meeting with families (online)			x
	Interviews, notes, and other translations	x		
	Technical Support		x	
	Follow up with the families			x
	Interviews, notes, and other translations	x		
14-15	Project Website translation	x		
	Final interviews			x

Translation team; C: Content team; R: Research team

3.2.5.3 Families

Families are properly the participants of the study. They attended two informative meetings where they listened to the project description, aims, and required commitment. They registered their interest in those meetings, and in a third meeting the consent form to be part of the study was presented by the project team and signed by families. Each of the families received the kit of materials for the activities, as well as the phones and Raspberry Pi.

Eleven families of La Campana-Altamira district were selected. The families were selected with the help of Valentino, the community linker from La Campana-Altamira Initiative which supports urban regeneration and socio-economic aspects in alliance with citizens, government authorities, and private organizations. He recommended the area and the strategy to contact participants. His reasoning behind choosing this area for the project was that the people at the top of the hill face challenges of mobilization, ownership of the land, and internet access. We contacted the families through Viviana, a community leader, who during the pandemic had been helping Valentino to coordinate the distribution of four hundred food baskets for people in La Campana Altamira. She chose a word-of-mouth strategy. There was a total of eleven families as seen in Table 3.5 who decided to be part of the Hyperlocal Learning Network La Campana-Altamira.

Table 3.5

Pilot study: Families

Family ID	Name	Family Member	Age	Gender
Family 1	Elisa	Mom	32	F

Family 1	James	Son	10	M
Family 1	Yuliana	Daughter	12	F
Family 2	Iris	Mom	38	F
Family 2	Florence	Daughter	7	F
Family 2	Nathan	Son	15	M
Family 3	Luciana	Mom	33	F
Family 3	Lucas	Son	9	M
Family 3	Josefina	Daughter	10	F
Family 4	Ingrid	Mom	34	F
Family 4	Alexandra	Daughter	11	F
Family 4	Ariana	Daughter	7	F
Family 5	Nieve	Mom	31	F
Family 5	Mia	Daughter	6	F
Family 5	Michael	Son	9	M
Family 5	Ashley	Daughter	12	F
Family 6	Katty	Mom	29	F
Family 6	Alma	Daughter	11	F
Family 7	Lila	Mom	28	F
Family 7	Ben	Son	5	M
Family 8	Viviana	Mom	55	F
Family 8	Jacob	Son	9	M
Family 9	Susy	Mom	32	F
Family 9	Esmeralda	Daughter	6	F
Family 9	Gloria	Daughter	13	F
Family 9	Yarezi	Daughter	12	F
Family 10	Leah	Grandmother	61	F
Family 10	Andrea	Granddaughter	13	F
Family 11	Denisse	Mom	33	F
Family 11	Itzel	Daughter	11	F

The families were located close from one another, as seen in Figure 3.6. The numbers represent the location of the 11 families and the location of the Raspberry Pi.

The families selected to have the Raspberry corresponded to a technical study made by the project team to determine the best location for connectivity.

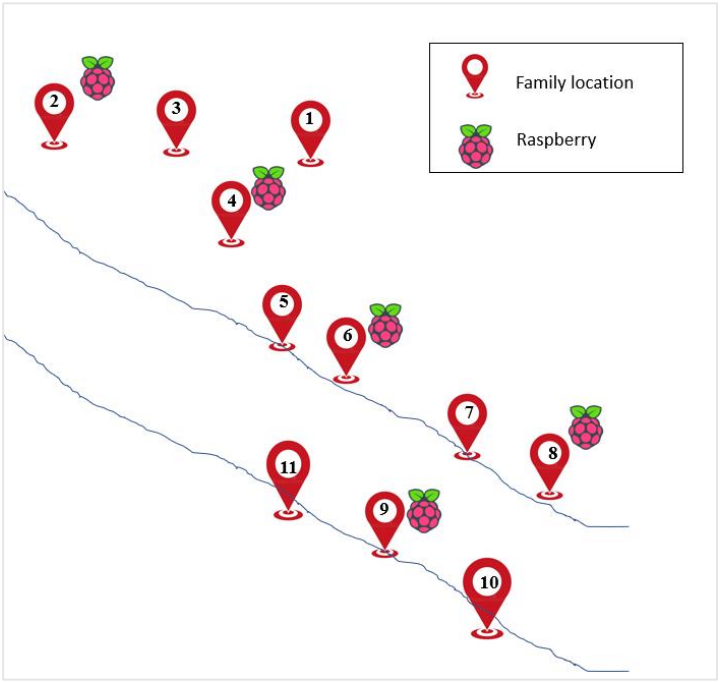


Figure 3.6 Families and Raspberry PIs location

3.2.6 Instruments

In accordance with the qualitative approach chosen there were three types of instruments used to collect data for the pilot study: semi structured interviews, researcher's field notes, and artifacts. The instruments will be described in the following sections, and you can find them in Spanish in Appendix B.1 to B.5.

3.2.6.1 Semi structured Interviews

An interview in qualitative research is an attempt to understand the world from the subjects' point of view (Creswell & Poth, 2018). Interviews can be structured, unstructured, or semi structured. Semi structured interviews allows to have some pre-established questions and the flexibility in the conversation with participants (Vela-

Peón, 2001). To understand the process of critical thinking, and transformation of the participants and project team, I carried semi structured interviews based on the four research questions established for this pilot study. To understand qualitatively the dialogic educational practices in this non-formal context of STEAM education I presented the families with the questions in Table 3.6 and the project team with the questions in Table 3.7.

Table 3.6

Pilot Study: Semi structured interviews families

Research Question	Questions for the families
What do dialogic educational practices look like in a non-formal context of education?	Can you describe step by step how you did the activities? How are the activities that you make in school different from those in Hyperlocal? How did you take the decision of making the activities? Can you give me an example? Who made the decisions?
How non-formal STEAM activities in vulnerable communities are a source of critical thinking in the Hyperlocal Learning Network La Campana-Altamira?	Who managed the Raspberry Pi? Did you find any difficulty? How did you solve it? What did you learn from the use of technology in your life?
How non-formal STEAM activities in vulnerable communities are a source of critical consideration of their own circumstances in life for the transformation of participants in the Hyperlocal Learning Network La Campana-Altamira?	What is your education? What did you do with the products you made? How could the activities that you did help you in the future? After this experience, what would you like to do next?
How the process of designing the Hyperlocal Learning Network La Campana-Altamira project shaped my own learning trajectory in terms of: (1) designing an intervention study with a multicultural team and (2) research methodology?	What can we do better in the following project?

The semi structured interview in Table 3.6 was applied to six out of the eleven families that participated in the Hyperlocal Learning Network La Campana-Altamira.

Table 3.7

Pilot Study: Semi structured interviews project team

Research Question	Questions for the project team
What do dialogic educational practices look like in a non-formal context of education?	Why did you choose to make a technology with the three sections of *Descubre, Comparte* and *Comparte más*? What was the purpose of each of them? What did you want the community to achieve with the project? Why did you choose a non-formal context for this project?
How non-formal STEAM activities in vulnerable communities are a source of critical thinking in the Hyperlocal Learning Network La Campana-Altamira?	Was it your intention for this project to promote critical thinking skills? Alternatively, what was your main intention for the participants through this project? (Do you think the activities were a source of critical thinking in the Hyperlocal Learning Network La Campana-Altamira?)
How non-formal STEAM activities in vulnerable communities are a source of critical consideration of their own circumstances in life for the transformation of participants in the Hyperlocal Learning Network La Campana-Altamira?	Did the community use the technology as you expected? -What did you discover? What do you think participants discovered with the use of technology? What improvements would you make to the technology? What role do you think technology should play in the everyday lives of participants? (His thinking about the role of technology)
How the process of designing the Hyperlocal Learning Network La Campana-Altamira project shaped my own learning trajectory in terms of: (1) designing an intervention study with a multicultural team and (2) research methodology?	What role do you think each of the participants of the research project played? What is your vision of the division of labor established in this project? To what extent a multicultural framework of participation between Mexico and the UK was useful or not for this project? Do you have any feedback about my participation in this project?

The semi structured interview in Table 3.7 was applied to all the project team that participated in the Hyperlocal Learning Network La Campana-Altamira.

3.2.6.2 Field notes

Field notes are an accumulating written record of observations and experiences produced in the field (Emerson et al., 2011). To produce them, it was necessary for me to participate in ongoing events during the visits because it supported the creation of rapport with participants. During the field experience I made jotting notes in my notebook about events and impressions to preserve accuracy. After the visits, I would immediately go home to make detailed field notes based on the observed actions and jottings to avoid mere evaluations or interpretations.

I had the opportunity to have a total of seven field experiences in La Campana-Altamira. The first five while doing the Hyperlocal Learning Network La Campana-Altamira project and two more after the project. From those experiences, I collected ethnographic field notes with the purpose to understand the families' dynamics related to their dialogic educational practices and create rapport with them. In that process, I wrote field notes with reflexive entries guided by Table 3.8 suggested points.

Table 3.8

Pilot Study: field notes families

Aspects covered in the field notes
Safety procedures
Observe, take notes
Create Rapport with families
Get their contact information
Understand the connections among them
Understand what is important for them
Understand their motivation to be in the project
Appreciate their stories, their efforts
Celebrate their lives and future projects
Create a reflection

There were two additional field notes about the families done by Renato during his first two visits to La Campana-Altamira with Valentino.

From the meetings with the Hyperlocal Learning Network La Campana-Altamira project team and undergraduate students to plan, design, and implement the overall project I also got field notes. From that process, I wrote thirty-five pages of field notes with reflexive entries to reflect upon the intervention process guided by Table 3.9 questions.

Table 3.9

Pilot Study: field notes teammates

Aspects covered in the field notes
What debates emerged? How was the teamwork done? What areas of opportunity were built?

3.2.6.3 Artifacts

The project generated artifacts related to the administration, design, implementation, and dissemination that were kept in a Google drive. These artifacts related to the Hyperlocal project included: pictures, documents, meeting minutes, Hyperlocal website, the MAZI platform content.

Additionally, I included my journal where I kept track of my own experience in the project and reflections I made with my advisor about the process. Table 3.10 holds some of the questions and considerations I had when writing my journal.

Table 3.10

Pilot Study: journal

Aspects covered in the journal
What role did I play in the project? What was my expectation about my work vs reality? How my role as a member of the team impacted the project? What did I learn? What are some areas of opportunity? What could I do better?

3.2.7 Research Procedure

As stated before, I played a double role during the project. First, there was my perspective as a participant observer whose purpose was to collect data to answer the personal agenda of my pilot study. Second, there was also a commitment to the interests of Hyperlocal Learning Network La Campana Altamira, as part of the project team. The impact of this double role in the research procedure is that for each of three phases: design, implement, and the post Hyperlocal Project, I carried parallel activities as shown in Table 3.11.

Table 3.11

Research activities

Phase	As part of the project Team	For my pilot study
Design (Weeks 1 to 12)	Supporting the research ethical procedures, including the design of consent forms, supporting the design of activities for families, designing undergraduate students' activities	Prepare the procedure of the pilot study based on research questions and readings about methodology
Implement (Weeks 13 to 18)	Report of the activities conducted in the field of study, supporting the data collection process, supervising the research team collection of data	Field visits to the families, creating rapport with the families, ethnographic field notes, designing semi structured interviews
Post Hyperlocal Project (Weeks 19 to 21)	Dissemination of the project in conferences, papers, and podcasts	Designing consent forms, applying semi-structured interviews to six families and all the project team

The data collection phase took part during, and after the implementation of the intervention. It is relevant to contextualize both research activities as part of the research procedure because this can be helpful to elucidate my role as participant observer which involved being part of the project team of the Hyperlocal Learning Network La Campana-Altamira, and as a researcher for my thesis.

3.2.7.1 Design

3.2.7.1.1 Social Design Experiment Hyperlocal Learning Network La Campana-Altamira

It involved planning the overall details of the project. I was introduced to the team in December 2021 through my advisor. By that time, the project team had already managed administrative issues related to submitting a proposal for funding, and some initial tasks on thinking about what STEAM activities to make. However, they were working on two main things: evaluating the four STEAM activities for participants, and the ethical application to comply with the Open University policy. I was informed of the previous work done through a Google document with the Tuesday weekly meetings minutes.

During the first week, my assigned task was to support the ethical application working on the information sheets for adults and children, as well as the consent forms. The process of ethical procedures involved a theoretical review from authors as well as a comparison of the current ethical policies in the topic of child protection research at the university level between the Open the University and Tecnológico de Monterrey, and at the country level between United Kingdom and Mexico (Águila et al., 2020; Campana Altamira, 2020b, 2020c, 2020d, 2020e, 2020a; J. Creswell & Poth, 2018; Eckstein, 2003; Gobierno de México, 2020; Tecnológico de Monterrey, 2020; The Open University, 2017, 2020; Valenzuela-González & Flores-Fahara, 2012). The information sheets and consent forms were prepared as documents in English, and then translated to Spanish.

Figure 3.7 Information sheet in Spanish

Figure 3.7 has a sample of the first four pages of the information sheet where the researchers explained the families about the Hyperlocal Learning Network La Campana-Altamira project using two characters: Oliver and Sophie.

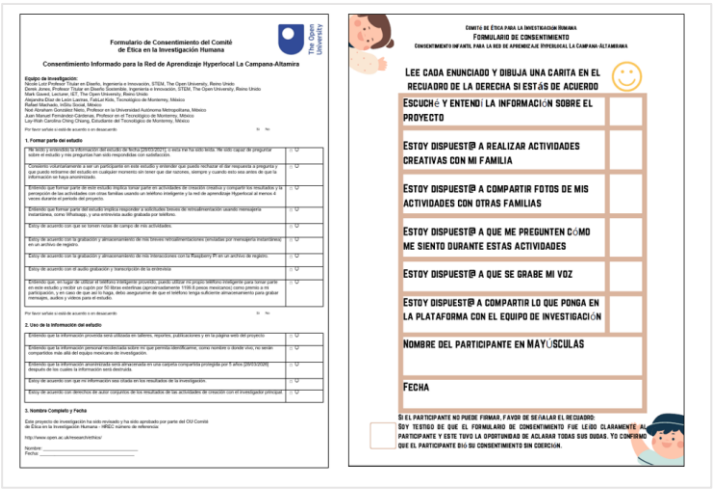


Figure 3.8 Consent Forms for Parents and Kids

Figure 3.8 shows the consent forms for parents and kids in Spanish. The main difference for the consent forms was the language used adapted for each group, the length of the statements, and the fact that the kids were asked to draw happy faces if they agreed with each statement.

During the second week, I received a kit with materials including the Raspberry Pi and the phone, so that I could assess the technology and activities: making a decoder, soap, mask and drawbot (a robot that draws). The third and fourth week, I designed the implementation for the undergraduate students, specifically the research team to which I was assigned. I was also working in the calendar for the family implementation program. At the same time Valentino and Renato had already two meetings to advertise the program to families in La Campana-Altamira.

The following 5 weeks, I collaborated with the undergraduate students training them about research. We had a kickoff session for the undergraduate students who joined the project as part of their community service program. We had online meetings scheduled every Friday with the whole team and contact through email or WhatsApp depending on the teams that we had created: translation, content creation or research. We had a shared drive for each of them, which allowed us to place all the work of the translation, content creation and research team there to make resources visible for everybody. During Friday meetings we would have a general debrief from each team to report about the work that we had done, and during the second part we would divide into the sub teams to work on specific agreements and tasks explanation. The tenth week, we had Holy Week recess in Mexico, so there was no activity. The eleventh and twelfth weeks, we had issues with the configuration of the technology, so we had additional training with the undergraduate students in which we could practice how to do semi structured interviews.

3.2.7.1.2 Designing my pilot study

In parallel to Designing the Hyperlocal Learning Network La Campana-Altamira project, I completed other tasks to design my pilot study. First, it involved preparing the pilot study procedure based on readings about the qualitative methodology that allowed me to make methodological decisions as described in section 3.2.2. The readings were informed by the theoretical background presented in section 2.3, which according to the Latin American schools they emphasized dialogue as a form of relationship instead of an analysis of talk as presented by the British school. Second, based on the research questions I decided on each instrument to collect data, so that each of them would answer the research questions by creating triangulation Tables (3.12 to 3.15).

3.2.7.2 Implementing the social design experiment

The implementation of the social design experiment (see Gutiérrez, 2008) phase consisted of the execution of the plan. A social design experiment prioritizes learner's empowerment precisely because these type of programs emerged from civil right movements (Muñoz, 1989). Researchers like Gutiérrez (2008) have used this methodology with non-dominant communities of students over decades rejecting traditional theories of home and school discontinuities.

During the thirteenth week we started the implementation with the families until week sixteenth. In the field visit to the families, we reviewed with them the information sheet we had prepared about the project and the consent forms as seen in Figure 3.9. After they agreed to participate and signed the consent forms, the families were given a box with the materials to complete four STEAM activities: decoder, mask, soap and

drawbot. At scheduled intervals, La Campana-Altamira community participants were asked to interact with the physical and online resources in the hyperlocal network from their homes. Community members accessed the resources in the Raspberry Pi's, the networking devices, to engage in making activities together as a family. They were asked to use the smartphone that was given to them to record their making activities in their homes producing textual, image, video, and audio data as they wished and upload it to the MAZI platform.

Figure 3.9 Explaining the information sheet and consent form to participants

The undergraduate students and I collected data in the form of follow up reports with the families. Through the smartphone, the families were able to stay in touch with us to help them with technical issues and answer questions around the activities. We filled one initial interview and four follow up reports, one for each of the activities. The family's personal number was also kept in case we could not reach the project phone. During these weeks, I also had the opportunity to visit the families four times where I created rapport with the families and the opportunity to produce field notes.

In the seventeenth week, we had planned the celebratory event with the families so they could present the projects. The families participated in the design of the celebratory event. They suggested to make the event on the street and that they would

take charge of making the food. The project team proposed to host the ceremony by making the line-up of activities and decorations. This was helpful because we took advantage to collect data. My role was to design questions for a final wrap up of the project, design the certificates for participants and lead the ceremony. Due to weather conditions in Monterrey, we had to suspend the event. The following week, we were able to continue with the celebratory event as shown in Figure 3.10.

Figure 3.10 Celebratory event of Hyperlocal

There, I was able to collect videos, photos, and testimonies of the families as well as field notes.

3.2.7.3 Post Hyperlocal Project

After we had finished the Hyperlocal Learning Network La Campana-Altamira I entered a Post Hyperlocal project phase where I conducted semi structured interviews.

Since I had the opportunity to visit the families five times including the closing session of the Hyperlocal Learning Network La Campana-Altamira, I had created a trust-based relationship with the families. So, during the post Hyperlocal project, I asked the families to interview them. I had semi structured interviews with six of the eleven families that participated in two visits. The participants that agreed to be part of the interviews are described in Table 3.12.

Table 3.12

Interviewed Participants

Family ID	Name	Family Member	Age	Gender
Family 3	Luciana	Mom	33	F
Family 3	Lucas	Son	9	M
Family 3	Josefina	Daughter	10	F
Family 4	Ingrid	Mom	34	F
Family 4	Alexandra	Daughter	11	F
Family 4	Ariana	Daughter	7	F
Family 7	Lila	Mom	28	F
Family 7	Ben	Son	5	M
Family 8	Viviana	Mom	55	F
Family 8	Jacob	Son	9	M
Family 9	Susy	Mom	32	F
Family 9	Esmeralda	Daughter	6	F
Family 9	Gloria	Daughter	13	F
Family 9	Yarezi	Daughter	12	F
Family 11	Denisse	Mom	33	F
Family 11	Itzel	Daughter	11	F

There was a total of sixteen participants who allowed me to have individual interviews. The youngest was 5 years old and the oldest 55 years old.

3.2.8 Ethical Considerations

During the Hyperlocal Learning Network La Campana-Altamira project, I designed an information sheet and consent forms for the participants as described in section 3.2.6.1. The design was based on the requirements of the international research institutions leading the project. Additionally, I designed three consent forms (as seen in Appendix C.1 to C.3) for participants to be part of my pilot study since I was going to apply additional instruments to collect data that were different from the ones in the project. The ethical considerations guiding the consent forms were: informed knowledge, privacy, confidentiality, and protection of the identity as described by Valenzuela-Gonzalez & Flores-Fahara (2012). To guarantee the informed knowledge criterion the participants were presented with information about my research work's nature and objectives. Privacy and protection of identity was achieved using pseudonyms instead of the real names of participants. Confidentiality was guaranteed using a question in which participants could refuse to answer questions and withdraw from the study at any time without giving reasons before the information has been anonymized.

3.2.9 Analysis Strategy

3.2.9.1 Organizing the Data

After collecting the data from the various sources and before analyzing the data, the first step was to store the data according to the instruments in an online drive folder with the purpose of holding an organized systematic naming of documents. The Interviews were named: Interview_ [Name of Interviewee] _[Date], the field notes were named: Field notes_[Researcher], Journal_[Date], and the drive was named Hyperlocal

with the folders according to the different areas of the project. The second step was to transcribe the semi-structured interviews verbatim for which I made use of Microsoft Stream and VVT cleaner. Third, the interviews in conjunction with the field notes and artifacts were imported into a computer-assisted qualitative data analysis software (CAQDAS). The use of a CAQDAS responded to the benefits such as the ease of retrieval, sorting and retrieve segments from the same code (Creswell & Poth, 2018; García-Horta & Guerra-Ramos, 2009).

In my case, I chose MAXQDA Analytics Pro 2020 after a market comparison of CAQDAS in which I weighted the structure of work that the software presents, the data types and format that it accepts, the minimum system specifications recommended by developer, and the price/time use of the license relationship. The fourth step was to group the documents in MAXQDA according to the type of participants from which I collected the data.

3.2.9.2 Analyzing the Data

After organizing the data, I started the analysis process. The analysis of data is responsive to the research questions and based on a qualitative perspective. In MAXQDA, I established deductively four themes based on the four research questions so that data could be split in chunks of information that were related to each research question. The next step was to start the codification looking at bits and pieces of information such as sentences, fragments, and dialogues that answered the research questions. Following the recommendations of Merriam & Tisdell (2016), the next step was to make use of the concept of categories to group the different codes by being

responsive to the purpose of the research, exhaustive, mutually exclusive, sensitive, and conceptually congruent. The categories emerged inductively from the coding process.

To guarantee a holistic view, different perspectives to the research questions were triangulated using as reference Tables 3.13 to 3.16. Having a conception in mind of stakeholders involved allow me to triangulate the information better.

Table 3.13

Triangulation of Pilot Study Research Question 1

Research Question 1: What do dialogic educational practices look like in a non-formal context of education?			
Families' Interviews	Field notes	MAZI	Project Team' Interviews
-Can you describe step by step how you did the activities? -How are the activities that you make in school different from those in Hyperlocal? -How did you take the decision of making the activities? Can you give me an example? Who made the decisions?	-Field notes of the visits & Reflections and opportunities to talk?	-Check for the content in the 3 sections: *Descubre, Comparte* and *Comparte más.* Were there many interactions? What did they upload? What messages did they send?	-Why did you choose to make a technology with the three sections of *Descubre, Comparte* and *Comparte más?* -What was the purpose of each of them? -What did you want the community to achieve with the project? -Why did you choose a non-formal context for this project?

As seen in Table 3.13 the triangulation for the dialogic educational practices were analyzed by contrasting and comparing the families, research team, MAZI platform and my own field notes. The purpose was that each of them re-tell from their own experience how did it happen and give voice to each of the participants.

In Table 3.14 the triangulation aimed to find how non-formal STEAM activities in vulnerable communities are a source of critical thinking in the Hyperlocal Learning Network La Campana-Altamira? It was key to contrast what families experienced with technology and what the research team envisioned the technology would develop in the families. Having access to the MAZI and written field notes allowed also to verify what the families did in contrast to what they said they did.

Table 3.14

Triangulation of Pilot Study Research Question 2

Research Question 2: How non-formal STEAM activities in vulnerable communities are a source of critical thinking in the Hyperlocal Learning Network La Campana-Altamira?			
Families' Interviews	Field notes	MAZI	Project Team' Interviews
-Who managed the Raspberry Pi? Did you find any difficulty? How did you solve it? -What did you learn from the use of technology in your life?	-Field notes of the visits & Reflections	How do they manage the use of technology?	-Was it your intention for this project to promote critical thinking skills? Alternatively, what was your main intention for the participants through this project? (Do you think the activities were a source of critical thinking in the Hyperlocal Learning Network La Campana-Altamira?)

In Table 3.15, the triangulation pointed to STEAM activities as a source of critical consideration. Different from the question on critical thinking, this research question aimed to observe how the project propelled a critical view of their life and the transformation they have gone through.

Table 3.15

Triangulation of Pilot Study Research Question 3

Research Question 3: How non-formal STEAM activities in vulnerable communities are a source of critical consideration of their own circumstances in life for the transformation of participants in the Hyperlocal Learning Network La Campana-Altamira?			
Families' Interviews	Field notes	MAZI	Project Team' Interviews
-What is your education? -What did you do with the products you made? -How could the activities that you did help you in the future? -After this experience, what would you like to do next?	-Field notes of the visits & Reflections	Check the pictures and compare to what they live	-Did the community use the technology as you expected? -What did you discover? -What do you think participants discovered with the use of technology? -What improvements would you make to the technology? -What role do you think technology should play in the everyday lives of participants? (*His thinking about the role of technology*)

In Table 3.16, I aimed to contrast my own field notes and journal with the perspectives of families and teammates. For families, the question was broad so it would give me details on the overall project methodology. On the other hand, the questions asked to teammates led to acknowledge the roles taken by each member and in that way they aimed to understand (1) What role did I play in the project?, (2)What was your expectation about my work vs reality?, (3) How my role as a member of the team impacted you?, and (4) What did you like about my work? what could I do better? This was particularly relevant for section 3.2.13 where I present the lessons, I learned from the pilot study.

Table 3.16

Triangulation of Pilot Study Research Question 4

Research Question 4: How the process of designing the Hyperlocal Learning Network La Campana-Altamira project shaped my own learning trajectory in terms of: (1) designing a social design experiment with a multicultural team and (2) research methodology?		
Families' Interviews	Field notes	Project Team' Interviews
-What can we do better in the following project?	-Field notes of the visits & Reflections -What did I do? -What thoughts were awakened? -What actions did I take?	-What role do you think each of the participants of the research project played? -What is your vision of the division of labor established in this project? -To what extent a multicultural framework of participation between Mexico and the UK was useful or not for this project? -Do you have any feedback about my participation in this project?

3.2.10 Data Collected

I provide a summary of the data collected during the pilot study in Table 3.17.

Table 3.17

Pilot study Data collected

Quantity	Type of Instrument	Description of the data
35	Field Notes	Field notes from meetings with project team and undergraduate students
9	Field Notes	Field notes from the visits to the families
6	Semi structure Interview	Post project interviews with families
7	Semi structure Interview	Post project interviews with teammates
1	Google Drive Folder	Contains the shared work among the project team around: administration, community materials, content, ethics, idea development, papers, proposal, technical, dissemination, social service management
5	Artifacts: Raspberry Pi	With the information uploaded by families
1	Personal Journal	Record of the events and experience including self-reflection

3.2.11 Results

In this section, the results from the pilot study that emerged from the Hyperlocal Learning Network La Campana Altamira project are presented. There are four themes that were proposed deductively from the research questions: i) Dialogic educational

practices in a non-formal context of education, ii) Non-formal STEAM activities as a source of critical thinking, iii) Non-formal STEAM activities as a source critical consideration of circumstances, and iv) Designing a dialogic educational social design experiment in a non-formal context. It is relevant to be reminded that while the themes were proposed deductively from the research questions, the categories for each of them emerged inductively after the coding process.

3.2.11.1 Dialogic Educational Practices in a Non-Formal Context of Education

The first theme: "Dialogic educational practices in a non-formal context of education" collects the categories related to the dynamics proper of the implementation of the Hyperlocal Learning Network La Campana-Altamira. Inside this theme there are five categories: (1) motivations, (2) *El Aparatito*, (3) teaching roles, (4) creativity and (5) capable of doing more than expected.

3.2.11.1.1 Category 1: Motivations

The category of motivations refers to the driving force to be part of the project. The data collected revealed that the project team, undergraduate students, and families had different motivations to be part of the Hyperlocal Learning Network La Campana-Altamira project which will be detail in the following paragraphs.

3.2.11.1.1.1 Project team

As stated previously, the project team was brought together due to the relationship created between Nancy and José while working in the creation of FabLab La Campana. After the creation of the Fab Lab, José had overseen the FabLab's operation. During the pandemic, Nancy and José had a spontaneous conversation about

the Fab Lab continuity, and how to bring educational opportunities to kids. From that conversation they brought an international team to create Hyperlocal Learning Network La Campana-Altamira. Nancy brough on board Daniel and Mathew who also collaborated with her in the same university. Meanwhile, José brough Amanda, Renato, Valentino, Nicolás and Lay.

Despite the diversity of the team in terms of nationality and life experiences, the motivations that they had to be part of the project shown to be centered to how their current work and profession was a source of helping others not only during the pandemic but for the upcoming future. We can exemplify that with comments such as the one made by Nicolás who said, *"I wanted them to have a network from where they could generate that connection for the construction of learning and obviously linking it with a creation process and a maker culture" (Interview with Nicolás Pos. 41).* He is a Mexican lecturer who previously worked with children in marginalized areas and STEAM activities which are based on the do it yourself and maker culture movements. His profession and current work as an educator have shaped his views on offering quality education which becomes a driving force to share it with others. In the case of Valentino who works as the community liaison with the people in La Campana-Altamira, he shared that *"It was important to reach that district, it was important to go uphill because they [the families] got the feeling we cared for them. This opened the door for us because now we got to meet more families and we can bring new projects" (Interview with Valentino Pos. 17).* Valentino's interest is rooted in bringing projects that can improve the quality of life of the inhabitants of the Campana-Altamira district in sustainable ways including the education and the linking of the community to new

opportunities of development. These two examples portray the project team's motivation to create and be part of the Hyperlocal Learning Network La Campana-Altamira.

3.2.11.1.1.2 Undergraduate students

For the undergraduate students one might think that the driving force could be the duty of completing the 480 hours of community service. However, this was denied by the actual events. First, they had the opportunity to choose the community service program at Tecnológico de Monterrey. The school offers a wide catalogue of projects within one of the ten social causes to be part. The Hyperlocal Learning Network La Campana-Altamira was registered within the cause number 5: "promotion of science and technology". During the spring 2021 there were seventy active projects that were offering community service during the pandemic. Second, the students were interviewed before been selected in the project about the reasons to be in the project. During those interviews, there were two main drivers that motivated the students to be part of the project. The first driver was expressed by the students in the translation team (Rene, Christian, Hector, and Abigail), and the content creators (Fátima, Abraham, Roman and Sara) who expressed their interest in the project related to applying their skills and experience. For instance, Rene and Hector had previous experience with programming projects and considered also that their English level was proficient. Their confidence in their skills seemed to be a motivator because they felt *"could be of help for the project" (GDF_SS_Hyperlocal SS_Pos J5 & J7).* The second driver was manifested by the research team (Omar, Lucas, José, and Leonor) to whom attracted the idea of learning about research through this project. José, an undergraduate in the

Communications program, hoped that *"I can develop skills in research that can be helpful in my career" (GDF_SS_Hyperlocal SS_Pos J15*). In summary, undergraduate students had as their motivations to be part of the project the skills and experience, and the idea of learning about research which also show a relationship with their background and expectations of knowledge.

3.2.11.1.1.3 Families

During the implementation of the project, families had been confined for 13 months due to the Covid-19 pandemic. Despite the efforts of the government and school authorities, children had intermittent opportunities to access quality formal education. Parents were faced with the challenge of supporting the continuity of their children's education. This happened especially due to the lack of engagement between children and teachers. Children "*would get frustrated with not being able to solve some of the homeworks since they did not receive any explanation about the academic content. They would also get bored at home of not doing anything"* (Field notes Lay_ 2021-06-05, Pos. 177). So, Hyperlocal was a non-formal project to engage not only children but families in dialogic educational opportunities. During the interviews, mothers, and grandmothers, were looking for an educational experience for their children; boost knowledge; and spending time together. For instance, during an observation, Lucía (a mother) shared that she wanted her children to be part of Hyperlocal because she had previous experiences with opportunities offered by Tecnológico de Monterrey and Distrito Tec, such as sports and painting programs. So, she expected Hyperlocal to also help her children in their educational experience. Similarly, for Ivanna, a grandmother, there is a willingness that her granddaughter *"could improve her knowledge with what*

she is currently learning in school" (Interview_Initial_Ivanna). Finally, Katty, another mother, mentioned *"My neighbor told me about the project. My girl likes to do arts & crafts and she is friends with my neighbor's girl. I wanted to have a good relationship with my girl because sometimes I feel her distant from me, so I would like to have more time with her (Field notes Lay 2021-05-24, Pos.140)".* In these three cases, adults are willing that their offspring become part of this project to deepen their learning. They are motivated to seek more opportunities within and beyond the community, and by learning about technology, making activities, and gaining competencies that are going to be useful for their everyday lives in the present and future stages.

3.2.11.1.2 Category 2: El Aparatito

The Raspberry Pi also known as *El Aparatito* by the families became the mediating technology to create the hyperlocal network. Participants used the Raspberry Pi's, MAZI platform, and smartphone to engage in the STEAM learning activities. Figures 3.9 and 3.10 offers a general view of the families' interactions with *El Aparatito.*

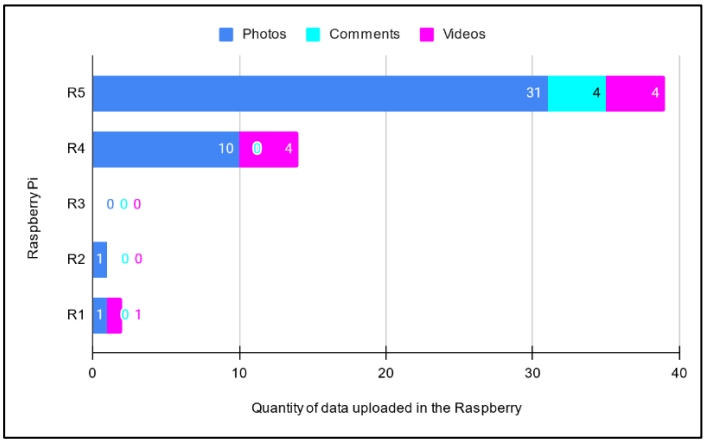


Figure 3.11 Data in the Raspberry Pis

In Figure 3.11 the vertical axis represents the five Raspberry Pi, while the horizontal axis is the percentage of uploaded data type (photos, videos, or comments). Raspberry 3 did not have any uploads. The main interactions were uploading pictures. From the forty-three photos uploaded, only in one of them adults appear in the background. The rest of the pictures are the kids making the activities or the products. Of the four comments, one is a greeting saying *"Hello"* and the other two are related to the soap making saying *"Soap"* and *"we finish the soap."* The videos were uploaded only by Lila who has a 5-year-old son Ben. The videos she uploaded were made using Tik Tok. She added effects and music to the videos.

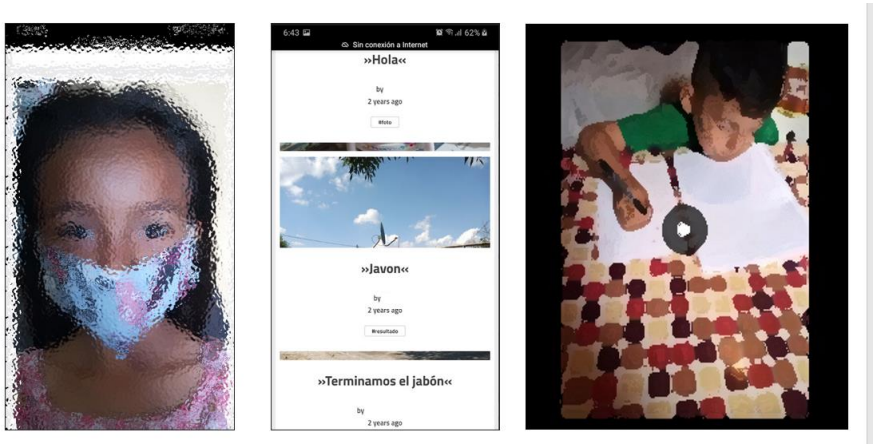


Figure 3.12 Samples of content uploaded to the MAZI

Figure 3.12 has sample content uploaded by participants to the MAZI. The first picture to our left is a sample of the pictures, here is Florence is wearing a face mask done with the materials given in the kits. There were also other uploads where the families uploaded the drawbot, and decoder. In the center, there is a picture of the messages that families uploaded. In the right, there is a sample of the video where Ben is decoding a message using his wheel.

The semi-structured interviews revealed that in the engagement with *El Aparatito* participants found the use of offline networked mobile learning easy to use and challenging them to think of the future uses of technology. The use of the Raspberry Pi to access information allowed participants to explore possibilities that transcended their own prior experiences with technology and offered wider perspectives of how it might be used in the future. The use of this offline network in Hyperlocal triggered their thinking about the possibilities of this technology for formal education. Transcript 3.1 is a conversation between a researcher, and two participants, a mother, and her daughter, about the use of the Raspberry Pi.

Transcript 3.1 The use of the offline network mobile learning for formal education

> ***Lay:*** *What did you learn from the use of technology in your life? Did it leave you any experience having used the Raspberry or the cell phone? How was your experience watching the videos from the Raspberry?*
> ***Alexandra:*** *From the Raspberry it was quite easy to use and connect.*
> ***Lay:*** *What will be easier to watch the videos from the Raspberry or from YouTube?*
> ***Alexandra:*** *With the device, it is more direct and nothing more.*
> ***Susy:*** *Well, it was fast, you go in and see the video that you wanted to see.*
> ***Lay:*** *If your teacher brought you the class videos in the Raspberry, would you use it?*
> ***Susy:*** *Definitely, it will be easier. In that way, it is all there easier to access and watch.*

In this transcript, the participants reflect on the ease of accessing videos from the offline network (Raspberry Pi and MAZI) compared to the online networks (cell phone, internet) they may already use. Susy mentions how the device was fast and helped in the

development of the activities. Here it is important to consider that the topography of the participants at the top of the hill was problematic, and limited access to fast and reliable global Internet connections, making the use of an offline device a faster alternative. Moreover, when I questioned Susy about the use of the Raspberry for a formal education, she answered that she would use it and that it would be easier.

The use of offline networked mobile learning was a tool to propel sharing. Participants encountered a limitation with the use of the Raspberry Pi to share information in the *Comparte and Comparte más section* because the photo sharing tool was initially set to only allow 2 Mb photos, which was the default setting. This became problematic because the default size of an image taken by the mobile phone provided was bigger than 2Mb. However, instead of not sharing their making activities with others, participants pursued workarounds to satisfy their desire to socially share the result of making with their neighbors and relatives using ICTs. Ingrid told the team *"My daughter sent it [a photo of the decoder creation] to her cousin through WhatsApp, so they were sharing ideas on how to improve the model"* and Lila said "*Before the pandemic I used to meet with Luciana outside and talk while washing clothes. During Hyperlocal, I met her to talk about the project and share what we were doing and how to solve the technology issues' (Field Note 3).* In both examples, we can see that technology served as a catalyst to reconnect with other participants as it served as a new (local) platform that was available to people of this community. Therefore, they found a new place in which they can share not only their results but also the process they established to complete the making activities.

3.2.11.1.3 Category 3: Taking Roles

This category of taking roles emerge from the "making process" that families went through while making the activities. Families had to agree which specific roles each member would take to complete the activities. From the interviews inquiring about who did what in the process, it was seen that roles were decided based on abilities, safety issues, and knowledge. For instance, in an interview with Viviana and her son Jacob (see transcript 3.2), she described how those factors became relevant to decide who took charge of which part of the process.

Transcript 3.2 Step by step making of the activities

> ***Lay****: Good. Let us start the interview with Viviana and Jacob. Well, first, thank you again for allowing me to do this interview. Could you explain to me how you did each of the activities?*
> ***Viviana:*** *I think with the face mask we started by cutting the fabric. We made some types of patterns with some leaves and from there we were guided ourselves to cut them. We cut them and sew them. It was there where I taught Jacob how to sew. He was very enthusiastic to learn how to do it. He wanted to learn. With the soaps, Jacob did it all. I hardly helped him. I only helped him to melt the soap in the oven because it was hot for him to carry. He emptied them in the cast and put the figurines. He also took care of the rest, the colors, the scents, and everything. Next, was the decoder. In that one I helped him because of the scissors. It was more dangerous because you were supposed to cut the cardboard. So, I cut the circles and the messages. He just put it all together. Finally, with the robot, he did it all by himself. But I just helped him glue the battery holder and the motor.*

Similarly, the actual abilities and previous knowledge of family members were relevant to the making process of the activities. Even though the fathers did not sign up for

Hyperlocal, they participated. When interviewing the families, six of them mentioned that dads helped in the drawbot project. Their role was fundamental in helping the families understand how the drawbot works; this can be linked to the fact that six families mentioned that the husband works in construction jobs. Additionally, age also became a factor to decide who would take care of the technology. In most families, children took the leading role in using the phone and accessing the MAZI platform. However, in the case of Lily, she took control of the use of the phone because Brad was five years old, and he was actively involved and engaged in the making process of the activities.

In this category of taking roles, it is relevant to note that the project team also had role even though they were not present while the families were making the activities. While designing the activities and selecting the technology, the team expectation was that communication could emerge among participants. Amanda recounts this in her interview "*We wanted Hyperlocal to be a tool to interact, to share. Not just to give information or to provide data, but that in some way we were looking for something that would motivate them to communicate" (IntAmanda_Pos. 6).* Communication in this sense, was seen in the fact that families make verbal agreements to take roles in the making of the activities. The process of making agreements was conducted using language to serve the negotiating of roles which expressed their beliefs, thoughts, knowledge, and previous experiences.

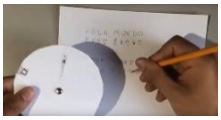
3.2.11.1.4 Category 4: Creativity

In this category of creativity is collected how the families were able to generate ideas and alternatives to what they were proposed. The celebratory event at the end of

Hyperlocal was the platform where families showed the work they had done versus the proposed projects.

Table 3.18

Activities proposed vs actual results

	Decoder	Face Mask	Soap	Drawbot
Proposed				
Actual results				
	11	45	100	11

The project had four activities with tutorial videos made by the undergraduate students. In Table 3.18, the first line shows pictures of the proposed products from the activities, and in the second one a sample of the products that the families produced, as well as the total quantity created. The products show a lot of personalization and additions to make them look different from what the tutorial videos suggested, showing the families' likes, and innovative ways to execute the activities *(Field notes Lay Pos. 45)*. The decoder was in most cases colored and had drawings on it. The face mask was personalized by adding characters or jewels. For example, Jacob added Spiderman cuts from an old sock he had, while Josefina used jewels to write "Tik Tok" on her facemask. The soaps had stickers and rings among other objects and colors. Alexandra

said that she used rings thinking that at the end of the use of the soaps, her sisters could have a prize for washing their hands. The drawbots were decorated and personalized, and the cables were put inside the cups, so they did not show on the outside.

Lila commented that she hopes that her child learns to do things by himself. Elisa's family mentioned the positivity that comes with engaging in creative activities: *"it opens our heads more, we play, we entertain ourselves as a family. We get a little distracted and we are not thinking negative things (Field notes Lay Pos 74)"*- As evidenced with the photographs and testimonies, families made an appropriation of the activities by adding novel items and materials that were available in the local community. Furthermore, the creativity shown in this category enhanced the agency and decision-making process of the community to promote a meaningful learning experience through the collaboration with others.

As noted by Nancy, from the project team, the space propels creativity and engagement. Nancy considers that in a non-formal context *"you might engage in something different, less inhibited like, you are much freer in what you do. This invites easier participation when you are making things, it is more it is less intellectually based, although what comes out of it is that you develop a kind of understanding, knowledge, and skills. It is extremely easy approach. So, for everyone you know and that is the goal for most of the people to be able to engage with. And this is the right way to show different ways of access to learning. You can always gain more if your family is with the community, so maybe it is an easier access to lifelong learning" (Interview with Nancy Pos. 22).* Nancy's statement was supported by children who

reported that in school activities they were limited by teachers who would always be nagging them and sending them boring homeworks *(Interview with Susy Pos. 55).*

3.2.11.1.5 Category 5: Capable of Doing More

Participants realized that they were capable of doing more of what they expected. Members of families realized that they were more capable of doing things that they believed they could previously do such as what happened to Viviana. In transcript 3.3, Viviana was amazed by what her son, Jacob, did. She could not believe that Jacob had used the motor of the drawbot to move to his toys: a car and an airplane.

Transcript 3.3 Capable of doing more

> ***Viviana:*** *He really liked the soaps, and the robot was what he really liked the most.*
> ***Lay:*** *Great!*
> ***Viviana:*** *In fact, with the robot's little motor he was putting it in an airplane and a car so that it can move.*
> ***Lay:*** *And did it turn?*
> ***Viviana:*** *Yes, they moved. I told him to take them off because he did that before the celebration event. I told him to take them off because he was going to show the robot.*

People from the community felt comfortable by adding materials or changing some of the original instructions of the activities. They use previous knowledge, experience, and materials to enhance the making process and produce a better result that was more relevant for their local conditions and possibilities. With these ideas in mind, people solved problems and felt that they could participate with a more active role by doing more. This category shows how a sense of agency was built through the development of the project in a communitarian and collaborative context. Families created dialogic

opportunities through the making of the decoder, mask, soap, and robot, the use of the Raspberry Pi, and their decision-making process.

Valentino, the community liaison, realized that sense of agency created and goes beyond in his comment when he says *"I think Hyperlocal leaves a thirst for learning in children. It allowed parents to have time with their children. The product was made by the family and there was enthusiasm in the children. And there was a particularly good accompaniment from the team in the place which is unprecedented. Never before these families had been approached like this to work, so it has influence before now they can see they can do more" (Interview with Valentino Pos. 15).* This capability of doing more was the effect of visually seen what they have created.

3.2.11.2 Non-Formal STEAM activities as a Source of Critical Thinking

The second theme: "Critical Thinking" refers to non-formal STEAM activities as a source of critical thinking. Here two categories are presented: (1) critical thinking as a result and (2) assess situations.

3.2.11.2.1 Category 6: Critical Thinking as a Result

This category collects the point of view of researchers about non-formal STEAM activities as a source of critical thinking. In transcript 3.4 Nicolás, a member of the research group, exemplifies this point of view where critical thinking was a result of non-formal STEAM activities, but it was not planned.

Transcript 3.4 Critical thinking for participants, a result of non-formal STEAM participants, a result of non-formal STEAM activities.

> ***Lay:*** *Among those benefits that you mentioned for the community, do you think that an intention of the project was also to develop critical thinking skills?*
> ***Nicolás:*** *I think no, it was not a goal at first. But. It was a given as a result.*
> ***Lay:*** *In what sense?*
> ***Nicolás:*** *In the sense that the activities had a plan proposed by us, but these activities did not remain the same and precisely through the interviews we found that people were first able to transform their activities. And this transformation was thanks to a reflective and critical thinking process of seeing what my possibilities are. As a mother, father, or a child if I do not have the materials, will I just stop and not investigate it to achieve the goal? If I do not establish an alternative solution that will allow me to reach the goal? Here is where critical and at the same time creative thinking of solving problems, is what allowed them to contribute to this project and make it their own. I think, that can be seen with the diversity of options that were observed in the exhibition. The diversity of products, of objects. And that they were not exactly what I was expecting at the end of the of the instructions, but that there was a transformation from what the people. They innovated in their creation process.*

For Nicolás transformation of the activities is an indicator of a reflective and critical thinking process. Transforming the original activities and personalizing them requires the families to have somehow assess the situation, at least in their mind, which involves conceptualizing the activity, the steps to follow and evaluating how to work towards achieving the goal. Mathew agrees with Nicolás in the fact that the non-formal STEAM activities developed critical thinking and on the fact that it was not planned as seen in transcript 3.5.

Transcript 3.5 Critical thinking for researchers, a result of non-formal STEAM activities.

Lay: *Was it your main intention for this project to promote critical thinking skills?*

Mathew: *Good question. No, that was part of it. huh? I think or OK this is a good question, it depends. Being a good academic, I suppose it depends on what lens you look at this through. Teaching skills and then perhaps this is an important part. I suppose I will be honest with you; I had not thought it through in detail. There were a lot of tacit understandings or shared beliefs of what is good education and what is good pedagogy between the team. So, we had many informal conversations, you know, for the record, as we are recording this, though, you know very well it became a joke that we kept the meeting notes, and we have so far ended up with something like sixty pages or seventy pages of meeting notes, and this is funny. But this is also an important point that there were many discussions that we had, and we were reflective as a team, and so I think that your question asking: what we were trying to achieve? There were many things we were trying to achieve, and we did not have many sessions where we formally theorized or reflected on our perspective start. We came as a research group towards shared goals. I think through the conversations both the practical situation and the desires, the ambitions we had. So, if I bring that back to give you a short answer, critical thinking is one of the skills that we were hoping to bring about. We were thinking, I was thinking about how we might continue an educational experience of positive social educational experience in times of pandemic. And I was aware that I was brought into a project that had a strong mission of continuing maker education and design education so some of these expectations are built into those educational models. I suppose informally coming back to your first question about the spaces that we created by creating a space for people to put their outputs and have conversations, we were implicitly asking people to reflect on what they had been doing. So, I suppose that there was implicit an affordance set up in the*

system to encourage reflective thinking

.

Mathew's answer has a key revelation in the topic of critical thinking because of the non-formal activities: the fact that the research group had tacit understandings to achieve a positive social educational experience. He also talks about how the team reflective thinking was collected in the different minute's documents showing that design of the non-formal experience also became a source of critical thinking. In these two transcripts, Nicolas and Mathew see critical thinking in participants in their ability to "assess situations" as part of the critical thinking development. This is precisely what is explored in the next category through the voice of participants.

3.2.11.2.2 Category 7: Assess Situations

Critical thinking is shown through a series of situations in which participants are faced with decisions having to assess what they are going to do. The assessing situations collects how different participants solved situations either in the making of activities or in the research.

A situation that emerged was that families reported an issue with uploading photos and videos, the situation challenged the research team who had to assess the situation before deciding. Renato and I went to visit Isolda's house.

Field notes 3-1. Renato finding solutions to the issue of uploading media.

We were outside of Isolda's house waiting for Renato to do the back up. Some kids were playing outside on the patio. Isolda came outside. We greeted each other and asked how she was doing with the project. She reported that she could not upload the pictures. So, Renato asked her to see the phone, he also could not upload it. I told him to check the configuration. Renato went to the camera app and decreased the size to 9 megapixels; it did not work. He tried

with 8 megapixels which was the lowest and he could not either. I suggested uploading the pictures to the Comparte más and the comments in the Comparte section in the meantime. He agreed, he gave the guide to Isolda and told her to upload in the Comparte más. As we moved to Luciana house, I asked Renato if we could increase the size of the file that the Mazi could receive, and he said yes but that would mean to replace all the software's. (Field notes Lay Pos. 100)

From this field notes, Renato assesses the situation, and it seemed like he went through in his mind through a process of creating a mental flowchart of things that could have go wrong. By asking Isolda through the process of uploading the picture he was trying to identify if Isolda was missing a step. When he guaranteed it was not that he downloaded the resolution of the camera. Later, he knew that there was an error in the programming, but it would mean to replace all the software's which was not viable because they had launched the program. It would have taken more time to re-program the software than what the activities will take to finish. So, he had to assess the situation to make a final decision.

Assessing situations can also happen in a matter of shorter conversations in which participants assess their choices. In the next field notes I question Josefina about her like of Kimberly Loaiza, a Youtuber.

Field notes 3-2. Kimberly Loaiza

Her daughter was smiling saying she figured out the message. While Luciana went to tell Renato where the best spot to connect was, I kept talking to Josefina, Luciana's daughter. I told her that her Tik Tok mask was beautiful, and she said she really liked it. I asked her why she likes Tik Tok? she said because of the videos. I asked her if she has one, she said no but that she

> *follows Kimberly Loaiza, so I opened Tik Tok on my phone to check who it was. Then I had to browse through her Instagram and google it. She is 40 years old, married, two kids, Mexican YouTuber, influencer, and singer. She said she likes to see her videos and that she wants to have a Tik Tok to dance too. (Field notes Lay Pos.104)*

Josefina's is Luciana's daughter, and I went to her house with Renato. While Renato was trying to fix an issue with the Raspberry Pi, I talked to Josefina about her mask which she had decorated with the words Tik Tok, a social media app for video networking. When I questioned her about Tik Tok, the videos and the influencer she liked, she had to take in consideration different point to solve a situation in this case the questioning I was making about her preferences. The Tik Tok decoration for her mask allowed me to propel a conversation that showed her way of assessing the situation. Nicolas comment in the previous category where he found that through transformation of the products there was critical thinking process, seems also to apply to the choices that we are making about the things that we like. Having non-formal STEAM activities as a source of critical thinking propel a space of assessing situations and how they could be solved. We saw it for researchers and participants themselves through the excerpts presented. Even though, assessing situations can be done in other daily situations, the STEAM experience is giving them the space and opportunity to experience the assessment in a learning context among family members where they pull together their previous knowledge experiences.

3.2.11.3 Non-Formal STEAM activities as a Source of Critical Consideration of Circumstances

The third theme: "Critical considerations of own circumstances". Inside this theme, there are two categories: (1) facing hardships together and (2) projection of future possibilities.

3.2.11.3.1 Category 8: Facing Hardships Together

Hyperlocal created a space for families and the project team to consider their own circumstances and reflect about their history. Historicity focuses on the reflection process in which the families and the project team can name their world and verbalize their circumstances. Susy's historization, as seen in transcript 3.6, of socio-economic hardship allows her to point to what really matters - education of her children - and through this she makes connections to future possibilities:

Transcript 3.6 Historicizing the importance of education

> *As my father used to say, the only inheritance I can leave to my children is education. In addition, it is very didactic for them, they learn a lot. They were most excited about the soap, but not when they saw those dinosaur casts because they did not like it for a girl. Imagine, if I want to sell it but only for boys. So, I told my daughter that if we see the same quality [casts] in downtown, we will buy them.*

Susy makes relevant that inheritance is not money but education. This connects to previous categories such as the motivation to be part of the project in which they wanted to be part of the project to offer better educational opportunities to their children. Another, relevant point is Susy making is when she shares that her daughter did not like the dinosaurs' casts for the soap because they are not *"for girls"*. Susy offers her to buy

some for. This points unconsciously points to how the society has established what is for girls and for boys. The social pressure impose invokes facing this hardship together.

The historization of participants' circumstances was shown through generative themes, topics that were relevant for them. In transcript 3.7 (Interview Lila, Pos 150-153) the dialogue reveals generative themes for Lila as she historicizes of how she came to live where she is and how she Figured out building and equipping her house through *'tandas'*[1].

Transcript 3.7 Generative themes

> ***Lila:*** *My house is about a block and a half away. I used to live with my mother. When I was pregnant, I did not want to be with him. While my whole pregnancy lasted, I was with my mom. He sent money and everything he could. After our son was two months old, I moved in with him. I have been living here for 5 years. Here is my room and that is it, we built it upstairs.*
>
> ***Lay:*** *How was that entire process?*
>
> ***Lila:*** *Well, I told you about the pregnancy: I spent it there with my mom and after our son was two months I came. The truth is that when I came here, well, I had nothing. He did not have a bedroom' door. We had a bed, but as I told you: I was regretting having left my mom's house, to having said yes. Little by little. I started buying the stove, the fridge and having to cook myself apart. We already built up and down, I have the kitchen here and upstairs we use it for the room. We struggled for what he worked for, but then the good thing is that in challenging times the tandas helped us. We use tandas because there are no loans for us and I do not like them, I feel like I*

[1] This is a Spanish word that refers to an informal saving method in which people can finance themselves. All the people involve bring the money to a common pool with families, friends, or colleagues. The total sum is rotated among the members of the "tanda" to receive the entire money and is paid biweekly or monthly as stipulated by participants. Tandas also serve as a short-term loan, as people can receive big amounts of money in a short period of time (Fundary, 2018, retrieved from https://medium.com/@fundary/ tandas-and-the-informal-economy-of-mexico-4f3c80c1c7ce).

am going to pay more. So, among all of us, my mom does tandas of 500 or 300 pesos and with my siblings join them; I have one sister and two brothers, my dad, my brother-in-law, one, my sister-in-law. We put the numbers together and raffle the numbers. When the tanda is done, it is no longer necessary to ask for a loan.

In this transcript the generative themes are tightly related to things that matter to Lila in daily life: relationships, housing, and finance. She reflects about how her pregnancy somehow led her to live with her husband. However, economic difficulties have been presented to build and equip the house. For that reason, they have used 'tandas' which are a way to finance themselves. All the participants in a tanda give a specific amount of money each month and one get all the pot in the month depending on the number they got. So, if the 'tandas' was one hundred pesos per month with five people, each month the tanda would be five hundred pesos. If Lucía got the number one, she would get the five hundred pesos for the first month, the next month she must pay one hundred pesos. The concern about economic sources generated that later in the interview, she mentioned the possibility of selling the soaps that she learned to make in Hyperlocal. Other generative themes that appeared in the findings were schooling, women violence, abilities, gangs, and the Covid-19 pandemic.

3.2.11.3.2 Category 9: Projection of Future Possibilities

After the implementation of the social design experiment, the families had the opportunity to make reflections about their future and possibilities. As part of that opportunity the families expressed their previous desires for the future before and after the sessions. Their previous desires for the future revolved around their ambitions for

their children to have opportunities for a different job profession than what their parents currently have. Transcript 8 *(Interview with Susy Pos. 269)* is a conversation with a mom and her two daughters and exemplifies their professional aspirations.

Transcript 3.8 Reflect about the future

Lay: *What do you want for your daughters in the future?*
Susy: *All the good things that can happen to them.*
Lay: *And what do you want for your future?*
Yarezi: *Lawyer.*
Lay: *What do you like about being a lawyer?*
Gloria: *if you do not know anything*
Susy: *Let her talk*
Lay: *Come on. Yes, tell us, tell us.*
Susy: *I am going to check the beans. [She leaves]*
Yarezi: *I want to be a lawyer because there are many things you must do, that is. As well as defend, as well as many cases of. I mean. How? As well as. Defend people, people.*
Lay: *Who would you like to defend?*
Yarezi: *No, well I would like to defend the ladies who are beaten by their husbands*
Lay: *And you?*
Gloria: *Well, I want to be a doctor.*
Lay: *What type of doctor*
Yarezi: *veterinarian*
Gloria: *No, a doctor to help people.*

In the conversation, Yarezi and Gloria expressed their desire to become a lawyer and a doctor. These two are different professions from what their parents do. Their father works in construction and their mom, Salomé, is a stay-at-home spouse. Their mother

got married when she was 18 years old, only finishing middle school. Her father insisted she did not need high school because she only needed to get married. The reasons given by the girls to choose their profession hint at social problems found in this context such as domestic violence, and gangs that they also comment on in their historization process.

After the social design experiment, when asking participants about what they could do with the acquired knowledge, their desires for the future can be grouped in three subcategories: apply for business, more STEAM projects, to learn other things. Susy exemplifies the desire to apply the knowledge they acquired for business: *"I was thinking of getting the soap to make bigger soaps to sell in my dad's shop. I told my dad I can make the soaps and sell them here. He said it is okay. We can put them in bags or in the same casts. We can charge 5 pesos for the big one. That would be less expensive than the cheapest in a shop." (Interview Susy, Pos 226).*

The acquired knowledge by participants opened the horizon for participants to dream about other possibilities. They could apply it for business, asks for other STEAM projects specifically to be taught and to propose specific topics of interest for future workshops. As Valentino said, *"Hyperlocal is a seed project which can help to build trust in the community, and this can help to transform their lives one step at a time" (Field notes Lay Pos. 3).*

3.2.11.4 Designing a Dialogic Educational project in a Non-Formal Context

Relevant to this pilot study, it was the opportunity that I had to be part of the team who designed a dialogic educational project in a non-formal context. From this

process of designing the experience two categories emerged: (1) doing research with an International Interdisciplinary Group and (2) Community service impact.

3.2.11.4.1 Category 10: Doing Research with an International Transdisciplinary Group

This category of doing research with an international transdisciplinary group collects the dynamics of the research team working together: their expectations and roles.

The team was a combination of 4 Mexicans, 3 English, 1 Venezuelan and 1 Ecuadorian. As stated in category 1 their motivations were centered in their current work and profession. Meanwhile their expectations were centered on what the project could generate and achieve. The team expected to generate creativity and conversation. Mathew narrates the purpose of each of the MAZI section and convey this expectation of generating deeper conversations through the spaces that they created saying that *"by creating a space for people to put their outputs and have conversations, we were implicitly asking people to reflect on what they had been doing. So, I suppose that there was implicit an affordance set up in the system to encourage reflective thinking" (Interview with Mathew Pos. 29).* The project team also expected to achieve alternatives to education in the Covid-19 and relationship among participants. Amanda stated that the project was an opportunity because *"education does not only happen in the classroom. It is one of the things that we work a lot with this type of projects. Children can learn how to do things and then transfer it to their homes, the community and continue to learn from it" (Interview with Amanda Pos. 8).*

The dynamics of the team can also be described in terms of the roles that each of the members played. Nancy, was described by teammates as the face of the project

whose leadership brought people together from different areas, propose a project and follow up on it. She had the ability to have empathy to understand others. Mathew and Daniel were the ones leading in the MAZI technology. Daniel was fundamental at questioning the team about the design to be centered in the participants. His role has its roots in his experience at teaching long distance courses in higher education as described by him *"I teach at a distance. So, again that is why we spent such a long time thinking about what the structures of these things were and, in the end, it turned out to be something simple" (Interview with Daniel Pos. 2).* Mathew role was particularly related to the technology but also, he would support the team to land the dreams. Amanda managed the "a*spects of theorizing and practical building and working with the web designers. She also oversaw the paperwork with the Community service students" (Interview with Mathew Pos. 39).* Renato helped to build the relationship the community and solve technical issues with them directly. Nicolás set research guidelines from a qualitative paradigm. Valentino was the community liaison who served as an advisor to approach the community. José role was to make reflection with Lay about the project. Lay's role was collecting on the ground information with participants.

Doing research with an International Transdisciplinary Group involved constant contact and the implementation of practices that were helpful for communication such as meeting notes with descriptions of the topics discussed and the agreements reached. The research team exercised dialogic practices during the project which became key in expectations and team dynamics.

3.2.11.4.2 Category 11: Community Service

One fundamental pilar for the project was the participation of undergraduate students in the project. In an interview with Valentino, he expressed the importance of the community service for students as seen in transcript 3.9

Transcript 3.9 The importance of community service

> *Unfortunately, the pandemic affected us a lot in social service, but being there in person is already very formative. Discovering the reality of these colonies is very formative. See the street, see the people, see. And that they discover that most of the country is like this, it is not how they live it daily, that is very formative. Secondly, I believe that when you do a project of this type, all your senses, everything, everything is related. I mean, you cannot say, I am going to work with children, not because you are with the children, but you also collaborate with the mothers. This one you work with children, but you also collaborate with moms. And then it is formative because you do not see your project, it is never a specific project, it is always a project in an environment and in a context. That is why we place emphasis on the induction workshop because we want to show that context. This and then is formative because traditionally the students are placed in a vertical position. I give, they receive. And to the extent that also as a training partner, because we are trainers, partners, trainers because we invert that line so that it is horizontal. They learn, we learn, we all learn. And then the students learn that what we do is important. But what they do is more important for them and for themselves. That is, there are many paradigms shifts that are required of the student. If you cannot tell them before, you must explain them as you go because if you tell them before, it is theory. And if you tell them as you go, it is because they are already watching. Now, there may also be students with a strong, for example, tendency to discrimination may happen. Or it can reach students that for some it is a waste of time to go to the community. So, you have those extreme cases, you also have a challenge. Most arrive, therefore, wanting to*

> *learn how to do something. But you also have some reluctant times. And well, they are also the target of social service (Interview with Valentino Pos 43).*

It is relevant two main points that Valentino made, one being the fact that the experience is formative to those receiving the help and to those giving the help, in this case the undergraduate students, and second, the fact that the non-formal experience opens the space for dialogic and horizontal relations. Joseph, an undergraduate student, agrees with the Valentino' perception: *"I think that in some way you can feel closer and get to know the people, then you realize the situation that they are experiencing, what they want to achieve and in some way. So, empathize with them. You feel a little closer to those people (Focus group_ Pos. 18)".*

Designing social projects based on the networking that involved different academic institutions are an opportunity not only to higher education researchers but for higher education students to develop different skills and connect to other realities. In the process it was relevant that students also could develop research skills such as collecting data. Lisa: said "*Yes, well, to create empathy and trust with families, I would introduce myself since I was part of the project and then ask how they had been and if they had some time now or later for me to chat with them, they would tell me yes and then I would ask some questions. Depending on the schedule I would ask them the questions or not. I added some other occasional topics of conversation. Then at that time I would thank them for all their time and invite them to continue with the activities (Focus group_Pos. 26).* It is organized ways in which the academic researchers can coach the process of higher education students by creating meaningful experiences.

The community service was also of impact to practice values. Unanimously, the undergraduate students agreed that with Hyperlocal the practice values such as the value of recognition of empathy, the value of ethical argumentation, integrity, civic and ethical commitment *(Focus group_Pos. 29).* Hector recognizes that the project "exemplifies *the concept of social service. Hyperlocal links you directly with the community. You have a direct impact at least in the people who participate in this project. I mean, it is something that I really liked about this project, and I think, it is undeniable that project" (Focus group_Pos. 34).* It is relevant to note that students had this perception even though the community service was done online due to the Covid-19 pandemic.

3.2.12 Discussion

The results in the pilot study can be summarized in Figure 3.13 which is a visually organized map of the four themes and eleven categories in which the data coded was grouped.

The experience of the pilot study as a feasibility study has shown that there is a niche in the implementation of dialogic educational practices in STEAM non-formal contexts as well as serving the purpose of evaluating the methodology implemented to analyze these dialogic practices.

Hyperlocal Learning Network in La Campana Altamira as a non-formal learning context created a networked and dialogic space that propelled the community's creativity and sense of being capable of doing more than they expected. This dialogic space allowed participants to assess different situations exercising their abilities to conceptualize, analyze and evaluate issues. In the dialogic space created by individuals

within a family and their immediate neighbours, the participants challenged their own goals and practices, and positioned themselves in the world. The dialogic educational practices resulted in giving voice to the families and the choice to be freely part of the project.

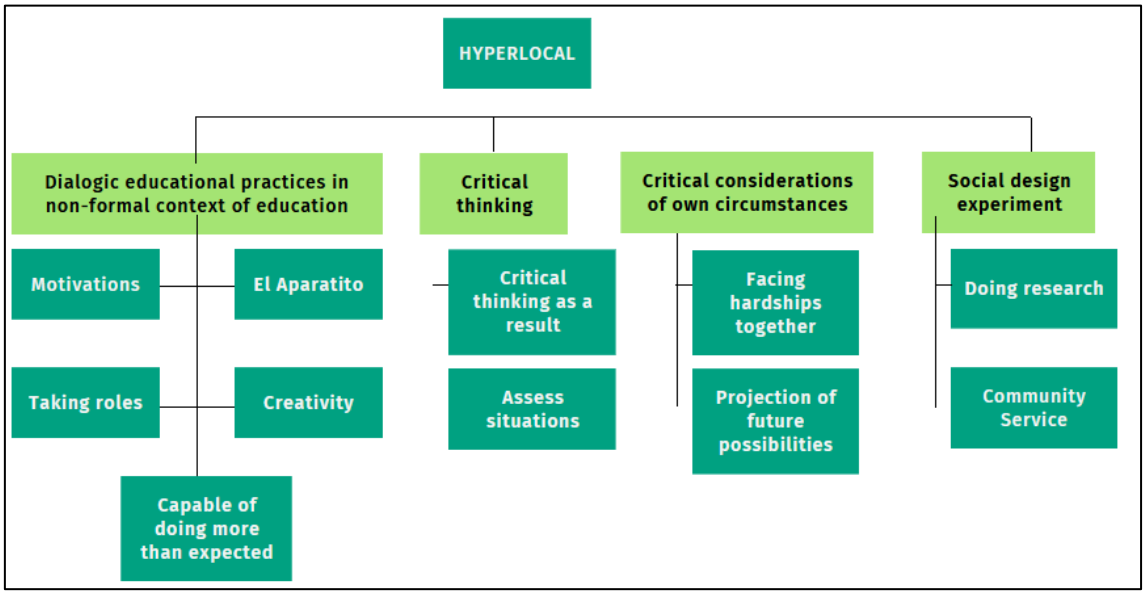


Figure 3.13 Pilot Study Categories

El Aparatito was seen as the mediating technology and became an excuse to connect neighbors through it and out of it. This tell us that participants were able to use technology not as they expected, but as they make more sense of it. Families combine different social networks and cell phone functionalities to make sense. That also implies that they went looking for solutions and alternatives connecting previous knowledge with what the activities were asking them to do. They were able to present in diverse ways their projects. Hyperlocal became a catalyst for dialogue and got the community members thinking about extending their personal opportunities. While the interest to 'share' could be observed, again, the community participants used a mixed approach to

how they did that. The use of technology also created an exchange of traditional teaching-learning roles within families. Children were the ones uploading the content while the mothers were the ones leading the sewing and cutting process.

Having a role as a researcher and companion who listened to their stories allowed me to hear their own historization process. They revealed that facing hardships together with families and neighbors created hope for the future. Voicing their historicity is an important part for bringing social change and transformation. It is relevant documenting the participants' experiences to legitimize the richness of the dialogic space created in a non-formal educational context. Moreover, the historization process of their own circumstances involves challenging their previous learning and future possibilities, so that they realize that they are more capable than what they initially thought. The effect of designing this experience is that for researchers was also a time to position to critically question their educational and research practices.

3.2.13 Lessons for the Main Study

Piloting the method was useful to establish a structure, assess the appropriateness of data collection and analytical techniques, set a timescale, and prevent potential mistakes for the main study.

3.2.13.1 What Worked Well

Qualitative Perspective: Through the pilot study, it was possible to confirm the richness of a qualitative perspective to portray a more in-depth information about participants. It is an inductive process that allows to describe the experience of those who lived it. The qualitative perspective allowed me to get to know participants in a deeper level making me aware of socio-economic circumstances that these families go

through. It was possible through the contact with them that they shared their family's history such as the death of relatives due to drug dealing or domestic violence in the area.

It was relevant in this process to create rapport with the participants. In this case, listening with attention to what they had to say, giving value to their words, and accepting their hospitality was fundamental to understand their concerns. As they shared with us in the celebration event some tacos, jelly, and fruit, I took some pastries to thank them for their time in the final interviews. Sharing food seems to be a symbol you are welcome and that you are grateful.

Ethnographic and case study instruments: The value of the ethnographic tools (participant observation, ethnographic field notes, and interviews) and the case studies (interviews and participant observations, documents, and physical artifacts tools) is that they provided a space for dialogue with participants and expressing their feelings, thoughts, and actions.

It was key to apply the instruments with the project team because it was a one-on-one opportunity to get deeper on their view of the project and how it connected to their own history. The lesson here is that as researchers these instruments allow us to create a space for participants to reflect upon their experience. This might be fundamental because they are being heard and while sharing, they go through their own realization process.

Data collection: The data collection was strong due to the design of the instruments. When thinking about the instruments, the triangulation process also came

to mind. It was fundamental to have designed the instruments with an intended purpose of matching the objectives of data collection among them. The result was that instruments were aligned to the research question and that a triangulation of information from various sources was available.

In the data collection process, it worked well to have jottings in the writings to record my impressions of the events as well as identifying key points relevant to participants. The organization of documents in the drive and in the MAXQDA also worked well because of the naming of the document based on the needs of the researcher.

***Designing the experience*:** in the process of the social design experiment, it was relevant to gain a broad perspective of the issues inside a research project such as the academic, administrative, ethical, research, and dissemination. All these was possible thanks to the collaboration of the researchers who put their skills at the service of the project. Moreover, the flow of communication was easier with a Google Drive space to keep artifacts, taking notes in the meetings about our thinking process and agreements.

Designing the experience for the community included also designing the experience for undergraduate students to be part of the project, the richness was in connecting with a community closer to them and exercising values such as empathy and collaboration. The community service that higher education students do is meaningful because they give and receive in the process. In that sense, connecting undergraduate students with the community adds to their personal and professional life. It was useful to provide undergraduate students with a calendar of activities and how their participation was moving through the project. Regular meetings with them and the use

of synchronic and asynchrony tools provided a trust-based and communicative effective relationship.

3.2.13.2 Changes and Additions

Quantitative and qualitative design: Even though the qualitative perspective worked well, for the main study is suggested the use of quantitative data to inform numerically the impact of the application of dialogic educational practices in STEAM activities. The proposal is to make a pre and post application using the Educate Insight critical thinking mindset test. This tests evaluates the motivation to think and to learn based on 5 attributes: mental focus, the learning orientation, the creative problem solving, the cognitive integrity and the scholarly rigor (Insight Assessment, 2021). It could be interesting to see how a quantitative tool could enlighten the impact of dialogic educational practices.

Field notes: To better inform the field notes, the proposal is to use an adapted version of the Co-Measure test. The original version of this test intends to observe individual student's collaboration when working in K-12 STEAM activities (Herro et al., 2017). However, adapting this test for the field notes to observe group's collaboration provides an overview of dialogic practices happening during the sessions.

***Timescale*:** Despite planning there could be circumstances that will need flexibility in the implementation. The pilot study implementation was scheduled for 4 weeks but due issues with contacting them, delay in the funding to purchase materials, technical issues with the MAZI digital platform, and inclement weather we had to be flexible with the dates. Thus, taking this in consideration can better support the planning of purchasing materials on time for the main study. Moreover, it is relevant to

acknowledge that the four sessions of the main study were limited on the opportunities given to participants. So, it is suggested that participants in the main study are exposed to more STEAM sessions.

Designing the experience: The dialogic educational practices should be purposely implemented in the design experience of the sessions so that we can track the impact rather than assuming they will come because of the tools and spaces provided. This means in the sessions to be intentional in including dialogic educational practices for the interactions of participants providing them topics and activities that propel reflection.

3.3 Main Study Design

3.3.1 Introduction

The main study described in this section aims to answer the research problem statement as described in section 1.4 for which the research question established was: To what extent dialogic educational practices in STEAM sessions have an impact in the critical thinking skills of participants of non-formal contexts of education? Regarding the term critical thinking skills is seen as a cognitive process for education as well as a sociocultural skill related to being critical about oneself circumstances. Even though, authors like Sensoy & DiAngelo (2017) differentiate between critical thinking and critical theory making it clear that critical thinking deals with the reasoning system while the critical theory attempts to a moral critique of culture, for this thesis the aim is that the critical thinking skill combine the critical in the reasoning and social spheres.

The main study design took in consideration the lessons, the experience designing a project, and the experience as a researcher in the pilot study. It is relevant to note that in between the pilot study and the main study, I conducted another project named CIRCA STEAM LEAF Mexico with the CIRCA Pintig organization from the United States. This project was carried in my internship with Professor Angela Mascarenas. I was responsible for the academic implementation of the project and administrative part. In CIRCA STEAM LEAF Mexico, I implemented 4 more STEAM sessions with some of the participants from the Hyperlocal project. Even though, the CIRCA STEAM LEAF Mexico is not described in this dissertation, it raised additional lessons that enabled to (1) strengthen the design of the High STEAM project which is in the framework where I carried the main study and (2) gave me the experience of applying, managing, and designing an international project as an administrator and as researcher.

For the main study, I conducted research under a mixed method design (Section 3.3.2) to answer the research question. The main study was done in the context of an extra school program, High STEAM, implemented in vocational high schools in traditionally marginalized areas in Monterrey, Mexico (Section 3.3.3). Participants from High STEAM were high school students and teachers and higher education students who were also invited to be part of my research (Section 3.3.4). Among the instruments that were assessed to answer the research questions qualitatively were field notes from the participatory observations, semi-structured interviews, focus groups, as well as documents, photos and videos produced in the project by the participants (Section 3.3.5). Meanwhile, quantitatively, the instrument used was the California Critical

Thinking Skills Test. The research procedure I followed was divided in five stages: the funding, project design, implementation, data collection, and analysis. (Section 3.3.6 and 3.3.7). I specify ethical considerations taken during the research for participants and me as a researcher (Section 3.3.8) Then, it follows a summary of the data collected (Section 3.3.9).

3.3.2 Methodology

For a long time, research studies focused on either quantitative or qualitative designs to respond to the research questions formulated. However, the methodological tradition has evolved to research designs that use mixed methods, also known as the third methodological movement (Tashakkori & Teddlie, 2003).

Historically, the term mixed methods had a different focus on its definition. For example, some saw it as methods (J. C. Greene et al., 1989), others as the methodology (Tashakkori & Teddlie, 2003), and some had a broader perspective that included the methods, methodology, and philosophy (Creswell & Clark, 2017). For this thesis, the focus of the definition that will be used is that mixed study refers to an approach in which the researcher collects and analyzes quantitative and qualitative data in the same study (Creswell & Clark, 2017; Shorten & Smith, 2017). This method involves multiple ways of seeing and hearing, multiple ways of making sense of the social world, and multiple standpoints on what is important, to be valued and cherished (J. C. Greene, 2007).

Some authors have agree on at least four approaches to mixed method designs: convergence parallel, embedded, explanatory sequential, and exploratory sequential

(Creswell & Clark, 2017; Edmonds & Kennedy, 2022). The method for the main study involves a mixed convergent parallel design.

The convergent-parallel approach is a concurrent approach and involves the simultaneous collection of qualitative and quantitative data (usually both QUAL and QUAN are the emphasis), followed by the combination and comparisons of these multiple data sources (i.e., the two methods are merged). This approach involves the collection of different but complementary data on the same phenomena. Thus, it is used for the converging and subsequent interpretation of quantitative and qualitative data. This approach is often referred to as the concurrent triangulation design (single-phase) and is supported by authors like Lincoln & Guba (1985) who established that pieces of information should be expanded by at least one other source or a second method because single items of information can contribute little to understanding the context of study.

The quantitative data will be collected in a pre-and post-implementation using the Educate Insight thinking mindset test (Insight Assessment, 2021). Meanwhile, the qualitative data will be collected during the participatory observations of the sessions and in focus groups with the designers of the experiences. Key participants will be interviewed with ethnographic interviews. Narratives of the life of the participants will be developed to explore the impact of the dialogic practices.

3.3.3 Context of the Study

The main study was conducted in the context of the High STEAM project, a project financed by the U.S. Consulate of Monterrey and implemented by Tecnológico de Monterrey and led by Professor Juan Manuel Fernández-Cárdenas. His lines of

research include the formation of communities of practice, the evaluation of educational quality and the analysis of speech in interaction in educational settings using digital technology, particularly in issues of moral development, culture of lawfulness, literacy, and science education. He has more than one hundred peer-reviewed and indexed publications and has led projects financed by the US Department of State, the British Council, CONACYT and Tecnológico de Monterrey.

High STEAM addresses the critical challenge of equitable access to quality education in communities of marginalized situation in Monterrey, and in a health emergency due to the COVID-19 pandemic. Education in science, technology, engineering, arts, and mathematics (STEAM) is vital to achieving the United Nations Sustainable Development Goals (SDGs). However, quality education in these subjects is limited by access to schools and programs that have the materials and academic staff to implement them. Moreover, with the declaration of the COVID-19 pandemic, access to this type of educational experience have been further limited, so it is urgent to design and implement inclusive and sustainable quality STEAM education activities for all. The main objective of the High STEAM project is, through STEAM activities, to generate transformative learning opportunities that contribute to social inclusion and sustainable growth in these communities.

High STEAM was a one-year project divided in four stages as seen in Figure 3.14. During the first stage, Summer, I trained undergraduate students in Dialogism through seminars parallel to designing the 20 STEAM sessions. The dialogism seminars were focused on the works of dialogic education definition, genesis, and on field examples (Alexander, 2018; Ching-Chiang & Fernández-Cárdenas, 2020; Fernández-

Cárdenas, 2014; Freire, 2005, 2005; González-Nieto et al., 2020). This stage included the design of a network and website strategy to contact participants and share information about the project with the community. The materials for the sessions were purchased, and the kits assembled and delivered to the high school teachers. The high school teachers were responsible for delivering them to their students. The next stage, Fall, was for the implementation of sessions 1 to 8. It included a welcoming session with the Monterrey U.S. Consul and a scholarships opportunity session. The implementation of the sessions was face-to-face, online, or hybrid depending on the circumstances of each school and their policies about Covid-19 pandemic. The third stage, Winter, there was a review of the modules 3, 4 and 5 which included sessions 9 to 20. Moreover, the corresponding materials for these modules were purchased, and the kits assembled and delivered to the high school teachers. Lastly, the Spring stage was the implementation of modules 3 to 5.

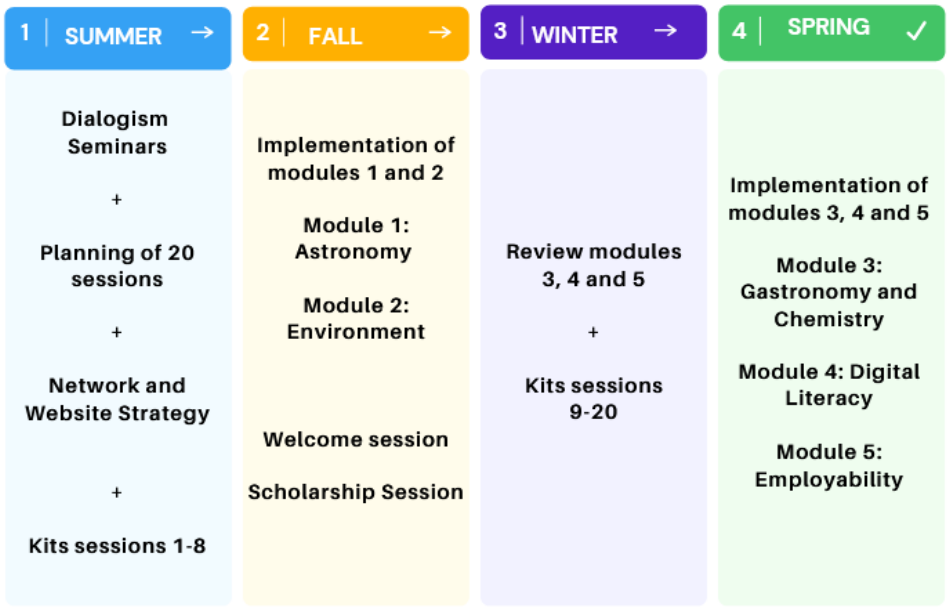


Figure 3.14 High STEAM schedule

High STEAM implemented 20 STEAM sessions with students and teachers from six technological high school campuses located in marginalized areas of the Monterrey metropolitan area. In each school, the best ten students were selected to participate with the accompaniment of a teacher who was trained and monitored as part of the project. The activities were grouped into five major themes, based on sources such as the National Science Foundation, NASA, the Smithsonian Museum, and other educational institutions in the United States. The five themes were: 1) Astronomy, 2) Environment, 3) Gastronomy and chemistry, 4) Digital literacy, and 5) Employability. The twenty sessions are described in Table 3.19. For a detailed explanation of each of the STEAM sessions you can check them in Appendix D.

Table 3.19

High STEAM sessions

Topic	Session	Explanation
1: Astronomy	1: Welcoming	Welcoming session for students and teachers, includes talks about scholarship opportunities
	2: Light the constellations	Identify constellations and elements of outer space, explore basic concepts of electricity
	3: Satellites	Understand the functions of an artificial satellite
	4: Art and cosmic connection	Using the elements of art – shape, line, color, texture, value – students make sense of images of planets, asteroids, comets, and moons, honing their observation skills and inspiring questions.
2: Environment	5: Monitoring our changing world	Explore how and why scientists monitor birds and how it relates to citizen science projects like eBird. Set the stage for discussions about birds as bioindicators in an ecosystem
	6: "Oceanography in a Cup"	Understand how foam forms in the oceans, density, and the effect of wind-driven waves
	7: Eco-audit	Raise awareness about the use of resources and determine the impact of decisions
	8: Climate Change	Express their thoughts on climate change through music and design a poster that represents the song they created
	9: Glow in the Dark Jell-O	Apply chemistry concepts in the kitchen
3: Gastronomy and cooking	10: Greasy Potatoes	Create awareness of the concepts of fat, calories, and estimations through the comparison of the smoothness of several varieties of chips
	11: Do it like Pollock	Create a safe space for the expression and development of creativity, an opportunity that can be turned into business
4: Digital Literacy	12: My digital footprint	Raise awareness about the individual digital footprint and how companies use that information
	13: Microsoft Word y PPT	Explore key functions of Microsoft office Word and Power Point
	14: Social Media Etiquette	Promote a culture within social networks that allows clear communication bridges to be built
5: Employability	15: Fake News	Create awareness of fake news specially in social media
	16: Designing my future	Design a prospective future to recognize areas of opportunity and strengths
	17: Excel	Use of key formulas
	18: My CV	Build skills to design resumes based on the position to apply
	19: Looking for a job	Use of LinkedIn as a tool
	20: Closing session	Delivery of certificates and final reflections on future possibilities

3.3.4 Participants

High school Teachers: In High STEAM, there were ten teachers, five males and five females, from technical vocational schools (CBTIS/CETIS) who applied to be part of the project. Table 3.20 has anonymized data about the teachers and the schools they belong to.

Table 3.20

Main Study: High School teachers

School	Total number of students in the school	Teacher	Years as a teacher	Years as teacher in the current school	Subjects that you are teaching
School 1	1500	Sara	10	5	Recruitment and Selection, Administrative Documentation, Training and Development, Hygiene and Safety at Work, Productivity and Quality, Research Methods
School 2	1678	Katherine	12	11	Math
School 2	1678	Raquel	6	4	Computer programming and web applications
School 3	500	Ramiro	3	3	Physics (I and II), Algebra
School 3	500	Edmundo	12	10	Computer programming
School 4	849	Leandro	15	5	Chemistry 1, Chemistry 2, Physics 1, Biology and Ecology
School 4	1005	Rafael	4	3	Physics and Math
School 4	1005	Elizabeth	20	6	Automation, Electrical Circuits, Physics, Milling Machine, CNC, Manufacture of metallic structures. Automation, Electrical Circuits, Physics, Milling Machine, CNC, Manufacture of metallic structures.
School 5	651	Margaret	11	2	Chemistry, Biology and Ecology
School 6	1900	Felix	35	25	Chemistry

The teachers selected for the project went through an application process which included a letter of intent as well as a consent letter from the school principals.

Higher education students: these are fourteen undergraduate and five PhD students from Tecnológico de Monterrey who designed and implemented the twenty sessions. The undergraduate students are students from different careers who are completing their community work program as part of the requirements for graduation. Meanwhile the PhD students are from Education school programs. Table 3.21 has the anonymized names of the students as well as their school program, age and working hours to the corresponding period.

Table 3.21

Main Study: Higher education students

Number	Student	School Program	Age	Summer	Fall	Winter	Spring
1	Amanda	Education	19	200	120	0	0
2	Pedro	Innovation and development	19	200	120	1	120
3	Eusebio	Educational Innovation	20	200	120	1	120
4	Armando	Organizational culture	20	200	120	1	120
5	Fernanda	Educational Innovation	20	200	120	1	120
6	Eunice	Educational Innovation	20	200	0	0	0
7	Roberto	International Business	19	0	120	0	0
8	Amy	Innovation and development	20	0	120	1	0
9	Olivia	Innovation and development	22	0	120	1	0
10	Alberto	Creative Studies	20	0	120	0	0
11	Carla	Design	20	0	120	0	0
12	Gerardo	Information Computer Technology	18	0	0	1	120
13	Chuy	Information Computer Technology	18	0	0	1	120
14	Elbert	Information Computer Technology	22	0	0	0	120
15	Lay	PhD Candidate	35	200	120	200	120
16	Derek	PhD Candidate	36	0	120	0	0
17	Miriam	PhD Candidate	40	0	120	0	120
18	Emma	PhD Candidate	40	0	120	0	120
19	Carolina	PhD Candidate	40	0	0	0	120

High school students: They are one hundred students who were studying the last two years of their technical vocational high school in marginalized areas of Monterrey. They belong to one of the three CBTIS or CETIS described in Table 3.19. The high school students in the project were 51% female and 49% males between 14 and 18 years old.

3.3.5 Instruments

The instruments to support the convergent-parallel approach described in section 3.3.2 methodology were done with techniques to establish trustworthiness. I followed recommendations made by authors like Erlandson et al.(1993) and Lincoln & Guba (1985) who point out that to establish trustworthiness some qualities in the procedures, findings and decisions should be credibility, transferability, dependability and confirmability. Specifically for this section of designing the instruments, I have considered a variety of sources and methods that in the analysis strategy will be helpful to triangulate information which elicits various constructions of reality within the context of study and build on the credibility of the data collected.

The instruments to collect data for each of the paradigms were the following: For quantitative: Educate Insight Thinking Mindset Test and for the qualitative: semi structured interviews, ethnographic field notes, focus groups and support documents produced in the project by participants. In the next sections, these instruments are described in more detail.

3.3.5.1 Semi-Structured Interviews

These semi structured interviews were applied to key participants of the High STEAM project who accepted to be part of my research. Tables 3.22 to 3.24 present the

questions for each type of participants. Additionally, in Appendix B you can find them in Spanish.

Table 3.22 Main Study: Semi-structured Interviews for high school teachers

Main Study: Semi-structured Interviews for high school teachers

Research Question	Questions for the high school teachers
To what extent dialogic educational practices in STEAM non-formal educational contexts become a source of historization and projection of future possibilities for high school teachers?	Please tell me more about you as a teacher (Why did you choose to teach)? What were your motivations? How long have you been a teacher? What makes you an excellent teacher? What methodologies do you use in your practice?) Describe your experience in High STEAM. (What is the impact of High STEAM in your educational practices? What did you learn from High STEAM? How can you use what you learn in High STEAM in the future?) Describe the experience for your students. How did the activities you had with your students were a source of dialogue? What did you see in your students in terms of reflection about their trajectories and possibilities for a future with hope? To what extent High STEAM activities were different to the activities usually conducted in your classes? If that was the case, what was different? [If you had to choose your favorite High STEAM session, which one would you choose? Why? Could you give me details of some aspects of freedom, creativity and play that were part of that session? Could you give me details of reflection derived from that session, in terms of your current circumstances and as part a possible future with hope? (Present and future)]

Table 3.23

Main Study: Semi-structured Interviews for high school students

Research Question	Questions for high school students
To what extent dialogic educational practices in STEAM non-formal educational contexts become a source of historization and projection of future possibilities for high school students?	Please tell me more about you (Who are your parents and what do they do? What do you like to do? What at are you good at? What is your dream for the future?) Describe your experience in High STEAM. (What is the impact of High STEAM for your academic life? Did you notice any difference with these activities in contrast to other classes? What did you learn from High STEAM? What do you think you can do with what you learn in High STEAM in the future?)

Table 3.24 Main Study: Semi-structured Interviews for undergraduate students

Main Study: Semi-structured Interviews for undergraduate students

Research Question	Questions for undergraduate students
To what extent dialogic educational practices in STEAM non-formal educational contexts become a source of historization and projection of future possibilities for undergraduate students?	Please tell me more about you (Who are your parents and what do they do)? What do you like to do? What are you good at? Why do you study your career? What is your dream for the future?) Describe your experience in High STEAM. (What is the impact of High STEAM for your academic and personal life? Did you notice any difference with the activities you designed and implemented in contrast to what you usually live in your classes? What did you learn from High STEAM? What do you think you can do with what you learn in High STEAM in the future? (Both as disciplinary [STEAM] and transversal competencies [dialogue])

3.3.5.2 Educate Insight Thinking Mindset Test

It is an instrument designed by Insight Assessment (2021) that measures the mindset using item prompt statements that express familiar opinions, beliefs, values, expectations and perceptions, and responders are invited to indicate the extent to which they agree or disagree with each. The test has a Spanish version provided by the supplier. The test has two parts: profile questions and the second part are the mindset questions as seen in Figure 3.15.

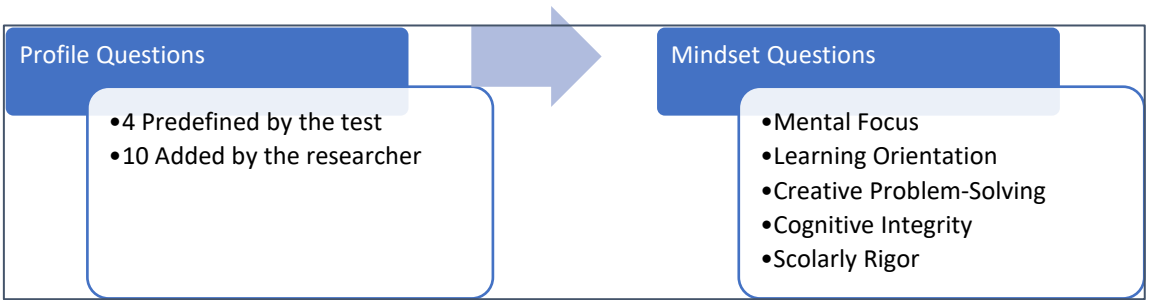


Figure 3.15 Main Study: Educate Insight Thinking Mindset test

The test collects information sociodemographic information of the participants through fourteen profile questions. The first four are predefined by Insight Assessment

and the following by the researcher. The fourteen profile questions are described in Table 3.25 and were designed to understand the socio-economic context of the high school students.

Table 3.25

Educate Insight Thinking Mindset test: Profile questions

Question	Predefined answers	Type of question
1. Name	(None)	Short answered
2. Email Address	(None)	Short answered
3. Age	(None)	Short answered
4. Gender	Female, Male	Multiple Choice
5. What is your mom's job?	(None)	Short answered
6. What is your mom's completed level of study?	Elementary, Middle School, High School, Undergraduate, Graduate	Multiple Choice
7. What is your dad's job?	(None)	Short answered
8. What is your dad's completed level of study?	Elementary, Middle School, High School, Undergraduate, Graduate	Multiple Choice
9. Do you currently work?	Yes, no	Multiple Choice
10. If you are working what is your monthly salary?	0-3000 pesos, 3001-6000 pesos, 6001-10000 pesos,10001-15000 pesos,15001-20000 pesos, more than 20000 pesos	Multiple Choice
11. How many people live at your house?	(None)	Short answered
12. What is the total household income?	0-3000 pesos,3001-6000 pesos,6001-10000 pesos,10001-15000 pesos,15001-20000 pesos, more than 20000 pesos	Multiple Choice
13. What would you like to study at the end of High School? Explain your answer	(None)	Short answered
14. What would you like to do in your future? Share your plans	(None)	Short answered

The second part is the seventy-two items to measure the mindset. The responses are based on a four-point Likert format ranging from "strongly agree" to "strongly disagree" with an intentional forced choice framework for each item where there is no neutral option. The five metrics measured by the Educate Insight mindset assessments are mental focus, the learning orientation, the creative problem solving, the cognitive integrity and the scholarly rigor, each of these describe in Table 3.26.

Table 3.26

Educate Insight Thinking Mindset test: Attributes

Mindset attribute	Description
Mental Focus	Mental focus is the discipline or habit of being diligent, systematic, task-oriented, organized, and clear-headed.
Learning Orientation	The Learning Orientation scale measures the tendency or habit of seeking to increase one's knowledge and skills; toward valuing the learning process to accomplish proficiency over a task; toward being interested in challenging activities; and toward using information seeking as a personal strategy when problem-solving.
Creative problem solving	Creative Problem-Solving is the habit or tendency of approaching problem-solving with innovative or original ideas and solutions; toward feeling imaginative, ingenious, original, and able to solve difficult problems; toward engaging in activities such as puzzles, games of strategy; and toward striving to understand the underlying function of objects.
Cognitive Integrity	Cognitive integrity is the habit of interacting with differing viewpoints for the sake of learning the truth or reaching the best decision, it is the tendency to express strong intellectual curiosity and value fair-mindedness and sound reasoning.
Scholarly Rigor	Scholarly Rigor is the habit of working hard to engage and to correctly interpret new material. It is the tendency to put forth the mental effort to achieve a deeper understanding of complex or abstract ideas and information.

The test was applied before and after the project.

3.3.5.3 Ethnographic Field notes

Are useful written accounts of the unfamiliar social world that detail each of the activities and then trace out their implications (Emerson et al., 2011). To better inform

the field notes, the proposal is to use an adapted version of the Co-Measure test as seen in Figure 3.16. The Co-Measure test assess students' collaboration when working in K-12 STEAM activities observing peer interactions, positive communication, inquiry rich/multiple paths and transdisciplinary approach (Herro et al., 2017). These attributes are supported by questions 2 to 5 so that the researcher can be guided by them.

FIELD NOTES

GENERAL DATA
Name of researcher: _____ School: _____ Teacher name: _____ Session number: _____ Number of students: _____

NOTES
1. Describe the session (What do you observe in the class? How do students and teachers behave? What was your participation) 2.Describe how the interactions between students and between teachers and students took place (Is there trust between peers to discuss criteria, identify goals? Do students volunteer to respond to requests from group members? Is there feedback?) 3.Describe the communication between students and between teachers and students (Did they respect ideas and commitments? Did they use socially appropriate language and behavior? Did they take turns speaking or were there constant interruptions? 4.Describe the multiple query paths (Did you notice if they consulted or referred to other sources of information? What else did they contribute?) 5.Describe the transdisciplinary approach (Are there relationships with local or global problems to solve? Are there collaborative resolutions? Are there tools to co-create and complete tasks? Do they discuss other disciplines?

REFLECTION
Reflect upon what call your attention. (What happened, or students said that called your attention?)

EVIDENCE (Place pictures of the session)

Figure 3.16 Main study: Field notes

3.3.5.4 Focus Group

These are focus groups with the undergraduate students to reflect upon their design and implementation experience of the sessions as seen in Figure 3.17.

Focus group for undergraduate students

(1) Describes the experience of designing dialogic scientific-technological experiences in this pandemic context. (What feelings, thoughts and actions did it awaken in you?)

(2) Describe your relationship with the students and teacher. (What did you learn from them?)

(3) Describe what knowledge/skills from your career you transferred to the project and vice versa

   a. Social justice: What was the impact of this project for the students and their teachers?

   b. Dialogism: What opportunities for dialogue were created through the activities? Evaluate the dialogue opportunities created in terms of their impact for teachers and students

   c. personal transformation: What was the impact of this project on your personal life? Has working at High STEAM made you think about your own studies in a different way, or change the way you approach your work?

   d. Social Service Values: How does this project reflect the values of social service (recognition and empathy, ethical argument, integrity, and citizen and ethical commitment)

Figure 3.17 Main Study: Focus group for undergraduate students

3.3.5.5 Support Documents

These are documents, photos, and videos related to the High STEAM project generated through the four semesters that the project took place. These documents were

collected in my personal drive as my initiative to keep track of the whole project acting as a personal diary of the project and represent a source of the field notes for my research.

3.3.6 Research Procedure

In Figure 3.18, I present a calendar of the scheduled research procedure that I followed with the five main stages across the 80 weeks of research.

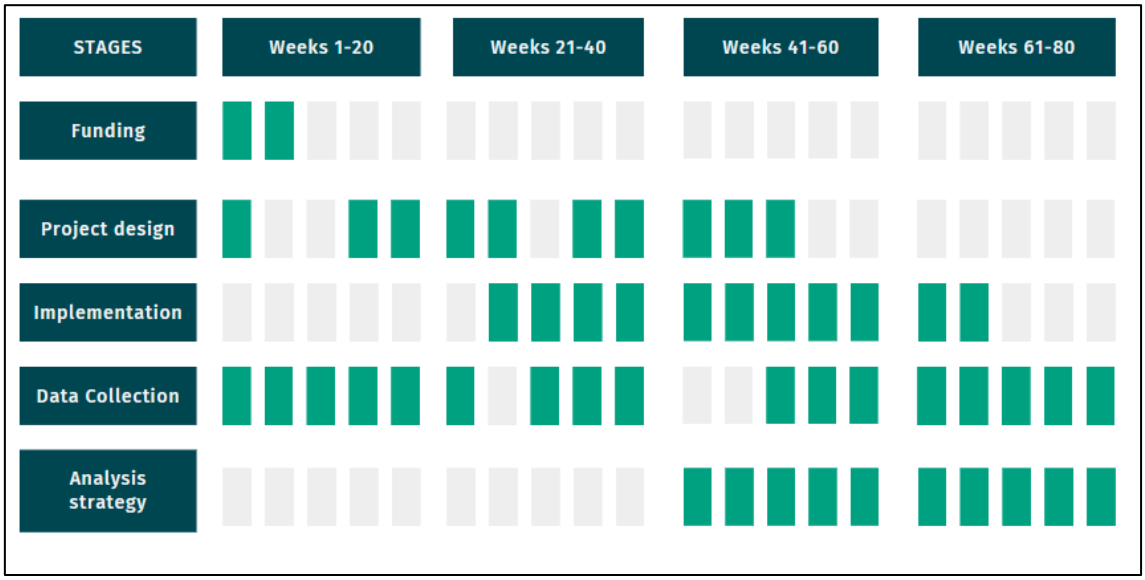


Figure 3.18 Main study Research Procedure

As stated before, I did my research based on the framework of the High STEAM project, in which I had an administrative and a researcher role. The project included research five phases: the funding, project design, implementation, data collection, and analysis. The *funding* stage involves the research, selection, and application of funding opportunities as well as the waiting time for the selection process decisions. The next stage, the *project design*, includes activities such as the paperwork between the U.S. Consulate of Monterrey and Tecnológico de Monterrey; registering High STEAM for the TEC Community Service so undergraduate students can be part of the project;

designing the experience for the undergraduate students; designing the experience for CBTIS/CETIS teachers and students, training teachers; contacting suppliers of the reasoning skills tests; purchasing materials for the sessions, assembling and delivering the kits. The *implementation* phase will include meetings with the teachers for training, coordinating the implementation of the twenty sessions per group of teachers, implementing the tests. *The data collection* stage will include the process of making field notes, focus groups and semi structured interviews. During the analysis phase the steps include the organization of the data collected, the anonymize the data, organizing the information the in MAXQDA, coding and analyzing the data.

In Figure 3.19, I have made more specific a timeline with details about the activities that took place during every semester as well as the qualitative and quantitative instruments used for the data collection.

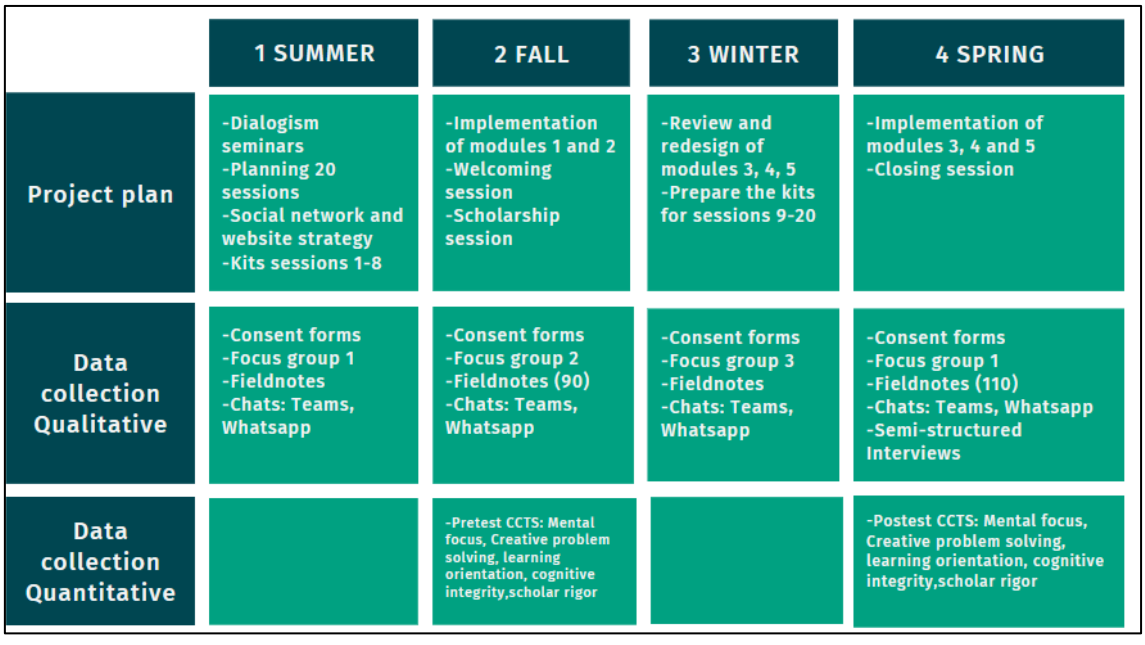


Figure 3.19 Data collection during project implementation

3.3.7 Analysis Strategy

Following the proposed mixed method convergent parallel design, the analysis strategy followed three phases. The first phase consisted of analyzing the quantitative data, the second phase analyzing the qualitative data, and the third phase bringing the quantitative and qualitative analysis together as described in Figure 3.20.

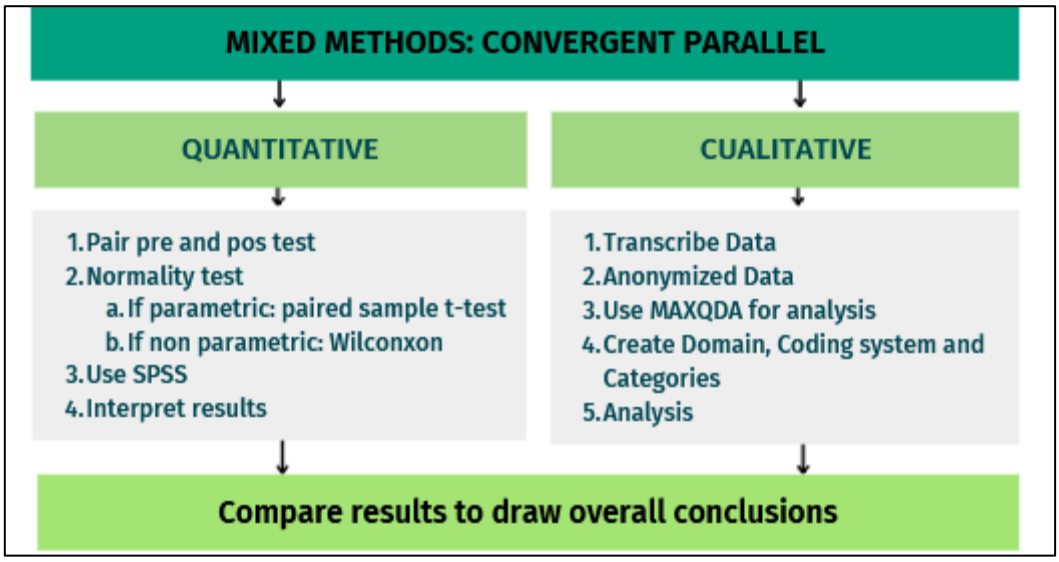


Figure 3.20 Analysis Strategy

A detail description of the analyze for the qualitative and quantitative follows in the next sections.

3.3.7.1 Quantitative Data Analysis

The quantitative data analysis targets to answer the research question "What is the effect the inclusion of dialogic educational practices in STEAM non-formal educational in high school students' critical thinking mindset and skills?" For that matter, I will make use of the two database reports (pre and post-test) provided by Insight Assessment. The Insight Assessment provides a report that includes three groups

of information: (1) Metrics, (2) Test-taker behavior, and (3) profile question as seen in Figure 3.21.

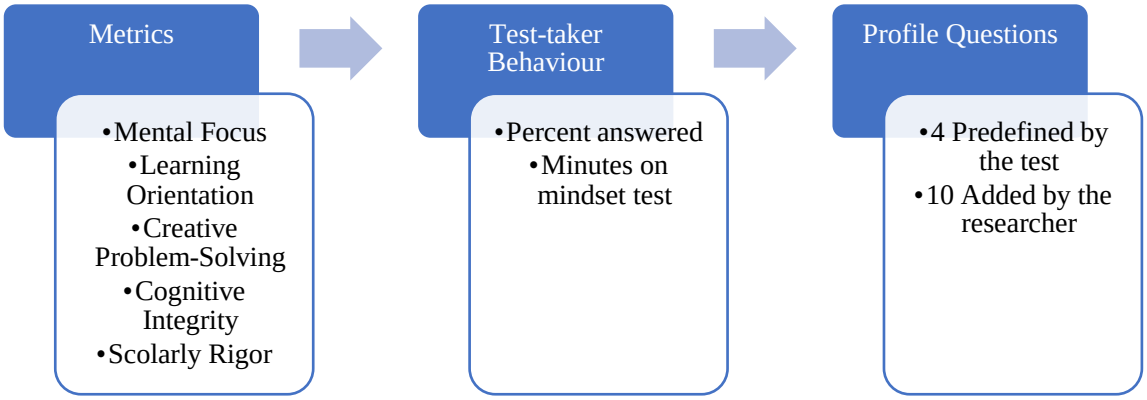


Figure 3.21 Educate Insight Thinking Mindset Report

The first step was to compare the two reports to see if the participants that answered the pre and post-tests are the same. The second step was to anonymize the tests by removing the name of participants. The third step was to check the test-taker behavior columns to make sure the percent answered is 100% and the minutes of the mindset is at least 5 minutes which is considered by Insight Assessment (2021) as the responding thoughtfully time. As a result, less than 5 minutes on test for an Educate Insight Thinking Mindset assessment is a conservative indicator of a false test. For that reason, tests were removed. The fourth step was to analyze the profile (see section 3.3.8.1.1) and metrics questions (see section 3.3.8.1.2) separately. While the critical thinking mindset questions served the purpose of answering the research question listed at the beginning of this section, the profile questions serve to give a socio demographic context of the participants.

3.3.7.1.1 Profile Questions Analysis

The purpose of the profile questions in the Educate Insight thinking mindset test was to learn more about the participants socio demographic context which included their parents' economic activities and schooling, and the participants household, working status as well as expectations of the future as part of the labor market. For that reason, the analysis of these profile questions was mostly focus on the frequencies of the responses to have a broad perspective of the data obtained using Table 3.27.

Table 3.27

Profile questions type of variables

Question	Variables	Type of Variable
1. What is your mom's job?	(None)	Nominal
2. What is your mom's completed level of study?	Elementary, Middle School, High School, Undergraduate, Graduate	Ordinal
3. What is your dad's job?	(None)	Nominal
4. What is your dad's completed level of study?	Elementary, Middle School, High School, Undergraduate, Graduate	Ordinal
5. Do you currently work?	Yes, no	Nominal
6. If you are working what is your monthly salary?	0-3000 pesos,3001-6000 pesos,6001-10000 pesos,10001-15000 pesos,15001-20000 pesos, more than 20000 pesos	Continuous
7. How many people live at your house?	(None)	Discrete
8. What is the total household income?	0-3000 pesos,3001-6000 pesos,6001-10000 pesos,10001-15000 pesos,15001-20000 pesos, more than 20000 pesos	Continuous
9. What would you like to study at the end of High School? Explain your answer	(None)	Nominal
10. What would you like to do in your future? Share your plans	(None)	Nominal

3.3.7.1.2 Mindset Questions Analysis

After applying The Educate Insight Thinking Mindset, we will have two sets of data: one corresponding to the pre-test, and one to the post-test. The database has for each test taker a numerical score ranging between 0 and 50 for each of the five metrics (mental focus, learning orientation, creative problem solving, cognitive integrity, and scholarly rigor). The scores as continuous data are helpful to point to improvements over time, and as indicative of qualitative ranges as indicating an overall attitudinal change as seen in Figure 3.22.

EDUCATE INSIGHT Thinking Mindset Scale Scores	Strongly Negative (Opposed*)	Somewhat Negative (Opposed*)	Ambivalent (Emerging*)	Somewhat Positive	Strongly Positive
	0 - 9	10 - 19	20 - 30	31 - 40	41 - 50

Figure 3.22 Mindset scores

To answer the question "What is the effect the inclusion of dialogic educational practices in STEAM non-formal educational in high school students' critical thinking mindset and skills?" we will make use of the continuous data provided by test comparing the pre and post test results. An initial strategy is to make use of the T-test to determine if the two sets of data are significantly different from each other. This only will be possible if they both have a normal distribution (or relatively normal) and the variance of the two sets of data are the same. In the case that these conditions are not fulfilled, I will make use of a Wilcoxon signed-rank test which is a non-parametric statistical hypothesis test because the same subjects are present in both groups and the

dependent variable is measure in continuous level. Additionally, I will make use of Table 3.28 to provide details to interpret the qualitative ranges.

Table 3.28

Critical thinking test meaning of results by attributes

Mindset attribute	Positive score	Ambivalent score	Negative score
Mental Focus	Indicates a person who endeavors to stay on task and approach problems and learning in systematic, focused, organized, and timely way. Mental focus is valuable because it directs attention to the duties and responsibilities of the task at hand.	Is characteristic of those who approach problems and decisions in an orderly, systematic, focused, and timely way on some occasions, but at other times do not.	Is characteristic of individuals who are more haphazard in their thinking, disorganized, unfocused, or easily distracted.
Learning Orientation	Indicates inquisitiveness and a desire to learn things. Typically, this person wants to engage in learning activities, values gathering relevant evidence, and recognizes the importance of giving reasons to support opinions.	Is characteristic of individuals who tend to have inconsistent attitudes toward learning or studying as ways to solve problems, acquire skills, or achieve goals. At times putting effort toward learning makes sense to them, but at other times not.	Indicates hostility or aversion to learning. These persons do not see studying or trying to learn something as a useful way to solve their problems or achieve their goals.
Creative problem solving	Indicates a person with intellectual curiosity, creativity, and a preference for challenging and complicated activities. Such a person may be seen as imaginative, innovative, adaptable, ingenious, or artistic. .	Is characteristic of individuals who occasionally seek to contribute imaginative, creative, or original ideas, but on other occasions are not inclined to do so. At times they may seek to understand how things work, and at other times they may prefer not to bother putting effort toward knowing the why or how of things.	Indicates someone who habitually pulls away from trying to solve novel problems or contribute original thoughts. These persons have difficulty feeling imaginative, and they do not enjoy games or problem-solving situations that demand tactical and strategic adaptation.
Cognitive Integrity	Indicates someone who is motivated to use their thinking skills to solve problems, and who values courageous truth-	Is characteristic of people who are willing on occasion to let others express alternative ideas,	Is characteristic of individuals who exhibit closed-mindedness, intolerance toward the

	seeking and open-mindedness even when dealing with complicated or difficult problems or issues.	but on other occasions are not so inclined. These individuals can be indifferent toward learning, apathetic or only mildly interested in discovering the truth to make decisions.	ideas or suggestions of others, bias, and desire not to learn new things or explore topics or ideas that might conflict with their preconceptions.
Scholarly Rigor	Indicates a person with the habit of putting forth effort to engage difficult material and to strive for deeper understanding. A person with this habit would not be put off by the need to read a difficult text or to analyze complicated situations or problems.	is characteristic of someone who occasionally is willing to put forth a serious scholarly effort, but on other occasions does not show that willingness or desire. Characteristically, this person may procrastinate rather than engage seriously in learning.	points toward the habitual tendency to avoid seeking new knowledge or examining updated content in depth. This is characteristic of people who are inclined toward superficial interpretations and who avoid material that is complex or abstract.

3.3.7.2 Qualitative Data Analysis

Like in the pilot study, the analysis strategy for the main study starts with organizing the data collected from various sources as described in figure 3.23.

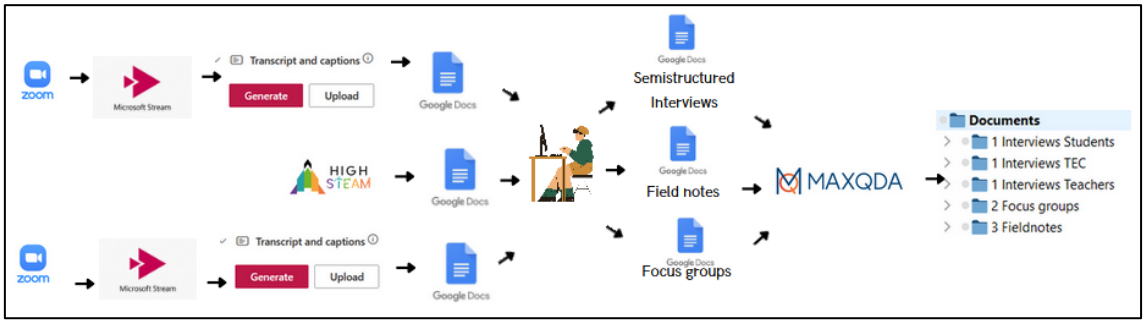


Figure 3.23 Analysis strategy Phase 1

The interviews were named: Interview_ [Name of Interviewee] _[Date], the field notes were named: Field notes_[Researcher], and the Journal_[Date], and the focus group: [Focus group] _[Date]. The transcriptions were done verbatim using Microsoft

Stream, VVT cleaner and a manual check. Then, the information will be imported to MAXQDA grouped according to the type of participants from which I collected the data.

The second part of the qualitative strategy was the codification process as described in figure 3.24

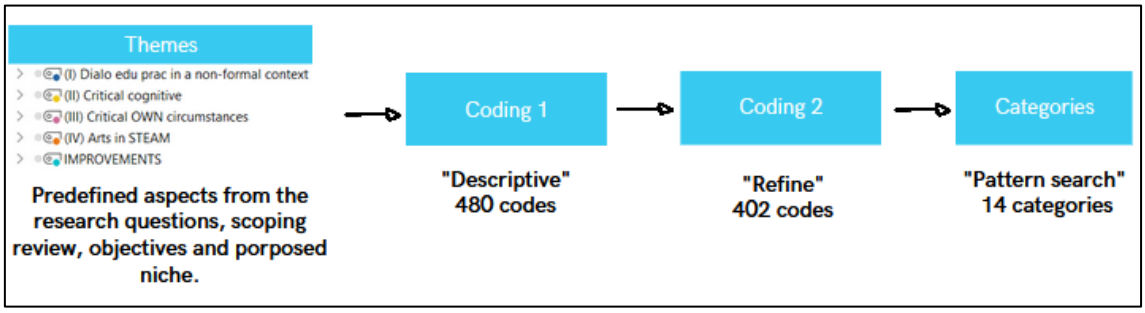


Figure 3.24 Analysis strategy Phase 2

For this second phase, two recommendations were considered. The first one coming from Merriam & Tisdell (2016, p. 161) whom emphasize that as researchers we should force ourselves to make decisions that limit the study and discipline ourselves not to go after everything. For that reason, I established deductively themes coming from the research questions, scoping review, objectives to support the process of keeping myself in the framework of the research. The second advice used was from Saldaña (2013, p. 63) who proposed that coding twice helps to get another perspective on the same information. In that sense, looking at bits and pieces of information such as sentence, fragments, and dialogues to answer the research questions happened two times. From the first coding I got 480 codes that were descriptive. In a second coding, I refined the codes to 402. Following the recommendations of Merriam & Tisdell (2016) the next step is to make use of the concept of categories to group the different codes by

being responsive to the purpose of the research, exhaustive, mutually exclusive, sensitive, and conceptually congruent. There was a search for patterns.

To guarantee a holistic view, different perspectives to the research questions will be triangulated.

(1) To what extent dialogic educational practices in STEAM non-formal educational contexts become a source of historization and projection of future possibilities for high school teachers?
(2) To what extent dialogic educational practices in STEAM non-formal educational contexts become a source of historization and projection of future possibilities for high school students?
(3) To what extent dialogic educational practices in STEAM non-formal educational contexts become a source of historization and projection of future possibilities for undergraduate students?

3.3.7.3 quan+Qual Data Analysis

After analyzing the quan+Qual data separately, in this phase I will bring together the analysis of both to answer the main research question: “How the design of dialogic educational STEAM experiences in non-formal educational contexts exert an influence in participants?” This last phase of analysis makes use of the quantitative analysis to inform the qualitative analysis. The idea is to point out at the relationship of categories found in the qualitative analysis and the critical thinking mindset test attributes.

3.3.8 Ethical considerations

The experience with the Hyperlocal Learning Network La Campana Altamira highly influenced the ethical considerations I took for the main study. For more detail on the general ethical considerations’ foundations that I followed you can see section

3.2.8 from the pilot study. Additionally, for the main study I implemented some other considerations that will be detailed following.

During the High STEAM project, I designed an information sheet and consent forms for the participants. I designed three consent forms (as seen in Appendix F.1 to F.3) for participants to be part of the main study since I was going to apply additional instruments to collect data that were different from the instruments of the project.

In terms of ethical considerations for the main study, I have also made explicit in the data collected section (3.3.9) information that was collected by higher education students during the project and information that was additionally collected by me after the High STEAM project.

3.3.9 Data collected

I provide a summary of the quantitative data collected in Table 3.29, and of the qualitative data in Table 3.30. Following Erlandson et al.(1993) criteria to establish trustworthiness the data collected contains thick descriptions as well as divergent data.

Table 3.29

Main study Quantitative data collected

Quantity	Instrument	Description of the data
118	Educate Insight Thinking Mindset Test	There were fifty-nine of these tests applied pre and fifty-nine post the application of the High STEAM sessions.

Table 3.30

Main study Qualitative data collected

Quantity	Instrument	Description of the data
8	Semi structure Interview	Post High STEAM project interviews with eight high school teachers that were not part of the data collected for the project but collected exclusively by me for my dissertation
7	Semi structure Interview	Interviews with seven high schools' students collected by higher education students
8	Semi structure Interview	Post High STEAM project interviews with eight higher education student that were not part of the data collected for the project but collected exclusively by me for my dissertation
4	Focus Groups	Four focus groups with higher education students at the end of each stage with questions designed by me
1	Google Drive Folder	Contains the shared work among the project team around, Record of the events and experience including self-reflection
135	Field notes	These field notes were collected by the higher education students during the project using a template I designed based on the Co-Measure which is an assessment for student collaboration in STEAM activities. I adapted the test to facilitate data collection.

Chapter 4: Results

4.1 Introduction to the Chapter

After implementing the research procedure in which I followed mixed method convergent parallel design, I also implemented the analysis strategy as described in section 3.3.7. In this section of results, I will present quantitative results (section 4.2) and qualitative results (section 4.3) to converge the results in the last section (4.4).

4.2 Quantitative Results

High STEAM served 124 students from vocational schools in traditionally marginalized areas of Monterrey during the implementation of the project. However, due to graduations and other socio-academic circumstances only seventy-four students were part of twenty sessions. From those 74, 59 students answered the EDUCATE INSIGHT Reasoning Skills in the pre and posttest phases. Hence, the total number of tests is 118.

4.2.1 Profile Questions

As stated, before in section 3.3.5 the EDUCATE INSIGHT Reasoning Skills first part had some profile questions that I asked participants to get to know more about the socio-economic background. Following, key information coming from those profile questions:

- High School students: Mode age: 17 years old pre and posttest. Twenty-eight females and thirty-one males answer the test. For the pretest fifty-one of the seventy-nine were working but for the posttest only forty-six were working.
- About the mothers: In the pre and posttest the highest occupation for mothers was to be a stay-at-home parent with 32 and 26, respectively. Only four of the fifty-nine mothers reached higher education.
- About the fathers: In the pre and posttest the highest occupations for fathers were the building sector and manufacturing with 12 and 9 for the pre and posttest. Only four of the fifty-nine fathers reached higher education.
- Households: The highest household number of members were 4, 5 and 6 for the pre and posttest. The variation of income per household is summarized in table 4.1 where we can see that almost 78% of the families live with less than 10001 pesos per month.

Table 4.1

Household income

Money range	Pre	Post
0-3000 pesos	18	15
3001-6000 pesos	15	18
6001-10000 pesos	13	14
10001-15000 pesos	6	6
15001-20000 pesos	4	5
More than 20000 pesos	3	1

4.2.2 Normality distribution test

From the fifty-nine tests, I applied a normality distribution test. In this case, I used the Kolmogorov–Smirnov test which is a nonparametric goodness-of-fit test to determine whether the distributions of the data are normal or not. I apply the normality test for each of the five attributes (Mental Focus, learning orientation, creative problem solving, cognitive integrity, and scholarly rigor) that was measured with the test. The results of the normality test are seen in table 4.2.

Table 4.2

Normality test

	Kolmogorov-Smirnova		
	Statistic	df	Sig.
Mental Focus PRE	.086	59	.200*
Creative Problem-Solving PRE	.103	59	.185
Learning Orientation PRE	.119	59	.038
Cognitive Integrity PRE	.080	59	.200*
Scholarly Rigor PRE	.126	59	.021
Mental Focus POST	.126	59	.021
Creative Problem-Solving POST	.093	59	.200*
Learning Orientation POST	.105	59	.168
Cognitive Integrity POST	.120	59	.035
Scholarly Rigor POST	.097	59	.200*

After applying the normality test, for the pre and post data, there are three attributes that do not follow a normal distribution: Scholarly Rigor in the pretest, Mental focus posttest, and cognitive integrity posttest. So, I decided to use the Wilcoxon Signed-Rank Test.

4.2.3 Wilcoxon Signed-Rank Test

To continue with the analysis, I applied a Wilcoxon Signed-Rank Test which is non-parametric test to see if there was a difference from the pre-test and post-test for

each of the five attributes. This test compares to related samples that is why is also known as a paired difference test of repeated measurements. With this test, I was aiming to find if there was a change in how students perceive the five attributes after taking the High STEAM program. Thus, the null hypothesis is that median difference is zero, in other words the medians of the two groups are the same, so there was not a change after applying the sessions. The decision rule is to reject the null hypothesis if the test statistic (the p value which in SPSS is given by the Asymp. Sig 2 tailed value) is less than the significance level (0.05).

In the SPSS software, I added the fifty-nine values from each of the five attributes for pre and post-tests. Then, I applied the Wilcoxon Signed-Rank following the steps in Figure 4.1 that started with clicking in the top menu the Analyze option.

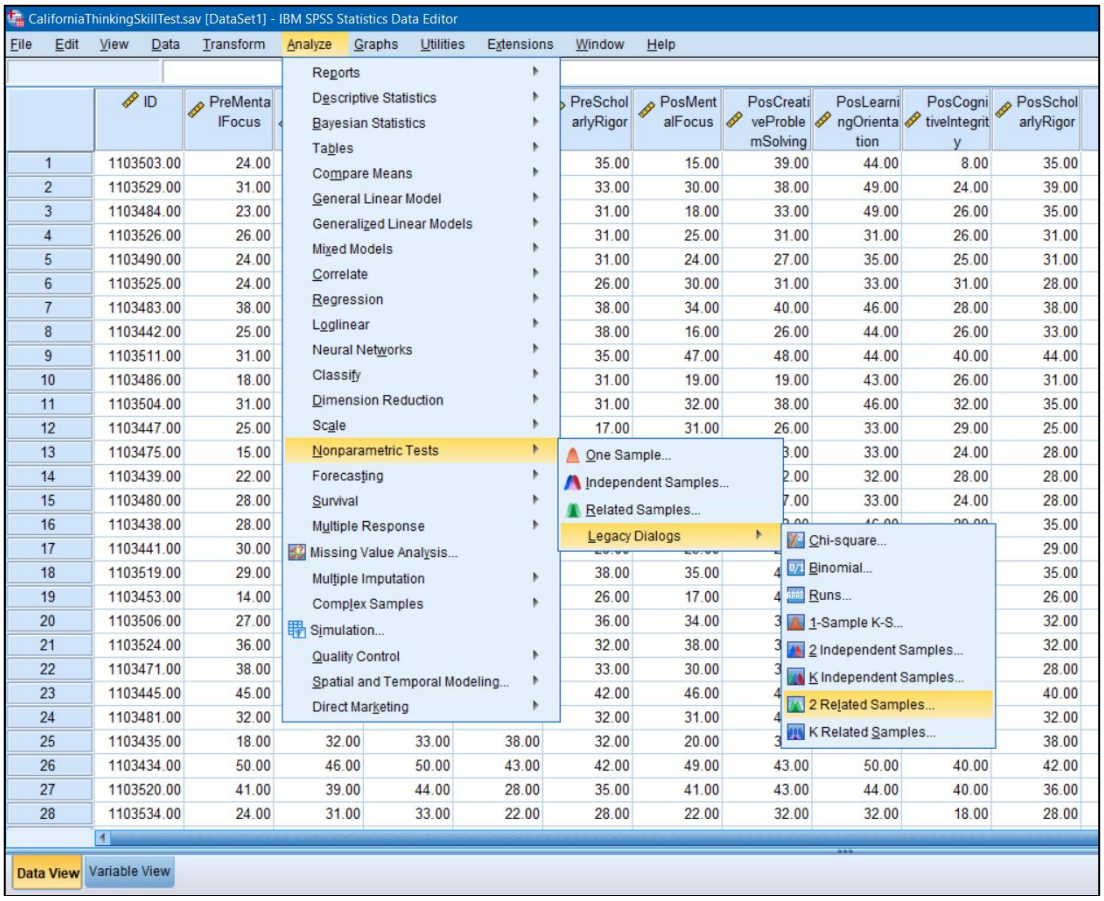


Figure 4.1 Wilcoxon signed-rank test in SPSS

SPSS output were two tables, the first one was Wilcoxon signed-rank test ranks shown in table 4.3 and the second one was Wilcoxon signed-rank test statistics show in table 4.4.

Table 4.3

Wilcoxon signed-rank test ranks

		N	Mean Rank	Sum of Ranks
Post Mental Focus – Pre-Mental Focus	Negative Ranks	29[a]	27.48	797.00
	Positive Ranks	25[b]	27.52	688.00
	Ties	5[c]		
	Total	59		
Post Creative Problem Solving – Pre-Creative Problem Solving	Negative Ranks	25[d]	27.20	680.00
	Positive Ranks	30[e]	28.67	860.00
	Ties	4[f]		
	Total	59		
Post Learning Orientation – Pre-Learning Orientation	Negative Ranks	19[g]	21.13	401.50
	Positive Ranks	29[h]	26.71	774.50
	Ties	11[i]		
	Total	59		
Post Cognitive Integrity – Pre-Cognitive Integrity	Negative Ranks	30[j]	28.52	855.50
	Positive Ranks	27[k]	29.54	797.50
	Ties	2[l]		
	Total	59		
Post Scholarly Rigor – Pre-Scholarly Rigor	Negative Ranks	18[m]	19.14	344.50
	Positive Ranks	25[n]	24.06	601.50
	Ties	16[o]		
	Total	59		

a. Post Mental Focus < Pre-Mental Focus
b. Post Mental Focus > Pre-Mental Focus
c. Post Mental Focus = Pre-Mental Focus
d. Post Creative Problem Solving < Pre-Creative Problem Solving
e. Post Creative Problem Solving > Pre-Creative Problem Solving
f. Post Creative Problem Solving = Pre-Creative Problem Solving
g. Post Learning Orientation < Pre-Learning Orientation
h. Post Learning Orientation > Pre-Learning Orientation
i. Post Learning Orientation = Pre-Learning Orientation
j. Post Cognitive Integrity < Pre-Cognitive Integrity
k. Post Cognitive Integrity > Pre-Cognitive Integrity
l. Post Cognitive Integrity = Pre-Cognitive Integrity
m. Post Scholarly Rigor < Pre-Scholarly Rigor
n. Post Scholarly Rigor > Pre-Scholarly Rigor
o. Post Scholarly Rigor = Pre-Scholarly Rigor

For table 4.3 shows that the mean of the positive ranks is larger than for negative ranks suggesting that values for post-test are larger than for pre-test. The Wilcoxon test will now decide whether this difference in mean ranks is significant or not as is illustrated in table 4.4.

Table 4.4

Wilcoxon signed-rank test statistics

	Post Mental Focus – Pre-Mental Focus	Post Creative Problem Solving – Pre-Creative Problem Solving	Post Learning Orientation – Pre-Learning Orientation	Post Cognitive Integrity – Pre-Cognitive Integrity	Post Scholarly Rigor – Pre-Scholarly Rigor
Z	-.470b	-.756c	-1.917c	-.231b	-1.556c
Asymp. Sig. (2-tailed)	.638	.450	.055	.817	.120

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.
c. Based on negative ranks.

The p values (quoted next to Asymp. Sig. (2-tailed)) are greater than the significance level of 0.05. So, we cannot reject the null hypothesis that the medians of the two groups are the same. The results suggest that students' mindset was equal for pre-test and post-test. In the case of the Learning orientation the p value is 0.055 which is the only who is just slightly greater than the significance level. It is interesting that the p value was relatively close the threshold of statistical significance so that we could reject the null hypothesis. This could mean that Learning orientation was the closest skill to be marked as different after the STEAM sessions. This attribute measures the tendency or habit of seeking to increase one's knowledge and skills; toward valuing the learning process to accomplish proficiency over a task. This talks about the fact that dialogic educational practices in STEAM could be having an impact by giving the opportunity to learners to verbalize and reflect.

4.3 Qualitative Results

In this section, I present the results from the main study that emerged from the High STEAM project. As explained in section 3.3.7.2 I used themes, codes, and then categories. There were four themes that were proposed deductively to keep myself in the framework of the research. The themes were: i) Dialogic educational practices in a non-formal context of education, ii) Non-formal STEAM activities as a source of critical thinking, iii) Non-formal STEAM activities as a source critical consideration of circumstances, and iv) The role of arts in STEAM. It is relevant to be reminded that while the themes were proposed deductively from the research questions, the categories for each of them emerged inductively after the coding process.

The coding process was done twice, one descriptive and one to redefine the codes (Saldaña, 2013). The first coding process gave me 480 instances codes, and the second one 402 instances codes. The codification process was done using the qualitative analysis software named MAXQDA 2020. The input documents were the 8 semi structed interview applied to high school teachers,7 semi structured interviews applied to high school students, 8 semi structured interviews applied to higher education students, 2 focus groups with higher education students and 45 field notes corresponding to five different groups for modules 1, 2 and 3. The selection of the 5 groups was done based on their teacher participation for the additional interview, the completion of the sessions with the highest number of students, tests taken and commitment to the project. The teachers selected were Katherine, Edmundo, Sara, Elizabeth, and Margaret.

After obtaining the codes, they were grouped in 14 categories as described in figure 4.2.

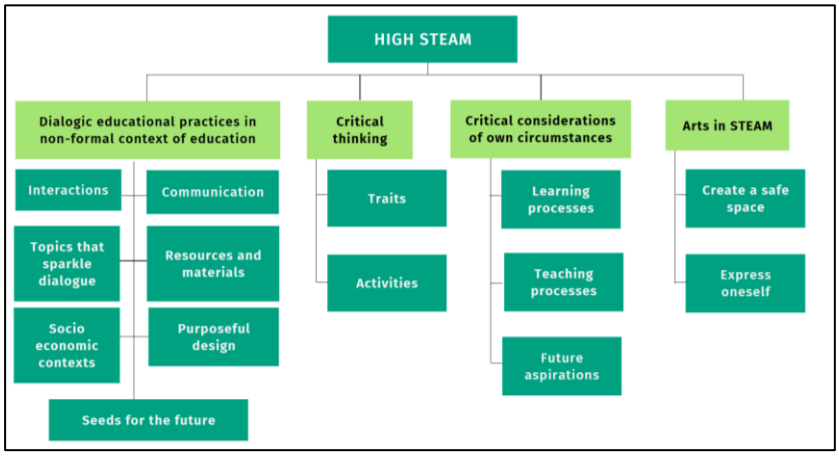


Figure 4.2 High STEAM themes and categories

This figure was an initial result of the analysis strategy that later on was developed into the context of the research question in section 4.3.5. The codes were grouped in categories using MAXQDA visual tools (MaxMaps and Code Map). These tools supported the visualization of the codes produced and the researcher interpretation of the relation was used to group them in the 14 categories.

Following each theme will explained as well as the categories inside. The categories will be illustrated with fragments of the interviews or field notes that are representative.

4.3.1 Dialogic educational practices in STEAM Education

The first theme: “Dialogic educational practices in a non-formal context of education” collects the categories related to the dynamics proper of the implementation of High STEAM in the 3 CBTIS and 3 CETIS. Inside this theme there are seven categories that emerged inductively from the codification process: (1) interactions (2)

communication, (3) topics that spark dialogue, (4) resources and materials (5) socio-economic context, (6) Purposeful design, (7) seeds for the future. Each of these categories will be explained in the following section.

4.3.1.1 Category: Interactions

This category refers to elements of interactions seen in the application of dialogic STEAM sessions. This category grouped codes present in the interactions such as get to know others, collaboration, class dynamic, questioning, freedom, smile and ludic session. There were three types of interactions: between higher education students and high school teachers, high school students and their teachers, and high school students with higher education students.

High STEAM had a variety on the way these interactions took place. In the first semester, six schools were physically present, two schools were hybrid and two purely online. The second semester all the sessions were taking place in the schools. Armando, a higher education student, said "I think the biggest difference in that sense was how it was adapted to the reality of the students (Interview with Armando Pos.17)." He referred to how interactions allowed to make changes in the design of the sessions. The sessions were flexible to adapt to the class dynamic putting at the center the student.

In the interaction between Eusebio, higher education student, and Edmundo, high school teacher, Eusebio describes the interactions as a mutual agreement from the first meeting. He said *"During the sessions he was always repeating instructions and helping to answer students doubts. We always had a good, I do not know if symbiosis would be the word, but this was a great one because he already knew the students. I had an exceptionally enjoyable time with them. He could make things easier for them or set*

up something he said. How to translate it a bit more so the students could grab it. But we always had a particularly effective communication. Everything was great and he helped me a lot, with some last-minute things, like we needed, I do not know computers and he said yes without any problem, and it was an incredibly good dynamic (Interview with Eusebio Pos. 40).” From what Eusebio reports is relevant to note two elements. First, Eusebio points to elements like having mutual agreements when they started working. This gave them the opportunity to dialogue about the working system between the higher education student and high school teacher. That means they had to agree on their roles for the sessions and how they would intervene. In the sessions, Eusebio points to been able to have a relationship with students where Edmundo knew the students.

Andy, a high school student, in these interactions says there is a sense of freeing herself while doing the activities. In transcript 4.1, she points in a second instance that she forgets everything else when she was doing the crafts. The plausible reason for her expressions is in the transcript too. She says she is fed up with the demands of the subjects she sees in school. She notices a difference between the way High STEAM sessions are done with her classes. The High STEAM sessions are done in a non-formal context where there are no evaluations and the products asked to students are part of the activity done in class. They contrast with the way subjects are carried in school.

Transcript 4.1 Freeing myself

> ***Andy:*** *Going into High STEAM was like freeing me personally. For me it was like to de-stress from all the school stuff and everything from high school and all that.*
> ***Lay:*** *Could you describe more what you mean by freeing yourself, de-stressing you?*

Andy: *when I was in class, well, in certain subjects that I did not like. An example is mathematics, I hate mathematics and there were certain subjects, others that I did not like either. But I was fed up with the demand of things you must do. You get fed up, then you go to those High STEAM classes in which they put you to do these activities in which you had to see inside yourself and release everything you had inside. To look what you have inside and free yourself. Another example is like when you do a craft, you feel a little liberated as if you forget everything else and then you focus on doing the craft well. It felt like that when I was doing an activity. I felt like I was already forgetting everything else.*

(Interview with Andy Pos. 24-26)

4.3.1.2 Category: Communication

This category collects codes about the communication process among participants. Elements that emerged from the dialogic STEAM sessions for this category are time to listen to others, become empathic, motivate students' participation, expressions, opportunity for changes and trust. Each of these elements will be illustrated with relevant examples in the next lines.

In transcript 4.2, Elizabeth, a high school teacher, points out how High STEAM gave her a space to listen to her students. She appreciates the specific opportunities given through the sessions to listen to students where they could share what happened and were their emotions related to what they saw in the session. It is effective for her to reflect upon this because she even realizes that her practice in school was just to let go the opportunity to communicate with the students in class and just let them go as soon as the bell rang.

Transcript 4.2 Listen to others

Lay: *Okay, I was telling you that, in that sense of what you are talking about, that the students feel heard, how did the High STEAM sessions help you to listen to your students and what did you learn from them with these sessions? That then and transform your educational practice.*

Elizabeth: *I realized several things. First, I was surprised that some know a lot about the subject, and some do not. They did not know the issues, how is it possible that there is this diversity in a group where they come from the same environment and have had the same school, the same teachers, the same things? So, I realized that as a teacher, I must be open. Diverse types of students, although I selected it from before, the information really depends on the person and not on the environment. That is something to visualize. I really liked all the sessions because for each topic a feedback time came up. In all the sessions there was a space, a time, to ask them, what happened to them, what they liked, and in this part, I feel that sometimes as a teacher when the bell rings, you tell them bye. And it should not be like that, so that is what I take for myself to leave time to give listen"*

(Interview with Elizabeth Pos. 37-38)

For Ramiro, another high school teacher, it is key that in the communication teachers "*allow students free expression without feeling a limitation. Accept all opinions and respect them as they are, look for a way to give them feedback without making them feel that they were wrong and that they can no longer give their opinion (Interview with Ramiro Pos. 44-45)."* In that sense Ramiro, is recognizing the emotions that can emerge from a student participation as an element in the communication. He points to consider how students can feel after feedback so he says it should be given assertively.

Sara, also a high school teacher, agrees with Ramiro and takes it further, she says "*listening to them gives you a different picture of knowing. Well, it is not just the*

structure of this, what you would like, for example, to put on your resume to get to know yourself a little bit, see what your weaknesses are, your strengths, listen to the other. It means being able to put yourself in their place, it is to be more empathetic as teachers. Knowing what they are experiencing helps a lot specially with this whole part of the pandemic. Knowing that sometimes they cannot deliver some homeworks at a time, but well, when you listen to them you know what is happening, what are they experiencing? You are a little more empathic. It simply helps you to get to know them better, to know who is on the other side and to be able to bring more to the students themselves (Interview with Sara Pos. 65-67). This acknowledgement that Sara makes about listening to students express a realization of the need to understand the circumstances that students are going through.

Communication is not only to hear people but to get knowledge about them which makes teachers more empathetic. It is possible then that these first two steps in communication lead to what Pedro, a higher education student, define as the students perking. During session 3 satellites, he shared "I *was quite pleased that when asking for volunteers to comment on their satellite findings, six students perked up. This is motivating because they begin to feel confident to share their ideas and this raises the sessions to another level (Field note Pedro Pos. 28)."* In High STEAM, the design of the sessions purposely created more moments for teachers to listen to students. That means teachers got to know more about their students than in a regular class. Teachers said they are becoming empathic with their students by listening to the topics that concern them. Hence, this results in this perking where students' motivation to participate increases.

4.3.1.3 Category: Topics that spark dialogue

This category refers to how the topics selected sparkled dialogue during the sessions. The topics selected sparkled dialogue because they had a theoretical and practical component and they connected to relevant situations of the participants.

For Carolina, a higher education student, who helped plan the sessions, the topics sparked dialogue because "*they were subjects that do not normally enter a school curriculum, also presenting them with new formats for their learning. That is format much freer and in which they are invited to contribute more with their voice, with their opinion. It was how the class was designed and its application. Students would learn to make fluorescent jelly and explore how to apply it in a real-life context. It was very practical to learn to make the jelly and on the other hand very personal level because what could you use it for in your life? The students had innovative ideas such as throw a party in the dark" (Interview with Carolina Pos.8).* Carolina also points here how the sessions did not treat regular topics in the curriculum but also how the format is freer reminding us that High STEAM sessions even though carried in high schools they were non-formal contexts of education. This allowed the team to design sessions with topics different from the regular curriculum.

The eco-audit session, climate change, and fake news were sessions that became relevant to students because they connected to real themes propelling communication to be purposeful and motivating students' participation *(Field notes Lay Pos. 296).* Precisely, in an interview with Raquel, a high school teacher, as seen in transcript 4.3

the selection of topics even propitiated that students show an ethical commitment in their personal and professional life.

Transcript 4.3 Sparkle dialogue through relevant topics.

> ***Lay:*** *Now the ethics session, the social networks, and the fake news, how do you think it impacted the interaction between the students?*
>
> ***Raquel:*** *Yes, yes it was interesting because, I do not remember what they were saying, well, I hope I am not confusing the session, but we were talking about what we could to stop fake news. As they are studying programming, I remember that a student said that she would no longer lend herself for fake news, to share fake information, or to do work to whatever it is because it tarnishes someone's name. Through social networks, that is, acting in a way that she is not herself. Other students also told me the same. He did not do it, but he would not lend himself as a professional either, that is, doing something that would harm a company, a person or someone else. And I remember that he told me, and I stayed like that, I mean, it is one of the things that the majority already agreed that you had to address yourself with respect before sharing. I know what information was true, in various sources, and well, if one is not sure, then simply not share the truth. In other words, I would not share the best one until, well, if it is something that threatens someone else, then report also send a true report that something that should not be there on the network."*
>
> *(Interview with Raquel Pos. 67-68)*

Raquel talks how her student make a statement that she would not use her programming knowledge that she studies to tarnish someone's name. The same happens with other students in the class who mimic the first student behavior because she stood up and verbalize this behavior. The dialogic educational practice gives the opportunity to present topics that spark dialogue.

4.3.1.4 Category: Resources and materials

This category of resources and materials groups codes related to the role of the resources in the spaces where the sessions took place, the kits with materials for the activities and the technological materials provided by High STEAM.

For Raquel, a high school teacher, the project was possible because of the resources and materials. She said "*You can fulfil the project, but it would not have been possible without all the materials High STEAM provided. The quality of the sessions, to have the slides, the videos, the order in which the session were given, the sequence, the truth is that it facilitated the development of the sessions. When I had doubts about something, I looked for it on the Internet or if my colleague here had seen it in the session, but the doubts or the details were minimal. The resources practically made my life easier and to have ready the material there saved time in the sessions so I could spend more time with students reviewing if they had questions (Interview with Raquel Pos. 63)".* This comment made by Raquel shows that having the resources supports dialogic practices in the sense that they spend more time focusing on the activity rather than trying to fix the lack of resources to make them happen.

Sara, another teacher explains the process of using the resources and having beforehand for the class (see transcript 4.4). It facilitated to have the materials ready so the teacher could use some flipped classroom activities sending the readings beforehand. As a dialogic educational practice, it could allow readers to go at their reading pace at home and come ready to discuss.

Transcript 4.4 Having the resources ready

> ***Sara:*** *Yes, well, the process is simple, you enter the page in the reviewed sessions section. What is the next session? And you review the video where it came in a synthesized way by the higher education students who were doing the design. There you could also see the learning objective. The higher education student downloaded all the documents prior to the session, for example, in the case there was a reading that my students had to download the TEC student would download it. Although it was virtual, we were in a transition between virtual and face-to-face. When my students were going to school, we would send them beforehand the documents. Even though I had them and it was still a little while to get to the essentials, that I am not going to print this document and that at that time in class it was given the previous reading so that later we can all understand what it is about. We had to do that because sometimes if you send the link somebody could not read it. Then a little more of the explanation of what we want to achieve with learning is lost. I agree that having the readings, the resources already ready and available, helps you a lot to be able to be with the kids and to achieve the objective.*
>
> *(Interview with Sara Pos. 19)*

There is a similar opinion by Ramiro, another teacher, who says that *"It was really something very practical, it made it much easier for me to be able to develop this project because it means having the material and the student having enough tools. It already allows me to allocate the time that I had, let us say to prepare that, to allocate it to look for new alternatives, new activities, new ways of approaching the subject. It was no longer necessary for the student to be somehow distracted by getting the materials, but simply to have them there (Interview with Ramiro Pos.49)."* Ramiro gives a twist in the use of the time, and it impact his own teaching practices. Having the materials ready allow him to think and search for the new alternatives for the session.

4.3.1.5 Category: Socio-economic contexts

The High STEAM sessions were planned to be given in vocational high schools that were in marginalized situations. Moreover, in August 2021 there was still a pandemic going on in Mexico.

Amy, a higher education student, involved in the planning comments on some of the challenges she faced when planning. In transcript 4.5 she mentions the limited access to technology by participants. So, she had to look for accessible solutions for everyone, she even mentions she had to look out from her comfort zone. That means she had to contrast her socio-economic context and the context of the participants for which she was designing the sessions. In these dialogic educational practices, we see that participants also face dialogue with their realities.

Transcript 4.5 Socio-economic context

> *For me, it was a challenge in terms of technology, not so much for me, but to find solutions that involved this and that were accessible to everyone, because we know that they do not always, that is, they do not always have the same resources. What we did before and after we realized that when implementing it did not work or even the same sessions as putting on a video or a presentation did not work because the resources that they had available. They were different from what we imagined. That was a challenge for me, it was easier right now because I had the context of how a hybrid session is conducted or something like that, but even so. We have those solutions that work for us in our classes, but that do not work the same for them. So, it was like a challenge in that part, but I still liked it because it was like looking for innovative solutions like. I mean a lot, something we did a lot was. We looked that the sessions could be adapted to being remote, in person. In other words, that they would use them on a computer that they would use it physically. How to make a collage of what to look for easy applications to make a*

collage or do it also in physical? So, I liked that, that it was like getting out of my current self, yes, thinking out of the ordinary, that is, getting out of my comfort zone, always thinking like those solutions, and thinking a little further. So, well, that was the most challenging, but also like something that would get a lot, a lot of fruit out of it.

(Focus group 2022_3 Pos 13)

Sara, a high school teacher says that the socioeconomic context in which the students live is difficult. She says *"knowing them, knowing what they think, what they are feeling in the socio-emotional part, so I have learned a lot from them. The fact that there are many difficulties because, well, the socio-economic part that they are experiencing. Well, yes, it is a bit complicated, but they really want to get ahead. They try to overcome this as much as possible and that knowing that the classes they are in, for example, in STEAM, opens this panorama for them (Interview with Sara Pos.42)."* This information of the socio-economic context can be related to the profile questions done to participant in section 4.2.1. Those profile questions gave a us some clues about the low incomes per households as well as the academic opportunities that the parents of participants themselves had.

The socio-economic context also affects schools. Some schools had difficulties with the projector so they could share it with students. Other schools did not have access to computer labs where they could do the digital literacy sessions. They all had to look for alternatives when necessary *(field notes Lay Pos. 238).*

4.3.1.6 Category: Purposeful design

This category collects the thinking process of higher education students and high school teachers in designing the sessions. Some of the elements to consider were technology, transformative experience, and dialogic learning.

In transcript 4.6 Eusebio mentions technology, transformative experience and dialogic learning as elements needed in the design. It is the purposeful design which opens the space for expressions and opinions.

Transcript 4.6 Elements in the design

> ***Lay:*** *Thank you. go ahead Eusebio*
> ***Eusebio:*** *Yes, this one. It was quite different from the first time we designed the first experiences. The same, as Amy commented a bit, this part of the technology. And already having a little experience with what we started, what we saw in the semester, implementing the first sessions. This one was a bit of a challenge, keeping in mind this topic of technology, but you must find a way to include the same science in finding out and always maintain this vision of that of transformative experience and dialogic learning. But I think that, well, I really liked that this week the dialogic learning was maintained. I do not know how, that in the sessions that we implemented this yes, many students participated. And I think that just this space was left as a safe space for expression and opinions on the subject and on the sessions. So, it is something that I rescue a lot from all the decisions that we were designing in this period. And then that would be all*
>
> *(Focus group 2022_3 Pos.15)*

Fernanda, another higher education student mentions in transcript 4.7 that even though there was a purposeful design and planning, there should be room for flexibility in the design. There are some things that could come up depending on the circumstances that arise.

Transcript 4.7 Flexible in the design

> *Of course, this is good regarding this experience, in my case, I have been since the beginning of the implementation of this project in the summer. Therefore, going through various stages, various parts of corrections, adaptations, improvements. This and that gives me a good broader perspective, not of all the effort that we are putting collaboratively for this cause and the fact now, as Pedro mentioned, right now the fact of landing the proposal. In addition, towards its context, it is what it considered, because with what we have most. We had to place more adaptations, then something that gives me a feeling that produces me, that this experience has produced in me, it is like this part of having when I go to plan to make proposals in my professional life.*
>
> *(Focus group 2022_3 Pos.19)*

Edmundo, a high school teacher, was not clear his role and the one from the higher education student in the implementation of the sessions as seen in transcript 4.8. Precisely the design purposefully left this agreement up to dynamic between the teacher and the higher education student *(Field note Lay Pos.278).* That means that there was an opportunity for them to set up an agreement and discuss the roles that each one would take. Rather than imposing, the purposeful design inside the educational practice leaves room for making agreements.

Transcript 4.8 making agreements in the design

> ***Edmundo:*** *I had very vague knowledge about the roles and STEAM in general. So, I started to investigate a little about what it was about and how it talked about science and technology in mathematics, because High STEAM caught my attention. The topics were interesting to me, I said, well, let us see, what this is about. At the beginning, with the first session we had, it was like some uncertainty, between whether they are going to be running the sessions, but nevertheless I had particularly effective communication with Eusebio, we came to*

a particularly good agreement to run each one of them. the sessions that at the beginning when the way of working was proposed to us. This as if it were done complicated, something tedious or as more work to what was our function within the school here. But now that we are running the sessions, we already realized that it was not as much as it had been said at the beginning, it was not the best week before because it was misunderstood in some sessions.

(Interview with Edmundo Pos. 33)

4.3.1.7 Category: Seeds for the future

The name of this category originated in an interview with Elizabeth a high school teacher. We were talking about the impact of High STEAM, and she said that the project was a seed for the future. This category collects how participants foresee that the sessions will have an impact in the future that we cannot see now. Seeds for the future refers to the perspective that all the impact of the project cannot be fully understood or seen in the present. It is in the future where some fruits can be seen.

Alberto, higher education student, sees an impact for participants in the present and future. He reported: *"I also feel that personal life can be combined a little with future life, since this is not over yet. I feel that each time they are going to learn more about this type of way of learning and it will help them a lot in their development as students, as well as their personal life because. They are developing skills that in a traditional classroom they would not have the opportunity to do, and that is what I had as a reflection (Focus group 2022_2 Pos. 11)*". Specially, he sees reflection as a seed for the future of the high school students' development.

Elizabeth, a high school teacher, in transcript 4.9 reports that High STEAM was a revelation for students. Now, they are more prone to search and inform themselves. She talks about also an impact that you might not be able to see now but later to transfer to other situations. This clearly states a long-term impact for participants.

Transcript 4.9 Looking for more

> ***Lay:*** *What was High STEAM impact in your students?*
> ***Elizabeth:*** *OK, well, look what I think happened was that they were more interested in other things than normally they were interested in the mechanical part and in the places that it gave them then, now they were not only interested. For this reason, if not, they already approached with other interests apart. An important experience because a world was opened for them, they realized there are more things, not just what they are studying or nothing else. They become interested and begin to be more informed people, they become interested in culture and begin to search for what is what, or why that word, then they begin to enrich them as a person and not so much as knowledge. The information that was there aroused their interest to investigate. Let us see, look where it is, what does he do and then after talking with them I already saw them with stability. It makes a strong difference in their lives, even if you cannot see it now. From there they are going to make an especially important change. It is already different because it made a change in their attitude and from there his life is going to be quite different. Quite different that they are going to investigate, they are going to see, they are not going to stay with him, he does not do it at all.*
>
> *(Interview with Elizabeth Pos.50-51)*

In transcript 4.10, there is an interview with Margaret, another high school teacher. She points out that the seed of the future that this project leaves to students is that they will remember it like a first aid course. That means that when they need it, they will transfer the knowledge to the situation that requires it. She talks about an

impact for the future. The project then becomes a seed of knowledge that can later be pull when students might require it. It will not necessary be seen now. Margaret points to having the experience as something of value. Note that this differs from a formal context where you are required to show your knowledge through evaluations.

Transcript 4.10 They will remember it like a first aid course

> ***Lay:*** *How do you think this will impact future possibilities for them?*
> ***Margaret****: Tie with one to get to know yourself regarding your emotions. Impact also where are they going? In other words, so that they too begin to see that they are not going to be students all their lives. Eventually, well, they are going to learn, that they are not always going to be inside a classroom, they are going to have responsibilities outside of it. And they are starting to have them as teenagers. So, they require skills that prepare them for this, maybe not right now. But will they remember that the circuits carry a positive and negative. Either they are going to remember some situation of with the chips, or they are going to remember a situation something in Excel at some point. I know that at some point they will arise, but I compare it to first aid courses. You have all taken first aid courses yourself. All good, you are already. We know that maybe if I tell you to see how a bandage is made, it will save a finger for a hand that has been cut in a reason, in a page. You are going to go, oh, no, the truth is I do not remember, I mean, it has its procedure, but I do not remember or how it happens, choking a person how they give themselves to a baby. What should I check with an unconscious person? The steps if we ask ourselves, is it yours or not, I remember, yes, I remember, etc. But I know when we are at that time. That part of first aid knowledge is going to come. I trust that it will be so with the students. If you ask them, well, not really. But that at that moment when I used it because they are in an Excel or Word sheet and need a template, a resume or when they are stuck looking for a job or something you want to know. They are going to draw on that part of the knowledge that they have in their mind, and they are going to remember. He appealed to that emergency memory. But then he could not know*

that, but he appealed to that.

(Interview with Margaret Pos.62)

4.3.1.8 Summarizing the theme

"Dialogic educational practices in a non-formal context of education" theme serves the purpose of understanding different elements related to the dialogic practices in High STEAM. One of the categories that emerge was the purposeful design which could englobe the other categories when thinking about this type of educational scenarios. When designing dialogic educational practices its relevant to understand the intertwined elements such as the interactions, the communication, the topics that spark dialogue, the resources, and materials the socio-economic context that fueled the experience. The well thought dialogic educational experience becomes then a seed for the future of the participants.

4.3.2 Non-formal STEAM activities as a source of critical thinking

The second theme: "Critical Thinking" refers to non-formal STEAM activities as a source of critical thinking in the sense of a cognitive ability. This means how the dialog educational practices were a source of critical thinking. Here two categories emerged (1) traits, and (2) activities. Each of these categories will be explained in the following section using relevant data collected in the research process.

4.3.2.1 Category: traits

This category has codes related to traits that appear in the development of critical thinking like observe, inquire, points of view and thinking interdisciplinary. This category is supported by studies such as the one from Castellanos-Ramirez & Alhelí-Niño (2018) who emphasize cognitive process in the construction of knowledge. They

point to online asynchronous dialogue in their research, while in High STEAM intervention, the synchronous and asynchronous dialogue also showed that the designers of the experience in the interviews realized that these traits appear as part of the critical thinking.

In an Interview with Sara, a high school teacher, she saw the impact of the last session where students were invited to the university. In transcript 4.11 Sara points out different situations that high school students observe while in the campus. Observing these situations impact their critical thinking skills at the time when evaluating decisions. They encountered a situation where they were struck by the fact that there was a lost box with bracelets. So, to take it or not to take? They were impressed by the fact that nobody took it.

Transcript 4.11 Observing

> ***Lay:*** *the session, the closing session, when they came here to the campus. What did they experience coming here on campus?*
> ***Sara:*** *Yes, the truth is that it was a genuinely wonderful experience, they were overly excited since they knew they were going to go, then leaving the school, from taking a transport, to arriving in Monterrey, although we are remarkably close, I would know the campus from afar, since it was seen in the distance. Knowing that there are other ways when we arrived at the library they saw a world of possibilities, the boys were around them with those who are there in the study part. Both them and I, to see all that beautiful study community. Between courses, the way in which the campus is transited is incredibly beautiful, the feeling, the vibe in general and that they were incredibly happy, and they asked me, teacher, is that we had never seen so many. A student was very struck by the fact that in one part of the campus there was a little box with bracelets and then you bought them and left the money there. So, all those small closing actions that,*

as it is that you leave the money there and nobody takes it, then it was genuinely nice to see all that in them, that they were amazed. Install some rooms, the desks how all the people who were walking there were structured, very friendly too. So, this was a genuinely nice experience to see all the opportunities that exist. It caught their attention a lot.

(Interview with Sara Pos. 51-52)

Another trait is that you explore and want to do more. Elbert, higher education student, says *"It is a good opportunity to instruct young people, because learning is nothing common and that it be an impulse for them to continue having that curiosity of wanting. Well, exploring and wanting to do projects I also feel like it is cool (Interview with Elbert Pos.45)."* He in the role of supporting the teacher also helped him to develop traits of inquiry.

Fernanda, another higher education student, explains how one trait of the critical thinking arising from dialogic educational practices is no longer to think linearly. She says *"for example, in my case I can see the impact on the way they think now with respect to some other situations. When a topic is presented, they no longer think linearly. I mean in, we are talking about mathematics, and everything is exclusive, closed, mathematics, theory, and like this square system is not. I do not know if I explain myself with that definition, but for example, now they have achieved it, relate a little more contrast, disciplines in plan, you do not go with the first thing, well, they do not go with the first thing. It is expressed like this, not as if they achieve this multidisciplinary connection, this and well, that somehow impacts how they see their life and the way in which they make decisions at their level and. And at their school level, well, this one to define a little more like what path to take, that is, no, they do not*

stay seated on a single idea and well, it seems greatly beneficial to me (Interview with Fernanda Pos. 8).

4.3.2.2 Category: activities

This category collects how the activities are purposeful designed to developed critical thinking as a cognitive ability that were thought in the design. In that process is important to find out the reasons and connections between the topics presented with the activities.

In an interview with Edmundo, high school teacher, he described the process and assess how it helped him the activities from High STEAM. That means that the activities also have a critical thinking skill development in teachers. Edmundo says *"It is one of the things that I saw, I say that not only the students but also me, this helped me a lot to expand what was knowledge. There were many things that one did not know, for example, or for what are satellites used? Many times, the satellites say, well it is only for telecommunications, it is not there, but if you realize that there is a satellite that is a telescope. This one and see how the constellations are formed and all those topics both for the students and for one as a teacher. This had a lot, a lot of value, be it in the content, they were things that one did not know and well through these sessions, well, I say without requiring a little more (Interview with Edmundo Pos. 23)".*

Armando, a higher education student, when designing the activities acknowledges the purpose as well as how students could receive the project. He says *"Each mind has different interests, but the general was this part of them working on how it related to some other disciplines such as collage. The collage and the digital literacy unit from data science. It was also something that impacted them a bit, like knowing that I am going to digitalize it, like everything we do online leaves a digital print. So even so, I think you do not read the policies of each new account, but you know they exist and that they can collect all your unequal stuff. Today I think this may be something that remains within the students (Interview with Armando Pos.13).*" The fact

that students remain with the knowledge leaves them with different perspectives when assessing situations.

For Elizabeth, a high school teacher, the activities gave time to reflect. She said *"They reflected, they put their points of view and the best of all is that they are aware that sometimes he simply, for example, does not know how to get to a piece of paper and throw it away because it is affecting, contaminating in some way, not in having that kind of awareness in the students. In all the sessions there were many topics that were very important, interesting that were not heavy or things that, for example, a subject of biology, we suppose that you have to see the entire agenda, I do not know how to talk about a particular topic, it is focused on what is the science and technology of the things that happen. Yes, sometimes it remains, it remains a little more in the students than studying not seeing it in a session or commenting on what they present, their points of view, well yes, it helps a lot (Interview with Elizabeth Pos. 85)."*

High STEAM proposed 20 sessions, 18 were destined to the work of STEAM and the other two were an opening and closing session of the program. The purposeful design of activities proposed by the higher education students where the STEAM components were present in the sessions are shown in the tables 4.5 to 4.9. These 5 tables show us that the planned construction of STEAM areas was present in the overall project. However, not necessarily the five areas were covered in each session. This probably had to do with the time the teachers had to implement the sessions to make the five areas visible in one session.

Table 4.5

STEAM in Module 1

MODULE 1 Astronomy	Session 2	Session 3	Session 4
Science	Cosmos, bases of Astronomy	Astronomy	The universe
Technology	Electrical circuit	3D models about El Niño and La Niña	
Engineering	Bases of electricity, voltage, current, resistance	Artificial satellites	
Art		Paper modelling	Watercolor
Mathematics	Size		

In Table 4.5 we can see that the 5 areas were present in the overall in Module 1. That means that there was an integration that build up. The area that was highly present was Science in contrast to Mathematics.

Table 4.6

STEAM in Module 2

MODULE 2 Environment	Session 5	Session 6	Session 7	Session 8
Science	Human impact in environment	Oceanography, Density, upwelling, Proteins, sea foam, plankton		Research on concepts and context of Global Warming
Technology		3D models about El Niño and La Niña	Prototype	sound bases for composition
Engineering			Prototype	
Art	Creative writing	Gastronomy		Songwriting
Mathematics	Problem analysis		Calculations	

In table 4.6 we can see that again there was a build-up integration of all the areas. Now science, technology and art became the most used while the engineering area was only used in one session.

Table 4.7

STEAM in Module 3

MODULE 3 Gastronomy and chemistry	Session 9	Session 10	Session 11
Science	Fluorescence Concept	fat of a variety of potatoes	
Technology	Preparation and use of lamp	Lucidpark, Canva	
Engineering			
Art			Abstract art
Mathematics		Measuring amount of fats	

In Table 4.7 for Module 3, according to the planning of the sessions, there was no use of engineering. This contradicts observation in which the use of materials they had were used to solve issues. This was shown for example in the way they had to handle the different sizes of potatoes' bags. It was also found when in session 11 for art they were all given different materials to create their art expression.

Table 4.8

STEAM in Module 4

MODULE 4 Digital Literacy	Session 12	Session 13	Session 14	Session 15
Science				
Technology	Social networks	Digital methodology	paddle, Awesomely, Lucidpark	Lucid charts, Kahoot
Engineering				
Art			Poem	
Mathematics			Addition	

In Table 4.8 for Module 4 we can see that the sessions highly pointed to technology because this was precisely the digital literacy module where the objective was to reflect upon technology.

Table 4.9

STEAM in Module 5

MODULE 5 Employability	Session 16	Session 17	Session 18	Session 19
Science		Databases		
Technology	Professional opportunities	Databases		Job search tools
Engineering				
Art			Design	
Mathematics		Formulas		

In the last Module, as shown in table 4.9 there was also a high emphasis in technology. The overall High STEAM sessions build for an interdisciplinary experience for the participants. These were not merely craft activities, but they rather had a scientific technological foundation.

4.3.2.3 Summarizing the theme

The second theme: "Critical Thinking" as stated earlier refers to non-formal STEAM activities as a source of critical thinking in the sense of a cognitive ability. The research points out to specific traits, as its first category, which are developed in to gain critical thinking such as the starting point of the scientific method which is observation. The second category in this theme is activities. The activities refer to the selection of topics and experiences that chosen to develop critical thinking.

4.3.3 Non-formal STEAM activities as a source critical consideration of own circumstances

The third theme is "Critical considerations of own circumstances." This theme aimed to observe how dialogic educational practices challenge oneself to become aware

of its own circumstances. Inside this theme, there are three categories: (1) learning process, (2) teaching practices, and (3) future aspirations. Each of these categories will be explained in the following section.

4.3.3.1 Category: Learning process

This category refers to how high school students become critical about their learning process. They evaluate their teacher and ways they became to be in the position they are. For example, Andy, a high school student, in transcript 4.12 evaluates the role of her teacher in helping her to learn. She describes the teachers' character and points to characteristics that become a criterion that make her teacher an ideal teacher.

Transcript 4.12 Evaluating my teacher

> ***Lay:*** *Do you think that she as a teacher has supported you to motivate you to study?*
> ***Andy:*** *Yes, obviously. She, in fact, one of my favourite teachers.*
> ***Lay:*** *Okey. If you had to have an ideal teacher, what characteristics would he have?*
> ***Andy:*** *If I had to have something like the teacher Margaret, the truth is that if she is very resolute, she is very responsible and understanding, she wants us all to learn, just like that. Like she is, I mean, she is more than a teacher, she is a friend who really tells you, oh, no, well, that is how it is done. She understands, she goes back and explain or to help you. She is more than a teacher; she is like a friend.*
>
> *(Interview with Andy Pos. 56-59)*

Martha, a high school student, reflected on why she studies programming. She said that since she was little, she has always been curious about technology. She could spend hours glued to the computer. Every window she opened, passing functions she found, led her to start moving programs and finding something that interested her and

wanted to know more. But moving to computers is not the only thing he does and likes to do *(Interview with Martha Pos. 25).*

4.3.3.2 Category: Teaching practices

This category refers to how teachers and high school teachers become critical about their teaching practices. This challenges her own circumstances by identifying and modifying actions of the participants.

Carolina, higher education student, reflects about her relationship with Ramiro, high school teacher and how they manage the teaching role. She said *"So, if we have a little more experience but I think that to begin with, this was something very new for Ramiro, not having to go into other topics. Leaving the field of physics, a bit and getting into subjects before a little more social or more than technology networks. And on the other hand, I saw that also because of this challenge that Roberto felt. He liked to get into the bone stuff a lot. Towards the beginning of the class, he put a lot of emphasis on data in definitions. So, the noble thing about him was that he paused and asked me if I wanted to intervene, so I did, that is where I asked questions of the students. And I think good. I feel like these were two quite unique styles. Even I would have dared to start with questions. For example, Ramiro's tendency was to introduce the title of the session and then follow suit. My tendency was always to introduce the title and ask the students what this title sounds like to them or if they have heard of that topic before (Interview with Carolina Pos. 22)."* Carolina points to the nature of Ramiro and his educational practices related to the area of physics. It was a transformation of the practices where they had to learn from each other and sort the way each one put the emphasis in the educational practices chosen.

Eusebio, higher education student, reports how teacher Edmundo thinks that *"an unusual way of teaching this class is that dialogue is opened more so that the students can contribute their experiences. When students contribute and show their point of view, it can be a little richer learning for the group in general. And so, I already hope that the teacher can carry that part and how to connect different elements in the classroom. Also, that homework is a bit more multidisciplinary job. I think that with that he could stay and take advantage of the teacher (Interview with Eusebio Pos. 37*)." When teachers become aware of new methodologies and become critical about their teaching practices, he can broaden his perspective to take actions for his classes in formal contexts. In the same line, another teacher, Elizabeth, makes a point of the situation in her school where she shared the class with another teacher, but she did not know the group. It became harder for her to know and impacted the dynamic *(Field note Lay Pos. 222-236).*

4.3.3.3 Category: Future aspirations

This category shows how participants show a change of mind about future aspirations after the sessions. In an interview with Andy, high school student, she expresses her dreams for the future. The dialogic STEAM sessions created a space for her to share her aspirations which involves verbalizing her thoughts. Transcript 4.13 points to Andy's future aspirations.

Transcript 4.13 Future aspirations

> ***Andy:*** *And, another thing that are already personal goals, which has been this, well, what is it called to make an animated series. In other words, a company hires me to make a series, make a movie, something like Guillermo Del Toro. It is a career, well, that makes movies. That is what I do not like very much about this*

character and in fact the way he does the stories I also quite like. Because it must catch your attention. In fact, yes, I also put quite a bit there, just now I do not remember.

Lay: *In which one of Guillermo del Toro?*

Andy: *Because you like to believe in that their stories are a bit. They are a bit more, if you will, in the dark, like they have a very, very deep meaning, and I really like that. This is like from the brain as from the brain, just as you get a lot of meanings and in fact, I do think that it does have to do with psychology, with psychology, then. That is why I said, oh well, I am going to study psychology because I am going to know more about the human brain, I think that will help me later to enforce other goals.*

Lay: *Also, what other goals do you have for the future?*

Andy: *Another of my goals is to also help animals, help children. Dubbing this a character's voice? Not even having a company my merchandise, all that will be someone recognized. Yes. An image of inspiration for others, also so that they see that it is possible and that if they really want to, they can achieve it. That, that would be like one of my goals too. Or key as internal? Not so much doing for fame, but for. He will help her for the growth, nothing else, so if he will help others more for that side than for the fame and all that.*

(Interview with Andy Pos. 35-39)

Also, teachers, report on future aspirations for their students. However, they tend to be more critical. Raquel says "*The truth is, I still consider that they are young to make such a decision. It is so important, but it seemed especially important to me that from now on, they begin to be mentioned. So that they start looking for what to discover if not, they do not know it yet, to do a retrospection that they like what they are good at and so that if there are skills that they need to work on, well so that they can work on them and be able to do this get a job perform efficiently in what they like and know that because of that. They can get a remuneration in some cases, profiles a little more, like*

already specific, like they are already surer that they like it, that they know more than they want and some others not so much. I know I like that, but I am not sure, I mean, they were still hesitant, but that is normal, I mean, they are young and well, the sessions you leave bells helped, right now they are in fourth grade, so they still have them. Practically 12 months a year to clear up those doubts, or to try to prove if you are not sure, I go out to try to prove that they like it and it will weigh, because perhaps to work on their own personally at home and investigate a little more and find out if it is at the end of high school doing what they want to continue or if they want to go to another area. As an activity I found it remarkably interesting because it helps them to ask themselves the question that they had not asked themselves before (Interview with Raquel Pos. 39)".

4.3.3.4 Summarizing the theme

This third theme "Critical considerations of own circumstances" is one that this researcher had an exceptional care to observe. The reason is that precisely the research explored how dialogic educational practices could become a source for participants to become aware of their own circumstances. Inside this theme, there were three categories: (1) learning process, (2) teaching practices, and (3) future aspirations. For communities in marginalized situations awareness of circumstances as well as a transformation of the future aspirations challenges participants to take a protagonist role in deciding their lives.

4.3.4 Arts in STEAM

The fourth theme is “Arts in STEAM.” This theme was proposed because of the results in the scoping review and the clues that the pilot study gave. Inside this theme, there are two categories: (1) Create safe space, and (2) express oneself. It was a constant reviewing the field notes, that arts played a significant role in the implementation of the sessions. Each of these categories will be explained in the following section.

4.3.4.1 Category: Create a safe space

The category “create a safe space” is how arts has contributed to make the classroom a safe place for students. Art has created a safe place by building self-esteem, connecting to reality, sparkling creativity, and acknowledging differences.

A safe place for example to build self-esteem like Katherine, a high school teacher, said *“Finally, the painting or drawing of the universe was useful for everyone to turn on their camera and comment on their perspective. I must add that these activities strengthen their self-esteem, in which they observe that one does not need to be an expert to be a talented artist. While what we did was Art, we need to be clearer on the STEAM issue and make its interconnection visible (Field notes Pedro Pos. 35).”* Here, the teacher realizes that Arts propelled participation from their student, first by wanting to open the camera and on sharing their point of views. It is relevant to see that she considers that art strengthen self-esteem because it could be connected to the attributes of a dialogic educational practice. In that sense, people with self-esteem could be more critical about their own circumstances and wanting to make the necessary changes to give a twist to them.

Another feature of creating this safe space through arts is that it connects to reality. As Ramiro, another high school teacher, reported from a student "*I can now understand in a more tangible way what you are teaching me. We developed that from the artistic aspects (Field notes Carolina Pos. 28).”* The student was referring to module 1 session 4 where students used watercolours to draw the universe. It was an activity that purposely invited students to Paint. Thinking about those who never had painted before or were not skilled at it, the students were given an activity of searching for a universe image that they would like to paint. Including this activity also created a sense of having a previous reference from which they do not have to start from zero. When the students says that it connects to reality, we must consider that the painting activity became a consolidation activity after previously looking at constellations and satellites.

Arts became a source of creating a space for creativity to sparkle. Lidia, a high school student, said "*When we did the do it like Pollock session, I took my little jars to make diamond too, that is, apart from the material that we had, so I showed part of my interest (Interview with Sara Pos. 59)”.* In this, the students were able to incorporate their own materials too. That means it allow freedom to personalize their projects too.

Finally, a safe place is a place where you acknowledge differences. For Milena, a high school student, in the do it like Pollock activity, apart from being delicious, the sweets, the artwork became an opportunity to see the person "they also have their things, and think of other things different from me, but it helped me to acknowledge that we are all different, obviously different in the way we look and think (*Interview with Milena Pos. 50*)." That participants can realize that there are differences make them

conscious of our own self while looking at others. It is the dialogue of the self and the other embedded in this safe space where helps us connect through the differences.

4.3.4.2 Category: Express oneself

Participants agreed that Arts in the sessions became a component to express oneself. Sessions 4, 5, 8 and 11 had an Art component named it painting or music. One session in which participants unanimously agreed that propelled this category of art allowing to express oneself was session eleven "Do it like Pollock (See Appendix D.11). In that session, participants received a carboard and a type of candy or eatable ink to make a piece of art like Pollock who did abstract art. After that, participants shared what was the meaning of their art.

In transcript 4.14 we can read Andy's description of what happened to her. She is a high school student. One key to take from the transcript is where she says she was able to tell the teacher "*I did not feel enough, and I had no friends in school. I was incredibly sad.*" Art created the space for Andy to express herself. She said her artwork helped her to express that she did not have friends in school. This is important for teachers because these kinds of activities support their knowledge of the students' dynamics which serve them as an input in the design of the sessions.

Transcript 4.14 Arts to express oneself – high school student

> ***Lay:*** *OK. Can you give me examples of the sessions that were most meaningful to you and why you liked them?*
> ***Andy:*** *I liked the most three sections. It was one from space which was that we had to put together a rocket. Of course, I remember it very well because you had to have teamwork and there, we all helped each other, and it was not like I am not going to do it. I mean, everyone wanted to do their part and it felt genuinely*

nice. Another was, I think in something from the water. That we all had to see our water footprint, something that. And no, I do not remember, what was it called about how much water we had used and how everyone there was surprised, I mean, like everyone there really understood the point of why we were doing this session and why we were seeing what we were seeing. The last one, it was the one where we had to use candy to make Art. Like a work of art, but with sweets. It was one of the most emotional sessions because really those who were there, yes, they did want to demonstrate something, and I saw it in them and me. I also did the same and I kind of really took it very personally. When I was asked the meaning of it, I do not know why but I cried a lot. It was painful. I told my teacher I did not feel enough, and I had no friends in school. I was incredibly sad.

(Interview with Andy Pos.45)

Eusebio, a higher education student, talks about the space that Arts opened. He said *"I liked that, like everyone else, they were extremely focused on how to express what they felt. Although some students did it as a little more explicit and not so abstract, some said it as the idea that they wanted to represent and if the explanation was needed, this a bit of the accompaniment of what it was. But I liked that they are extremely focused, and this activity gave them a new way in which they can express this freely."* (Interview with Eusebio Pos. 27). When Eusebio talks about a new way, it is precisely, the opportunity that Arts open in space for participants to express their feelings and emotions.

Elizabeth, a high school teacher, recognizes how she previously did not see the value of art for a class. In an interview she talks about art not been in her common thinking process and that she was surprised that her students liked it (see transcript 4-

22). This position is common and more in a vocational school, where they are dealing with careers more oriented to having a manufacturing job.

Transcript 4.15 The value of arts in science to express oneself

> ***Elizabeth:*** *art is not like my favourite subject; I am more about the machines and how to change the pieces and do the maintenance. However, last week we did a closing ceremony to give students awards. We took photos, we gave them a lunch and the principal asked them what they liked, and they mentioned the class about Pollock, which is about art done after the era of the Second world war. I thought they were going to talk about the satellites. However, they talked about the art and how it felt. In this part, I was reflecting and saw how much I lack to give something like this more priority. I am thinking about the irons, about the practices of automation and the part where they can express themselves, I forget it. In High STEAM you know to give them space to express themselves and that I can also give them feedback so art can be incorporated with science.*
>
> *(Interview with Elizabeth Pos. 40)*

4.3.4.3 Summarizing the theme

The last theme has to do with Arts in STEAM. The previous experience in the pilot study and scoping review had already given clues of the possible impact of arts. It is relevant to notice that it creates a safe space, and the limitations of physical place become secondary compared to assurance of oneself to express.

4.3.5 Summarizing the qualitative results

In the previous sections, I presented the categories that emerged from the coding process according to the themes that supported keeping the analysis in the framework of the research. Figure 4.3 departs from the four themes that were proposed to start the

coding process and shows how the categories relate to each other in a more inductive way to answer the research questions.

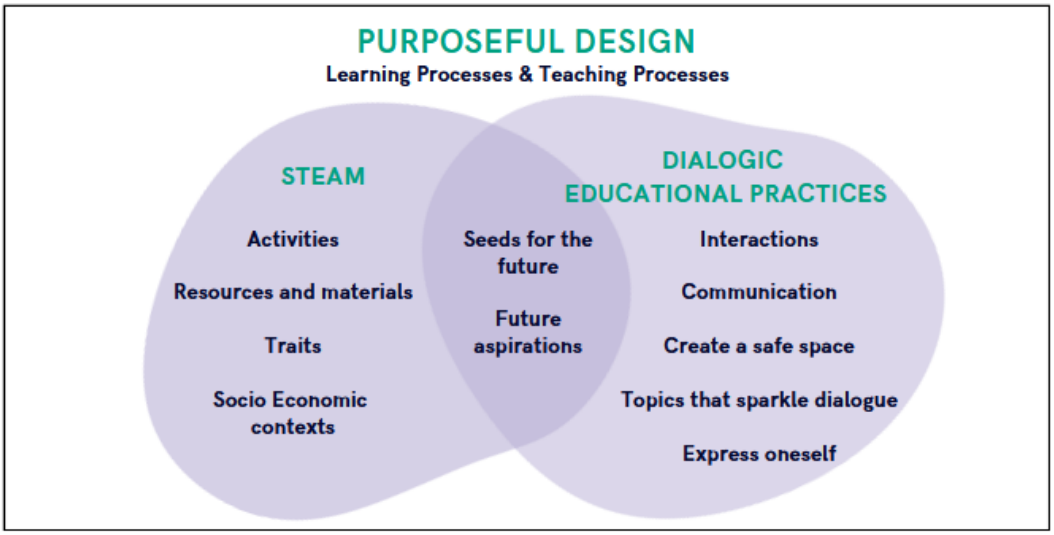


Figure 4.3 Purposeful design of Educational Experiences

Figure 4.3 is key for showing how there should be a purposeful design of the learning and teaching process for STEAM Dialogic education. These two categories are fundamental to understand the information that comes from participants. The first component STEAM has four categories: activities, resources, and materials, traits, and socio-economic contexts. These categories in STEAM show elements that need to be considered in creating the STEAM sessions. The second component of dialogic educational practices gives us a portray of elements that reflect these practices. In the purposeful design, when combing STEAM and dialogic educational practices we could see that two categories emerge: seeds for the future and future aspirations. These two categories show an impact in the critical thinking skills of participants of non-formal contexts of education. The impact is the fact that dialogic educational practices give an opportunity to verbalize knowledge, thoughts and emotions leading to reflect about oneself circumstances and enrich the knowledge about participants. These three aspects

support not only changing educational practices of those who teach but also those who learn.

4.4 Converging results

4.4.1 Introduction

The proposed methodology for the main study to assess the impact of dialogic educational practices in STEAM sessions in the critical thinking skills of participants of non-formal contexts of education was a convergent-parallel approach. In the analysis strategy, it was proposed to analyze the qualitative and quantitative data separately; then converge the results and the subsequent interpretation of quantitative and qualitative data. The use of the concurrent triangulation design (single-phase) gave the following results shown in Figure 4.4.

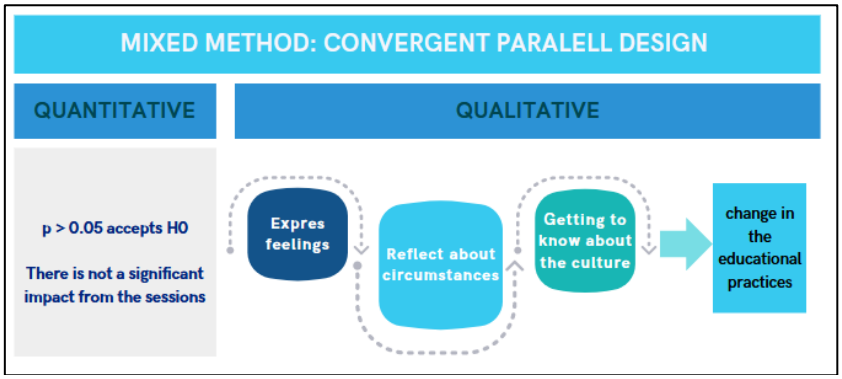


Figure 4.4 Summary of results from the convergent parallel design

4.4.2 Quantitative results

The quantitative results (section 4.2) from applying the pre-test and post-test suggested that students' mindset was equal for both sets. The results came from applying a Wilcoxon signed-rank test for each of the five attributes (mental focus,

learning orientation, creative problem solving, cognitive integrity, and scholarly rigor) that was measure before and after the application of High STEAM sessions. However, the attribute of Learning orientation was just slightly greater than the significance level 0.05. This attribute measures the tendency or habit of seeking to increase one's knowledge and skills; toward valuing the learning process to accomplish proficiency over a task. As a researcher, I was expecting that this attribute and creative problem solving would have been the attributes that show a difference in the post test because the sessions to High STEAM naturally pointed out to them. The creative problem-solving measures is the habit or tendency of approaching problem solving with innovative or original ideas and solutions.

I was expecting these attributes were the ones that proved a high difference after applying the 20 STEAM sessions because they are part of 4 competencies that STEAM is supposed to achieve. I infer that they did not come high because of the lack of intentional reflection on these topics with the learners. This shows a limitation on the design of the sessions and the evaluation. This means that when planning the session, the evaluation component should be purposely pointed through the activities.

4.4.3 Qualitative results

On the other hand, for the qualitative results (section 4.3), four themes were proposed deductively from the research questions and fourteen categories emerge inductively after the coding process. The themes and categories assessed the impact of dialogic educational practices in STEAM sessions in the critical thinking skills of participants of non-formal contexts of education. The first theme "Dialogic educational

practices in STEAM education" gives key elements that set the framework in which the High STEAM sessions are taking place under the theoretical framework of dialogism.

The second theme "Non-formal STEAM activities as a source of critical thinking" reveals the traits that emerged and the activities that propel critical thinking among participants.

The third theme "Non-formal STEAM activities as a source of critical consciousness" observes three categories in which participants become aware of their circumstances in this case their learning process, their teaching practices, and their future aspirations. This is fundamental that had emerged because the purpose of using the dialogic framework was precisely to give tools to communities in marginalized situations to become aware of the situation and the possibilities of a different future. With the three categories we can appreciate the impact for participants.

The fourth theme "Arts in STEAM" was purposely included as a theme not only because of the discussion in the literature review but because of the impact that was seen in the pilot study. In the High STEAM design phase, Arts was aiming to contribute to dialogic practices as a source connected to verbalize emotions and thoughts. It is relevant to notice the sense of agency created through arts. The categories that emerged from this theme were the "creation of a safe place for students" where they discovered differences with others and a second category "to express oneself". An example of how students expressed themselves was when making the pieces of art. When expressing the emotions, they were able to verbalize the reasons behind their creations, which allow teachers and higher education students to learn more and understand about the socio-economic context of the students.

The qualitative results give us clues on the importance of an intentional design of dialogic educational practices so that it becomes source of critical thinking and critical consciousness for participants is.

After presenting the quantitative results (in section 4.2) and qualitative results (in section 4.3) there is an apparent contradiction on the results that we got. In one side, the quantitative results show that there was not a numerically impact after the application of pre-test and post-test to participants. Meanwhile, the qualitative data is richer in examples where there seems to be an impact from the implementation of dialogic educational practices in the STEAM sessions. So, what is the possible explanation to this apparent contradiction? Is there a weight more on the qualitative or quantitative? Or what is in between them can help us formulate the case for the two results to converge? Following, I proceed to describe my reasoning process to explain these results.

4.4.4 Attributes found in the categories

Having the quantitative results not showing an impact of the sessions while the qualitative give us an impact through the categories that emerged. So, what could explain the difference in the categories and test results? The quantitative result had five attributes for the mindset test. Even though the project did not declare which attributes were supposed to be impacted, neither in the proposal or in the sessions' design, there were two attributes: Learning orientation and creative problem solving that the High STEAM project naturally pointed out with the proposed activities.

The learning orientation scale measured the increase of valuing the learning process while the creative learning measured the feeling towards been imaginative,

ingenious, and solve difficult problems. By the descriptions, of the purpose of what these two attributes are trying to measure, the qualitative results show that there are categories that match up with these descriptions.

For the learning orientation scale, which p-value was just slightly greater than the significant level, the matching categories in the qualitative results are two categories under the theme “non-formal STEAM activities as a source of critical consciousness”. The categories are learning process and teaching practices. The learning process refer to how students become critical about their learning process. I also added the teaching practices categories because it refers to how teachers became critical about their own practices going through a learning process during the social design project.

For the creative learning scale, there are two matching categories in the qualitative results that are the Art in STEAM theme: create a safe space and express oneself. These two categories match up the creative learning scale because the safe space is said to spark creativity and builds on the person self-esteem. Moreover, the fact that a category of expressing oneself had emerged supports an impact related to the creative learning scale because it gives us an account of a context that promotes freedom to let creativity flourish. If the High STEAM sessions had an environment where students were to be repressed, the creative learning could have not prospered.

4.4.5 Cultural relevant pedagogy

The cultural relevant pedagogy (CRP) concept could help us explain the difference between the quantitative and qualitative results. According to authors like Brown et al. (2019) who use CRP, there are multiple aspects that need to be considered in the students’ achievements such as the student learning, cultural competence, and

critical consciousness. We see that the cultural competence and critical consciousness foundation is in a sociocultural aspect that the quantitative test might not take into consideration.

There is a socio-cultural aspect that might not be reflected on the quantitative test. If participants in marginalized situations had been previously exposed to 11 years of a banking education rather than an education shaped by dialogic practices, then their mindset might not be quickly changed. That does not mean that there was not a learning or change in the mindset. As one of the teachers said is like a first aid course. It will come out when the situation triggers it. There is a cultural competence and critical consciousness that now students can pull as the learning they gain but that was not measure in the test.

It is relevant to note that examples of cultural relevant pedagogy make a call for teachers and experienced designers to consider not only previously who are the learners but also during the sessions, to learn what is culturally relevant for them in order to enrich the experience. For example, in Monterrey two relevant social topics that were impacting the society at the time of the STEAM sessions were the lack of water and the feminicide case of Debanhi Escobar. These topics were brought in the conversations of sessions 7: Eco Audit, 12 My digital footprint, 14 Social Networks Etiquette, 15 Fake News.

The fact that learners brought these topics to show us the ability to connect knowledge to problematics that they have in their daily activity.

4.4.6 Mixed method: convergent parallel design

Figure 4.4.1 gave us already a hint about how the quantitative and qualitative data apparently contradicted themself. However, in section 4.4.4 we saw that qualitative categories match up some of the attributes in the applied test. The test itself became an experience for learners as an exercise to express their perception. Not necessarily their perception of themselves against the attributes reflected what they expressed in their interviews, what was observed by the teachers and researchers. The qualitative data proved to be useful so that the research not just tried to answer the question numerically but allowed to observe and enrich the answer to the research question from what was observed.

Chapter 5: Discussion

5.1 Introduction

In this last chapter "Discussion," my aim is to synthetize (section 5.2) and evaluate (sections 5.3 and 5.4) the research work done to fill the gap in the literature about dialogic educational practices in STEAM sessions in non-formal contexts of education. Moreover, I also reflect on the highlights and main contributions for Educational Innovation (section 5.5). Finally, recognizing the limitations of this research, the chapter also includes a section for futures lines of research (section 5.6).

5.2 Main findings synthesis

While in section 4.4 I converged the results of the research, in this section I discuss about the main findings around integrating STEAM areas of knowledge, sociocultural view in STEAM, learnings for non-formal contexts of education, and the learnings for formal contexts of education.

5.2.1 Integrating STEAM areas of knowledge

During the scoping review, previous research had shown that none of the articles reviewed had an integration of the 5 areas of knowledge in STEAM. Instead, from the thirty-two articles selected for the scoping review showed that only nine studies integrated the four areas, sixteen studies used only one STEM area during their research while seven studies integrated two STE(A)M areas.

This research reveals that the integration is possible through an intentional design of the educational experience. Authors like Howe, Luthman, et al., (2015) even though integrated two areas, they talked about how reflecting on the concern on the integration of math and science they proposed to make the epiSTEMe project. As instructional designers we could think of the design of one session and maybe all the units we give in the semester or school year. However, this research experience shows that in order to integrate the areas of knowledge is necessary to think on the whole process of learning considering the needs of the learners as well as the needs of the society.

The integration of the subjects, an interdisciplinary education, challenges to our current educational models. In the non-formal context of education, the model is: you have an activity and then they propel the use of the areas of knowledge. Meanwhile, in a formal context, learners are filled with areas knowledge and then push them to apply them into activities. Think about how in school schedules, our learning is organized by subjects and not by projects that integrate the areas of knowledge. This impacts the way we organize our own way to structure our world. A clear example is the 2030 sustainable agenda which proposes different problematics, and the efforts seem to be isolated from each other when the goals are related.

A challenge when integrating the areas of knowledge in the non-formal context of education was to name academic constructs during the course of the sessions in contrast with a formal context of education. While in the formal context of education teachers share the constructs to describe mathematical, scientific, technological, artistic, and engineering knowledge, the STEAM activities in non-formal context of educations

lacked all the support to do this task. Then, I can point the fact that one of the functions of teachers to integrate the areas of knowledge is to be language teachers of the academic constructs. However, this does not demerit the scientific learning process given with the sessions because the fact that in the non-formal context of education they did not receive all the academic constructs that could be explore in subject-by-subject class does not mean there was not STEAM knowledge. Rather, it shows that learning process are present and academic constructs created according to the social interaction who will be given their own structure and meanings to the constructs they create.

The STEAM approach becomes fundamental for the categories that emerged in the research, because the scientific knowledge combined with dialogic practices support participants critical questioning of themselves, their interactions, communications, socioeconomic circumstances, aspirations for the future and become seeds for their future actions.

5.2.2 Sociocultural view in STEAM

The sociocultural view in the educational practices favored the STEAM paradox. In the problem statement and theoretical framework chapters, I pointed to how STEAM became a paradox because development was also accompanied by some inequalities that lead to socio-economic gaps. By combining a sociocultural view to STEAM, in this research specifically through dialogic educational practices in communities living in traditional marginalized situations, STEAM education is strengthened in the promises it carries. It is relevant to have applied a socio cultural view which matches what authors like Planas (2018) claim. He said that that exclusive sets of norms, practices, and forms

of knowledge cannot produce language and meaning in isolation and separately from other constructions of culture. Moreover, in another study (Page-Reeves et al., 2019) researchers also found that taking in consideration the skill sets, knowledge, experience, perspectives, and wisdom to bolster the foundations of Indigenous sovereignty would support the reality and future possibilities of native Americans. These types of studies match with the findings of this research in which the cultural relevant pedagogy supports the incorporation of this paradigm to explain the impact of dialogic practices.

By adding the dialogic educational practices more horizontal relations are created because the actors involved become aware of (1) their own circumstances and (2) that it is in their hands to transform them. They are given back, by others and themselves, their dignity as human beings. This makes them free to express themselves and to take actions to challenge their own future aspirations. It means STEAM with dialogic educational practices does create a critical consciousness while learning STEAM knowledge.

5.2.3 Learnings for non-formal contexts of education

Learnings from non-formal contexts of education could be divided in the 5 stages that these projects went through: funding, project design, implementation, data collection and analysis strategy. In this section, I will evaluate the first three sharing strengths and challenges from the projects. The other two will be later evaluated in the chapter.

The social design experiments for Hyperlocal and High STEAM were done with international funding in the midst of the Covid-19 pandemic. This funding facilitated the acquisition of materials for the participants to implement the sessions that according

to teachers was useful because learners already had the material complete. That means teachers did not have to deal with lack of resources to make the STEAM activities facilitating the teaching process. If this project were to be replicated within the schools, it could be helpful to incorporate the support of the industry specially because these are vocational schools that are preparing the labor force.

The project design phase for Hyperlocal and High STEAM were done differently. While Hyperlocal was planned for four STEAM sessions, High STEAM was planned for twenty STEAM sessions. Both projects' designs had a common social justice agenda. While Hyperlocal supported the access to STEAM education for families in marginalized situations, High STEAM supported dialogic STEAM education for students and teachers at high schools in marginalized situations. The Hyperlocal activities were relevant to the pandemic situation. On the other hand, High STEAM activities were relevant for high schoolers who were preparing themselves for the manufacturing industry. Both project designs use STEAM as way to bring dialogic practices. Sharing the design goals with the higher education students and the teachers was fundamental to align the participants to dialogic educational practices.

The implementation of Hyperlocal and High STEAM depended on the arranged structured. For both projects higher education students designed the digital resources for the sessions with the support of the collaborative feedback given in the weekly briefing meeting. In the case of High STEAM, higher education students supported high school teachers having weekly meetings. This was different to regular schools' practices in which teachers only have a monthly meeting scheduled to share with their own academic area. However, through High STEAM the purpose was to create a horizontal

teaching relationship among the teacher and higher education student where they could share about the teaching practices implemented. The consciousness created by teachers in the encounter with this ‘academic partner’ challenged their educational context, their own practices, and their own circumstances. By having this cooperation in dialogic understanding, the high school students received a non-formal STEAM education in which the teacher and higher education students implemented sessions of dialogic experiences. The high school students were exposed to an education in which the activities target to develop the sense of agency of participants as well as the horizontal relationships with them.

5.2.4 Learnings for formal education contexts

High STEAM sessions were outside the formal educational curriculum that left implications for formal contexts of learning. First, they challenge teachers’ educational practices. High school teachers implementing High STEAM were invited to work in a project with 5 pillars: STEAM, dialogic education interinstitutional work, culture and knowledge, and sense of agency. These pillars challenge their current educational practices specially in their relationship with the students. High STEAM by opening spaces of dialogue in the sessions put an emphasis on getting to know the students and creating safe spaces for students to express themselves. Teachers realized that when they gained their students trust and become empathic to their situations, students were more prone to participate in class enhancing the learning environment. Second, it challenges the curriculums topics and their connection with students’ culture. The topics selected for High STEAM sparked the interest of students not necessarily because they are better than the ones proposed in the curriculum but rather, they show a connection

with relevant topics for students that inspired them observe, to inquire, and to share their own experiences valuing that previous knowledge they carried with them. A third implication for formal contexts of studies is the purposeful design of educational experiences should have with room for flexibility. High STEAM by having resources ready for the sessions allowed teachers to focus on class more on enjoying the lifelong learning of their students and focusing on their practices.

5.3 Evaluation of the theoretical framework

As stated in chapter 1.4, the research problem statement is generated with a strong critique in STEAM education not being enough for communities in marginalized situation. The reason is the complex paradox that STEAM education by itself has provoked creating economical gaps among world citizens. In that sense, the pursue of STEAM education should not only support the integration of the areas of knowledge but create critical consciousness among participants about their circumstances. Hence, there is a need for a critical perspective to work hand on hand with a STEAM education. In this research, the proposal was to bring to research dialogic education as the component that can bring a genuine interdisciplinary education.

The dialogic educational practice framework works under a sociocultural paradigm that I have been working as a member of the Research Group on Educational Innovation, specifically working with the line of Sociocultural Studies led by Professor Juan Manuel Fernández-Cárdenas. This group aims to analyze the sociocultural context where the educational processes are conducted. The group does educational research addressing key concepts like the social practices, cultural tools, identities and

trajectories in communities of practice (Fernandez-Cardenas, 2022). Through this community of practice, I have channeled my desire for making research with a social impact. This group opened the opportunity for my research in social justice education. I have been part of this group adding to the conversation of dialogic educational practices through the 3.5 years of my PhD Journey. My cosmopolitan experience added to the sociocultural studies' conversation on teaching practices seen from different educational systems perspectives.

As stated earlier, the use of dialogic educational practices as the theoretical framework for this research is fundamental in the pursuit of that social justice education agenda. In the case of Latin America, the current educational systems still carry colonization features that reinforce hierarchical structures in all institutions which limit mobility. Moreover, it uses education as method to deposit knowledge in the learners. The socio-cultural framework through the implementation of dialogic educational practices become relevant to break the vertical relations and make us talk of horizontal relations between participants. The teacher is no longer in a position of provider of knowledge but rather becomes a designer of an educational experience.

The socio-cultural framework also allows us to understand the role of culture and cultural tools in the education process. It calls us back to see that numbers do not measure everything. There is a richness on the field notes and interviews that help us explain deeper.

Weingart & Joubert (2019) found that science communication owes its present configuration to several interlocked developments: universities and research organizations have been subjected to market-oriented competition for public funds and

students. This precisely talks about the challenges found in public education such as the ones found in this research. Formal public education still needs to guarantee access to resources.

5.4 Evaluation of the methodology

In my research there was a social justice agenda in education. The Hyperlocal and High STEAM projects provided me the opportunity of not only researching but give birth to these projects. That means I had double roles related to High STEAM, the first one was as a project designer and the one as researcher. My first role gave me the opportunity to have first-hand information such as knowing the intentions and aims of the projects since their inception. To do my job as a researcher, I had to take time also apart to prepare and implement my methodological strategies.

5.4.1 Methodology

As declared previously, this research has a social justice agenda. The socio-cultural paradigm and the social design experiment provided a framework that led this study. It was in the dialogic educational dynamic where culture plays a significant role for critical consciousness and thinking. The paradigm challenged the educational practices in STEAM, not leaving it just knowledge but considering the sociocultural artifacts that surrounded this educational ecosystem.

The use of a convergent parallel design gave indeed a richness of perspectives to this research that aimed to understand the impact of dialogic educational practices in non-formal contexts of study. The selection of the methodology challenged previous

research that only use quantitative or qualitative methods. This mixed method research aimed to bring learnings from non-formal contexts of education to the formal contexts of education which are traditionally measured by different indicators. There was an apparent discrepancy in the results obtained that will be explored in section 5.4.3.

5.4.2 Participants

The selection of participants for the pilot and main study was strategic. For the pilot study, the help of key people in the community was relevant to gain the trust of the participants. The socio-cultural challenges that could have arisen from the community in the marginalized context were dissipated with the help of the key informant. For example, in the use of language, the word for 'research' in Spanish is 'investigación' but in the cultural context due to drug dealers is associated to police investigation. So, the key informant suggested the use of word 'estudio' which literal translation is 'study' in English.

In the main the study, the fact that the main study launched a call for teachers was key in developing the relationship with them and the students. My job as a coordinator of the program helped me build the rapport with participants. Hence, I enjoyed their willingness to share their experiences with the classes which gave me a better understanding of the social context of the participants. It was key to support them in the day to day needs that were presented in the project.

One of the fruits of this research project is the work done with higher education students. The two studies were supported by the work of higher education students which increased the network of impact connecting different stakeholders in the society.

Moreover, the training I designed, and the support given increased their experience as researchers as well as achieving the purpose of their community service program.

My positionality in the study had a cosmopolitan view that contributed to the exercise and relation with participants. I was a female Ecuadorian Asian descendant living in Mexico to pursue my PhD degree. This combination created an interesting portray of me as a researcher. First, it was interesting how my Asian look and native speaking in Spanish gave me an icebreaking conversation. We would start with so where are you from. I would share my story "I am Ecuadorian, my dad was Chinese, he went to Ecuador when he was 20 and my mom is Ecuadorian, but her parents were Chinese". This quickly would give me a way to connect with participants specially those who were not necessarily from Monterrey, or their parents were coming from other states of the Mexican republic. My privileged position of studying at Tecnológico de Monterrey gave me an opportunity to discuss with teachers about their situation in their high schools. They wanted to express their passion for education and let me connect with their aspiration of being part of the university one day.

5.4.3 Data collection and analysis strategy

The data collection and analysis of this mixed method was done separately at the same time. For those reasons, the data collection instruments were fundamental for the results. The quantitative data came from the mindset test applied to participants who were evaluated in 5 attributes meanwhile the quantitative came from interviews, fieldnotes and focus groups.

During the process of converging the quantitative and qualitative data, there was an apparent mismatch of the information. The validity of the test is not put into questioning, but it leaves the door open to develop tools specifically for the project. The attributes measure was not all necessarily expected to be developed with the implementation of High STEAM so if the project was to be done again, I might reconsider the use of the test. This has nothing to do with the validity of the test but to match up better the objective of the test with the design of each of the sessions.

The California Critical Thinking Skills test was not matched up previously with the design of the sessions. It was expected that the High STEAM sessions would lead to the attributes measured in the test, but there was not an intentional match up. The qualitative data gave us insight that there was an impact for the students involved in the High STEAM program.

The methodology in its essence combined quantitative and qualitative data. The amount of data from the project was vast making it necessary to follow rigorous procedures to make calculations and the coding process. It took more time than expected to organize the data and later to codify it. In a next project, I would reduce the amount collected for the time framework that was given.

5.5 Evaluation of the Impact of the Intervention

The intervention was successful in bring together 6 public schools, 1 university and 1 consulate to work together and make the alliances to achieve the goal. High STEAM was an intervention in which private and public institutions formed a network

playing different roles with the main objective of generating transformative learning opportunities that contribute to social inclusion and sustainable growth in these communities through STEAM activities. Another strength was the reputation of the university played a major role at the time it calls for institutions to be part of the project.

The intervention was weak in the expertise of the STEAM designers of the sessions. They were not necessarily all educators or experts in the STEAM didactics; some were studying education meanwhile others were studying engineering. To come together with the STEAM sessions, the process of designing the sessions was an exercise of presenting the design, receiving feedback, and making changes to the session. They would also go through a feedback process with the high school teachers in the implementation. Another weakness was to make more explicit in the sessions the STEAM concepts for high school students as well as the connections with the Educate insight test attributes. This became a weakness because there was a privilege given to the dialogic and transformative learning.

If I were to do the intervention again, I would find experts to train in STEAM didactics the higher education students so they could design stronger STEAM sessions. If I were to do the project again, I would increase the number of high school students per classroom. I realized that the design of the experience needs to be intentional and accompanied.

5.6 Innovation

This research work started with my own personal agenda of transcending by living a purposeful life. I took a special commitment to achieve social justice and found

in education my way to do it. Growing up in a Latin American context, there was always a questioning on why other countries had a developed status. What they had done so we could implement the same. In that search, I remember my business classes where the more developed countries usually would have more business in the secondary, tertiary, or quaternary sectors. Hence, scientific, and technological education resonated my mind showing a connection with development. But the STEAM education could not alone fulfil the promise for Latin America specially for communities in marginalized situation who have a limited access to quality education. In that search, dialogic educational practices as a source of critical cognitive and critical about own circumstances became an attractive proposal to research.

I had the opportunity to make my research in Mexico thanks to CONACYT which is the governmental institution responsible for establishing public policies in humanities, science, technology, and innovation in the whole country to strengthen the scientific and technological independence of Mexico. I have been one of 85000 students that yearly has benefit from this institution that supports the scientific research. In that line they hold a National Strategic Education Program (PRONACES-Education) that promotes social inclusion through an interdisciplinary, comprehensive, and horizontal approach. Through Hyperlocal and High STEAM, I have contributed to impact more than two hundred participants to experience dialogic STEAM education. In that sense reducing illiteracy and promoting access to quality education in which learners can express their voice in the public space, which in turn strengthens the political practice. The projects also inspire them to imagine and transform themselves and their realities.

My research aligns with the purpose of CONACYT and PRONACE-Education by offering an understanding on the impact of dialogic educational practices in STEAM education. The dialogic educational practices in STEAM education are an innovation of my thesis work because they become a source of critical thinking for participants in marginalized situations. These practices strengthen their self-assurance, motivate their scientific spirit, and create safe places to establish dialogues. The learners are central and the activities in the design consider different opportunities to make out of these interdisciplinary experiences in non-formal contexts an alternative to current education.

Another relevant innovation is how the social design experiments I did with my pilot and main study had a broader perspective in participants and content. The network of people that was built involved private and public institutions, educational and non-educational institutions that were challenged to work together with separate roles but aiming to the same objective. In applying dialogic educational practices in STEAM education through the sessions, I realized that higher education students also became designers of the experience, meaning they were peers of the high school teachers they were accompanying. The high school teachers, where the way for High STEAM to enter schools and develop non-formal education experiences in which their perspective of teaching was broaden. The high school students had an activity to look for and reincorporate after the pandemic. So High STEAM and Hyperlocal became an alternative solution to avoid school learners the risk of dropping schools as well as reincorporating to school activities.

When replicating these kinds of works is a key innovation to be able to understand where the program fit within the learning process and wellbeing of the

learners. That means, to know the socio-economic context in which they are, as well as demographic and psychological behavior. As teachers we might implement the same STEAM sessions but depending on the learners we have, we might need adapt and be flexible with the way the sessions were planned.

Arts, arts, and more arts in STEAM. The use of Arts in applying dialogic educational practice was a way to detonate the expression of emotions and feelings. This opens the floor for a safe space for participants to perk and increase participation. They become active actors of the learning experience they are living through the artistic activities. When having the time to include intentionally artistic activities, this can propel dialogue and ways to build trustful learning spaces.

5.7 Future lines of research

With my initial intention of living a purposeful life to transcend and finding in education a way to do it, I could say research is continuous and we should keep moving after it. Some ideas remained in the inkwell, but I would like to open some of them for futures lines of research for others or for me to keep contributing to humanity. I would want to focus on leaving three themes for futures lines of research.

5.7.1 Methodology

There is always room for improvement. I would want to explore how qualitative research can be more systematic. In the other hand, with the quantitative methods to study the thinking mindset of the participants, the experience tells me that future research could work on instruments that are adapted to the projects.

I would research also on how to redesign STEAM sessions considering the attributes of the Educate Insight test. I think this could deepen the study.

5.7.2 Research process

About the research process could focus on higher education student's role and impact for them and others through their community service program. It was indeed powerful to see how students can benefit their personal and professional life through a service project. I consider that a future line of research is on how to connect higher education with society through these learning experiences in non-formal educational contexts that they had. The most powerful impact I saw was with the higher education students who were part of the whole project because they were active in all the strategic and operational process.

If I could have another project, I would research deeper on the design of an accompaniment program between teachers of upper secondary level and students of higher education at the state and federal level.

5.7.3 Long term impact

Scientific and technological education could generate long impact for societies to which governments should keep an eye on. Hence, a line of research could be to focus on the funding necessary to establish and maintain these programs for a long-term period so they could be replicated. I think it would be important to search for alliances with higher education students who feel passionate about STEAM education. The line of research can be taken by public policy doctoral candidates who pursue economic development through educational policies.

STEAM in the formal context of education for public schools who usually have difficulties in accessing resources makes me think on how research could focus on making research on inexpensive educational resources to implement STEAM and the material for the teacher.

5.8 Final words

Seeking to reduce marginality also implies offering quality education. It involves raising our voices, searching resources, and above all ACCOMPANY in the design of educational experiences. Accompany in daily life, accompany in dreams, accompany in happiness and sadness, accompany in doubts and uncertainties, because accompany is to love, accompany is to serve, accompany is to care, and above all accompany is a donation to other.

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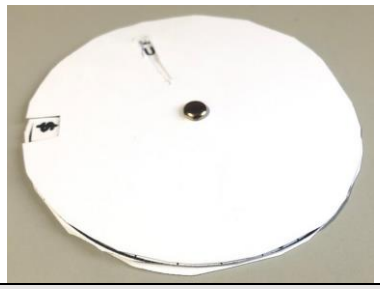
Appendix

Appendix A: Pilot Study – STEAM Sessions Design

Appendix A.1: Decoder instructions

<table>
<tr><th colspan="2">Activity # 1: Decoder</th></tr>
<tr><td rowspan="3">  </td><td>Justification of on the selection</td></tr>
<tr><td>This activity aims to be an icebreaking activity as well as promote dialogue through the collaboration in decipher a message.</td></tr>
<tr><td>Designed by</td></tr>
<tr><td colspan="2">Content creators (Abraham, Andrea, Josefina, Fátima)</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">Scissors, paper, pencil, ruler, thumbtacks, compass (or circular objects with three different sizes)</td></tr>
<tr><td colspan="2">Steps</td></tr>
<tr><td colspan="2">
Make sure to have all the materials needed
Cut three circles made of cardboard about 15 cm of diameter
Set two aside, they will be the outside of the decoder.
Use the other circle to draw two inner circles. One smaller than the other.
Draw fifteen lines that cross the middle point so that all the letters and some symbols can fit in.
Erase the smallest circle
Write the letter in the inner circle and the symbols in the outer circle.
Draw two windows, one corresponding to the inner circle where the letters are and draw the window in the outer circle to the matching symbol you want. For example, if one of your symbols is a triangle, and the letter that it represents is A then make sure the windows match.
Make sure to make the window where you can see the matching letter and symbol.
Bring all the cardboards together
With the help of a scissor make a hole in centre of the three circular cardboards.
Put the thumbtack to unite the three cardboards.
Give recommendations and advice on how to share the information.
</td></tr>
</table>

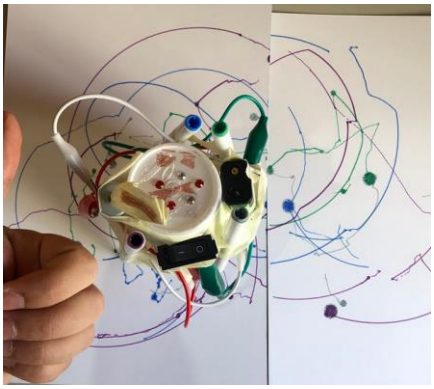
Appendix A.2: Soap instructions

<table>
<tr><th colspan="2">Activity # 2: Soap</th></tr>
<tr><td rowspan="3">  </td><td>Justification of on the selection</td></tr>
<tr><td>Due to the Covid-19 pandemic, the aim with this project was to find a creative way for families to remember to wash their hands.</td></tr>
<tr><td>Designed by</td></tr>
<tr><td colspan="2">Content creators (Abraham, Andrea, Josefina, Fátima)</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">Melt & Pour Crystal soap base, Dinosaur moulds, one aroma essence, dyers, pair of latex gloves, pot, water</td></tr>
<tr><td colspan="2">Steps</td></tr>
<tr><td colspan="2">1. Make sure to have all the materials needed
2. Put your gloves
3. Cut in pieces the Melt & Pour Crystal soap base
4. Place it in a bowl that you can use to melt
5. In a pot at medium heat pour a cup of water
6. Place the bowl at the top of the pot
7. As the bowl gets hot the soap base will melt, make sure to stir it
8. Add aroma essence
9. Remove from the heat
10. Add dyer
11. Pour the soap base in the dinosaur mould
12. Wait until its cold and harden</td></tr>
</table>

Appendix A.3: Face Mask instructions

<table>
<tr><th colspan="2">Activity # 3: Face Mask</th></tr>
<tr><td rowspan="2">  </td><td>Justification of on the selection</td></tr>
<tr><td>Due to the Covid-19 pandemic, the aim with this project was to motivate participants to wear face masks as well as deal with the shortage of them in the market.</td></tr>
<tr><td rowspan="2"></td><td>Designed by</td></tr>
<tr><td>Content creators (Abraham, Andrea, Josefina, Fátima)</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">Two pieces of fabric, glue, knitting kit, scissors, black neobolt, elastic, textile marker, sticky beads</td></tr>
<tr><td colspan="2">Steps</td></tr>
<tr><td colspan="2">Make sure to have all the materials needed
Cut two pieces of fabric 25x15cm and a piece of black neobolt with the same size
Place the black neobolt and one piece of fabric together.
Use the knitting kit to sew the face mask. Remember to put the elastic for the face mask at the two ends.
Add the second piece of fabric and sew it.</td></tr>
</table>

Appendix A.4: Drawbot instructions

<table>
<tr><th colspan="2">Activity # 4: Drawbot</th></tr>
<tr><td rowspan="2">  </td><td>Justification of on the selection</td></tr>
<tr><td>An activity that has proven to be enjoyed by kids. This will engage families in a fun activity while learning how to make the drawbot.
Designed by
Content creators (Abraham, Andrea, Josefina, Fátima)</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">Two batteries, 1 battery holder, 1 switch, Cayman cables, 1 robot motor, 1 foam cup, tape, 3 markers</td></tr>
<tr><td colspan="2">Steps</td></tr>
<tr><td colspan="2">1. Make sure to have all the materials needed
2. Place the batteries in the battery holder
3. Connect the Cayman cables to the battery holder and the robot motor
4. Since we do not want the motor to be endlessly running, we are going to add the switch
5. Remove one Cayman cable side and connect it from the robot motor to the switch.
6. Attach the circuit to the cup
7. Add a piece of tape to the robot motor so it acts like a boat sail.
8. Now you can turn on your drawbot</td></tr>
</table>

Appendix B: Pilot Study - Data collection Instruments

Appendix B.1: Semi structured interviews families (Spanish)

Estudio Piloto: Entrevista a las familias

1. Me puedes contar paso a paso cómo hicieron las actividades
2. ¿Cómo se diferencian las actividades que hicieron en Hyperlocal de las actividades de la escuela?
3. ¿Cómo tomaron decisiones acerca de las actividades? ¿Me puedes dar un ejemplo? ¿Quién tomaba las decisiones?
4. ¿Quién manejó el aparatito? ¿Encontraste dificultad en usar el aparatito? ¿Cómo solucionaste el problema?
5. ¿Qué aprendiste del uso de la tecnología en tu vida?
6. ¿Hasta qué grado de la escuela estudiaste?
7. ¿Qué hiciste con los productos que creaste?
8. ¿Cómo te pueden ayudar las actividades que realizaste en un futuro?
9. Después de esta experiencia, ¿qué te gustaría hacer a continuación?
10. ¿Qué podríamos hacer mejor en un próximo proyecto?

Appendix B.2: Semi structured interviews project team

Estudio Piloto: Entrevista para equipo del proyecto

1. ¿Por qué elegiste hacer una tecnología con las tres secciones de Descubre, Comparte y Comparte más? ¿Cuál era el propósito de cada uno de ellos?
2. ¿Qué quería que lograra la comunidad con el proyecto?
3. ¿Por qué eligió un contexto no formal para este proyecto?
4. ¿Fue su intención para este proyecto promover las habilidades de pensamiento crítico? Alternativamente, ¿cuál fue su principal intención para los participantes a través de este proyecto? (¿Crees que las actividades fueron fuente de pensamiento crítico en la Red Hiperlocal de Aprendizaje La Campana-Altamira?)
5. ¿Usó la comunidad la tecnología como esperaba? -¿Qué descubriste?
6. ¿Qué crees que descubrieron los participantes con el uso de la tecnología?
7. ¿Qué mejoras le harías a la tecnología?
8. ¿Qué papel crees que debería jugar la tecnología en la vida cotidiana de los participantes? (Su pensamiento sobre el papel de la tecnología)
9. ¿Qué papel cree que jugó cada uno de los participantes del proyecto de investigación?
10. ¿Cuál es su visión de la división del trabajo establecida en este proyecto?
11. ¿En qué medida un marco multicultural de participación entre México y el Reino Unido fue útil o no para este proyecto?
12. ¿Tiene algún comentario sobre mi participación en este proyecto?

Appendix B.3: field notes families

For the visits made to participants, I created a list of considerations when writing my field notes.

Estudio Piloto: Aspectos para tomar en cuenta en las visitas con las familias

1. Procedimientos de seguridad
2. Observar, tomar notas
3. Crear una relación con los participantes
4. Obtener su información de contacto
5. Comprender las conexiones entre ellos
6. Entender lo que es importante para ellos
7. Comprender su motivación para estar en el proyecto
8. Apreciar sus historias, sus esfuerzos
9. Celebrar sus vidas y proyectos futuros
10. Crear una reflexión

Appendix B.4: field notes teammates

For the meetings I had with my research teammates, I created a list of considerations when writing my field notes.

Estudio Piloto: Aspectos para tomar en cuenta en el trabajo con el equipo del proyecto

1. ¿Qué debates surgieron?
2. ¿Cómo se hizo el trabajo en equipo?
¿Qué áreas de oportunidad se construyeron?

Appendix B.5: journal

Estudio Piloto: Aspectos para tomar en cuenta para el diario

1. ¿Qué papel jugué en el proyecto?
2. ¿Cuál era mi expectativa sobre mi trabajo vs la realidad?
3. ¿Cómo impactó mi rol como miembro del equipo en el proyecto?
4. ¿Qué aprendí?
5. ¿Cuáles son algunas áreas de oportunidad?
6. ¿Qué podría hacer mejor?

Appendix C: Pilot study - Ethical Forms

Appendix C.1: for Parents that participated in the Hyperlocal project

Estudio Piloto: Consentimiento informado para adultos

Mi nombre es Lay-Wah Carolina Ching Chiang, soy estudiante del programa de Doctorado en Innovación Educativa del Tecnológico de Monterrey. Como parte de mi programa me encuentro realizando un estudio piloto para mi disertación titulada *"Prácticas educativas dialógicas: Casos de estudio en contextos no formales"*. Por tal razón, me gustaría invitarte a ser parte de mi estudio. Tu experiencia en el proyecto Hyperlocal Learning Network La Campana-Altamira es de mi interés.

A través de mi estudio quiero conocer el impacto que dicho programa ha tenido para ti y tu familia. Este proyecto de investigación ha sido revisado y ha sido aprobado por Dr. Juan Manuel Fernández. En caso de cualquier duda lo puedes contactar a través del correo j.m.fernandez@tec.mx.

Por favor señale si está de acuerdo o en desacuerdo colocando un visto en el recuadro.

	Sí	No
Se me ha leído la información del estudio de fecha [24/06/2021]. He sido capaz de preguntar sobre el estudio y mis preguntas han sido respondidas con satisfacción.	□	□
Consiento voluntariamente a ser un participante en este estudio y entender que puedo rechazar el dar respuesta a pregunta y que puedo retirarme del estudio en cualquier momento sin tener que dar razones, siempre y cuando esto sea antes de que la información se haya anonimizado.	□	□
Entiendo que formar parte de este estudio implicó tomar parte en actividades de creación creativa y compartir los resultados y la percepción de las actividades con otras familias usando un teléfono inteligente y la red de aprendizaje Hyperlocal al menos 4 veces durante el periodo del proyecto.	□	□
Entiendo que formar parte del estudio implica responder a solicitudes breves de retroalimentación usando mensajería instantánea, como WhatsApp, y una entrevista audio grabada por teléfono.	□	□
Estoy de acuerdo con que se tomen notas de campo de mis actividades.	□	□
Estoy de acuerdo con la grabación y almacenamiento de mis breves retroalimentaciones (enviadas por mensajería instantánea) en un archivo de registro.	□	□
Estoy de acuerdo con la grabación y almacenamiento de mis interacciones con la Raspberry Pi en un archivo de registro.	□	□
Estoy de acuerdo con la grabación de audio y transcripción de la entrevista	□	□
Entiendo que la información proveída será utilizada en talleres, reportes, publicaciones y en la página web del proyecto.	□	□
Entiendo que la información personal recolectada sobre mí que permita identificarme, como nombre o donde vivo, no serán compartidos más allá del equipo mexicano de investigación.	□	□
Entiendo que la información anonimizada será almacenada en una carpeta compartida	□	□

protegida por 5 años [28/03/2026] después de los cuales la información será destruida.	
Estoy de acuerdo con que mi información sea citada en los resultados de la investigación.	□ □
Estoy de acuerdo con los derechos de autor conjuntos de los resultados de las actividades de creación con el investigador principal.	□ □

Nombre completo: _____
Firma: _____ Fecha: _____

_____

Appendix C.2: For Children that participated in the Hyperlocal project

Estudio Piloto: Consentimiento informado para niños

Lee cada enunciado y dibuja una carita en el recuadro de la derecha si estás de acuerdo.

Escuché y entendí la información sobre el estudio de la maestra Lay	
Estoy dispuesto a compartir mis aprendizajes del proyecto Hyperlocal para el estudio de la maestra Lay	
Estoy dispuesto a compartir fotos de mis actividades con otras familias	
Estoy dispuesto a que se grabe mi voz	
Estoy dispuesto a que se me tomen fotos y que estas sean publicadas	
Estoy dispuesto a que se compartan mis aprendizajes del proyecto Hyperlocal	
Nombre del participante en mayúsculas	
Fecha	

Soy testigo de que el formulario de consentimiento fue leído claramente al participante y este tuvo la oportunidad de aclarar todas sus dudas. Yo confirmo que el participante dio su consentimiento sin coerción.

Nombre del Representante: _____
_____
Fecha: _____

Appendix C.3: For the project team

Estudio Piloto: Consentimiento informado para equipo del proyecto

Mi nombre es Lay-Wah Carolina Ching Chiang, soy estudiante del programa de Doctorado en Innovación Educativa del Tecnológico de Monterrey. Como parte de mi programa, estoy realizando un estudio piloto para mi disertación titulada "Prácticas educativas dialógicas: estudios de casos en contextos no formales". El estudio piloto tiene como objetivo aumentar la probabilidad de éxito en el estudio principal al probar los instrumentos de recopilación de datos y también la estrategia de análisis.

Me interesa tu experiencia en el proyecto Red Hiperlocal de Aprendizaje La Campana-Altamira. A través de mi estudio piloto quiero saber el impacto que ha tenido el proyecto Hiperlocal para ti, la comunidad y para mí. Por esta razón, me gustaría invitarte a ser parte de mi estudio.

Si decides aceptar esta invitación, tu participación consistirá básicamente en compartir conmigo tu experiencia en el proyecto Hiperlocal a través de una entrevista semiestructurada que me permitirá triangular información para mis preguntas de investigación. Además, das tu consentimiento para la grabación de audio/video y la transcripción de la entrevista.

Toda la información obtenida en este estudio será estrictamente confidencial. La información recabada será protegida de tal forma que no se permita el acceso a personas ajenas al proyecto. Si se publican los resultados de este estudio, los resultados solo contendrán información global de todos los participantes.

Tu participación en este estudio es voluntaria y de ninguna manera afectará las relaciones con tu institución. Si decides participar ahora, pero luego deseas cancelar tu participación, puedes hacerlo cuando quieras sin ningún problema.

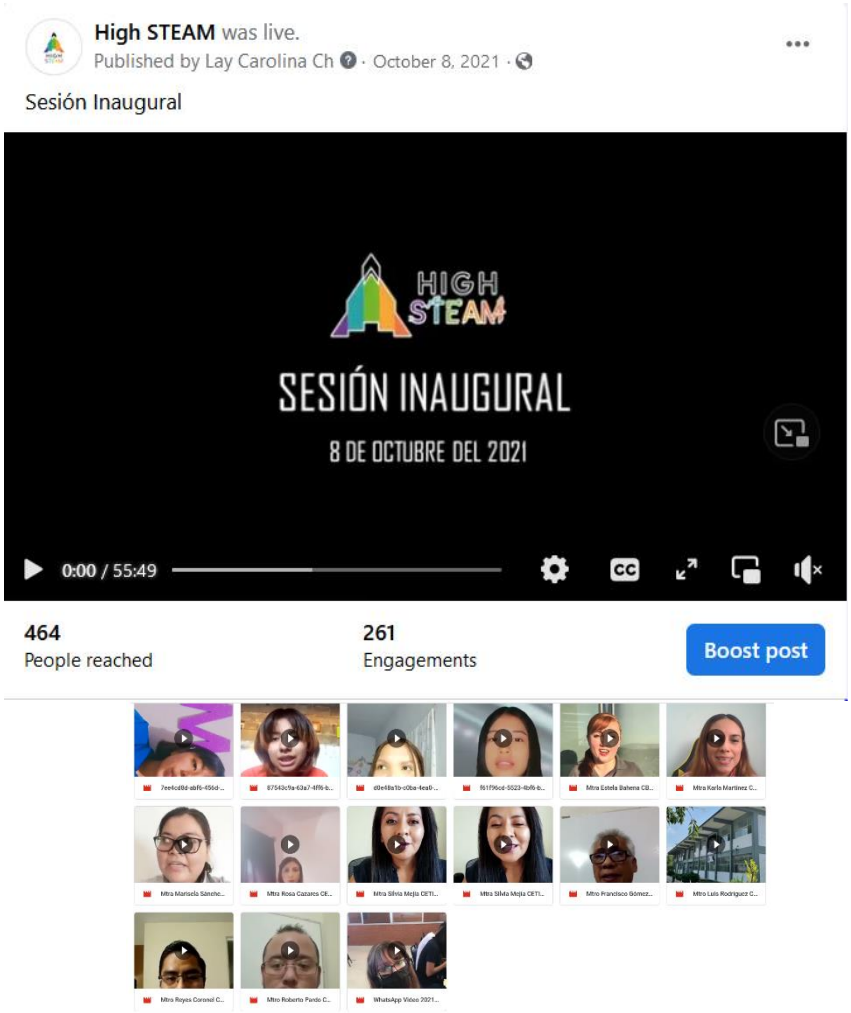
Si tiene alguna pregunta, por favor pregunte. Si tienes alguna pregunta que quiera hacer más tarde, estaré encantada de responderla. En este último caso, puedes comunicarte conmigo o con mi asesor a [Lay Wah Ching: A01683423@itesm.mx, o al Dr. Juan Manuel Fernández: j.m.fernandez@tec.mx].

Si decides participar en este estudio, por favor firma tu nombre y fecha al pie de este formulario, como una forma de expresar su aceptación y consentimiento a lo aquí estipulado.

Nombre: _____
Fecha: _____

Appendix D: Main Study – STEAM Sessions Design

Appendix D.1: Opening Ceremony

HIGH STEAM SESSION # 1	
	
I. INFORMATIVE DATA	
Unit: [1] Astronomy	**Lesson:** [1] Welcoming ceremony
Objective: Welcome participants and explain the units' dynamics	
II. MATERIALS *List all the materials that students will need for the session*	
• Mobile or computer to access the Facebook Live and zoom meeting	

III. STEAM CONTENT

Identify the STEAM Areas used during the session

- From the participants speeches, the connections to the different STEAM disciplines should be pointed out, as well as the program that will be implemented for High STEAM

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

The welcoming ceremony will be divided in two days:

Day 1: Scholarship opportunities (Zoom meeting)

1. Welcome by Dr. Juan Fernández
2. Garza Foundation opportunities for scholarships by Dr. Juan Fernández
3. Tecnologico de Monterrey program "Leaders of the future" Testimony
4. Question and Answers

Day 2: Welcoming speeches (Zoom meeting and Facebook live)

1. Welcome by Dr. Juan Fernández
2. The linking processes of the DGETI with science, technology, and art (Prof. Felipa Longoria, head of the DGETI State Office in Nuevo León)
3. The School of Humanities and Education, Dr. Roberto Dominguez (Associate Dean of Graduate programs, EHE, Tecnológico de Monterrey)
4. Research and social impact, Dr. Francisco Estrada (Associate Dean of Research, EHE, Tecnológico de Monterrey)
5. The agenda of the School of Humanities and Education (EHE) on issues of social justice and social innovation (Dr. Judith Aurora Ruiz, Dean of the EHE, Tecnológico de Monterrey)
6. Empowering communities through technology and education (Roger C. Rigaud, United States Consul in Monterrey)
7. Closing of the event

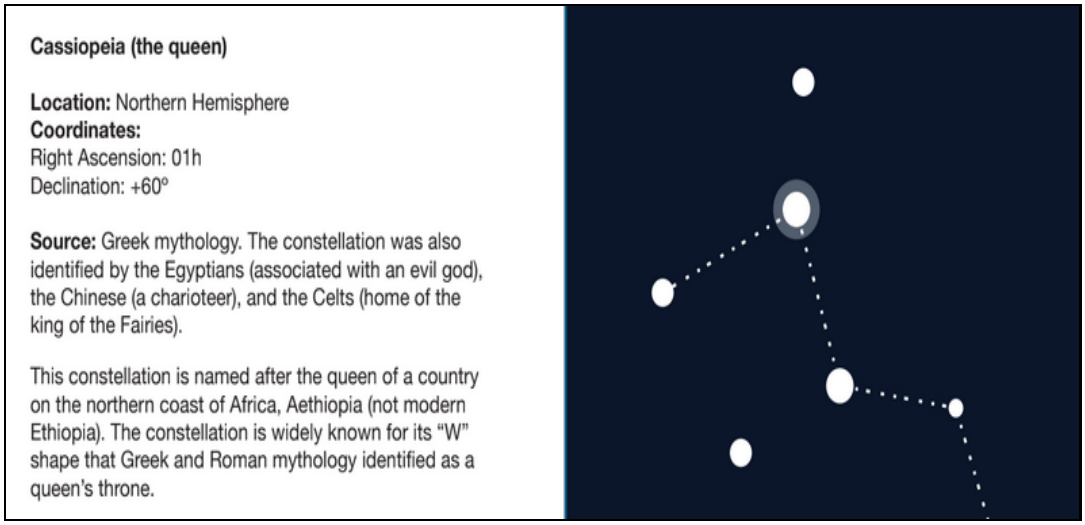
V. INDICATORS

List how an outsider can identify components of dialogue in the session

- Comments in Facebook Live
- Comments in Zoom
- Space for Questions and answers

Appendix D.2: Light the constellations

HIGH SEAM SESSION # 2



I. INFORMATIVE DATA

Unit: [1] Astronomy	**Lesson:** [2] "Light up the constellations"

Objective: Identify constellations and elements of outer space. Explore basic concepts of electricity

II. MATERIALS

List all the materials that students will need for the session

- CR1632 3V Coin Lithium Batteries 10 Pack
- Copper Conductive Adhesive Tape, 1/2" Width, 2.75 mil Thick, 36 yd Length, 3" Core
- Round Multicolour LED Light Emitting Diodes 2-pin LED Diffusers 3mm/5mm 200PCS
- ACCO P3415 Paper Clips, Holds Up to 35 Sheets, 50 mm, 100 Clips
- Legal Copy (Colour, 100-499 SHEETS) NASA Images of exploding stars/pulsars/neutron stars

III. STEAM CONTENT

Identify the STEAM Areas used during the session

- Sciences: Knowledge of the cosmos, bases of Astronomy
- Technology: Managing elements to build an electrical circuit
- Engineering: Basics of electricity, voltage, current, resistance.

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Synchronous Session

- Introduction (15 minutes): Without anticipation, give ALL participants 10 minutes to dress up as astronauts and select 3 items to take with them on the mission. The remaining 5 minutes will simulate a take-off: https://www.youtube.com/watch?v=5GrPwHrc3HI
- Developing (10 minutes): Introduction: What do you see in space? Present images of: Planets, Galaxies, Black Holes, etc. (Generate conversation about your observations). Constellation theme (Old constellation maps may be presented; ancient observations to the present day). Have you seen any constellations? (40 min) Development of activity "Illuminate the constellations". While developing, talk about electrical circuits: Ohm's Law
- Closing: Sample of your lit constellation (Upload evidence to TEAMS), Constellations in the sky with program: https://skyandtelescope.org/interactive-sky-chart/

Asynchronous Session

- Construction of your galaxy (Upload evidence to TEAMS)
- Closing questions:

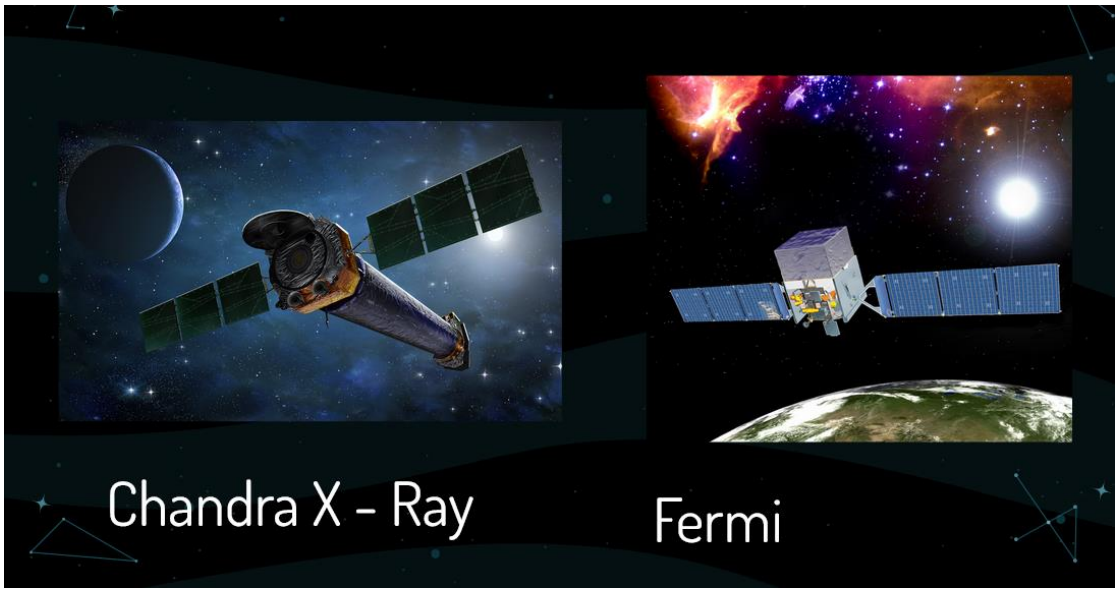
V. INDICATORS

List how an outsider can identify components of dialogue in the session

- Dialogic space: Historicity
- Meaningful and rewarding experiences: Motivation to learn, Connecting with the future

Appendix D.3: Satellite

HIGH STEAM SESSION # 3



I.INFORMATIVE DATA

Unit: [1] Astronomy	**Lesson:** [3] Satellites

Objective: Understand the functions of an artificial satellite

Based on: https://science.nasa.gov/astrophysics/universe-spacecraft-paper-models/

II. MATERIALS

List all the materials that students will need for the session

- Impressions for Gravity Probe B
- Impressions for Chandra X-Ray Telescope
- Scissors, cutter
- White School Glue
- Scotch tape
- Ruler
- Nail
- Colours blue, gold, black
- Wooden sticks, metal hook, wire

III. STEAM CONTENT

Identify the STEAM Areas used during the session

- Sciences: Astronomy
- Technology: 3D models about El Niño and La Niña
- Engineering: Artificial satellites
- Art: paper modelling

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction: 10 minutes

The class begins with the teacher asking the students if they have the necessary materials for the class. After reviewing the materials, return to the discussion about the items in the space. While the elements are taken up again, the teacher asks what elements there are in space that man has put there, thus introducing the discussion about artificial satellites.

Have you heard of some?

What are they for?

How many satellites could there be?

The teacher gives the basic information to the students about how many there are, the most important ones and their important parts.

Development: 60 minutes

First section: Students will investigate the satellite assigned to them 30 minutes maximum

The teacher divides the group into two teams, one to investigate and make the Gravity Probe B model and the other to make the Chandra X-Ray Telescope model. In teams they will make a small presentation about their satellite:

Who developed it? (Institution, University, Country)

What is your function?

To make this presentation, the teams are sent to Breakout Rooms

15 minutes

At the end of the 15 minutes, the teams return and present their satellite data to the class.

Next comes the heaviest part, doing the modelling. 40 minutes

Explain the instructions: follow the instructions as a group so that each student has their own model of the satellite. The teacher finally sends the instructions to the chat and once the students have downloaded them, he sends the teams to two Breakout rooms. The objective of this section is that the students within the work teams can solve any inconvenience that may arise during the assembly of the satellite. The teacher spends a few minutes in one Breakout room, and switches to the other, and so on. As the students build the model, the teacher asks questions such as:

How would you explain to someone what a satellite is?

What functions does an artificial satellite have?

What is the country with the most satellites?

Eventually, the students will not finish the model since it is a complicated job.

Closing: 5 minutes
The closure is noticeably short since the activity is a bit heavy. But the teacher will give the instructions for the previous activity.

Post-session: 10 minutes
Upload a photo of the finished model, or as advanced as possible, students can also make the opposite model to their team.
Take a photo of the model and make a small written reflection answering the questions:
What elements of my daily life use satellites?
Of all the functions that the different artificial satellites have, which one catches my attention the most? Why?

V. INDICATORS

List how an outsider can identify components of dialogue in the session

In transformative learning the student:

- The student picks up experience from the last session during the introduction of the session
- The student creates awareness about satellites and their use in everyday life
- Seeks to build an individual meaning during the final reflection
- There is an open space not controlled by the teacher where the students support each other to solve the problem: assemble the satellite

Regarding dialogic learning:

- The students externalized information about their satellites to the class
- It is intended that students can internalize knowledge from their point of view, during the teacher's questions in the breakout room and final reflection
- Students' voices are empowered during the satellite presentation
- Historicity: return to concepts from the last session about what makes the space, class begins with experience of the students

Appendix D.4: Art and cosmic connections

HIGH STEAM SESSION # 4

I.INFORMATIVE DATA

Unit: [1] Astronomy	**Lesson:** [4] Art and cosmic connection

Objective: Using the elements of art - shape, line, colour, texture, value - students make sense of images of planets, asteroids, comets, and moons, honing their observation skills and inspiring questions.

Based on: https://www.jpl.nasa.gov/edu/teach/activity/art-the-cosmic-connection/

II. MATERIALS

List all the materials that students will need for the session

- Notebook Canson 100
- Block DoArts Pro Drawing 200gr 14.8x21cm
- Watercolours
- Pencil

III. STEAM CONTENT

Identify the STEAM Areas used during the session

- Science (The universe) and art (Watercolours)

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction (15 minutes)
Conduct a survey among the students about the general knowledge learned in the previous modules. Then the teacher will have the students search for images on the internet whether they are satellites, constellations, universes, planets, etc. Students will present their choices in front of a couple in group sessions and then the teacher will randomly pick four people to present in front of the whole class.

Development (70 minutes) 10 min to explain the activity
The teacher will give the instructions to conduct the activity of painting the images that the students chose. Where the students will use watercolours, pencils, and sketchbooks to recreate the images they obtained from the internet. They will be able to make representations of the space if they consider it pertinent and their capacities.

Closing (20 minutes)
Students will present their works of art made in the time allowed by the teacher. After the presentations of 5-6 students, if there are no more volunteers, the activity and the session will be closed.

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Student participation
Images brought by the students
Students who have submitted their drawings

Appendix D.5: Monitoring our changing world

HIGH STEAM SESSION # 5

I. INFORMATIVE DATA

Unit: [2] Environment	**Lesson:** [5] Monitoring our changing world

Objective: Explore how and why scientists monitor birds and how it relates to citizen science projects like eBird.
Set the stage for discussions about birds as bioindicators in an ecosystem

Based on: https://dl.allaboutbirds.org/ebird-9-12?__hstc=161696355.f961c959a2869ead05dcabd50e8a833f.1615442942233.1615442942233.1615442942233.1&__hssc=161696355.1.1615442942234&__hsfp=1520541778#_ga=2.218381401.1795939320.1615442941-185213099.1615442941

II. MATERIALS

List all the materials that students will need for the session

- 1 Professional notebook 100 sheets
- Material for writing and drawing in the notebook:
- Pencil
- Rubber
- Pencil sharpener

- Feathers
- Colours
- Markers

III. STEAM CONTENT

Identify the STEAM Areas used during the session

Sciences: Recognize the human impact on the environment, design and evaluate possible solutions to reduce the impact of man on the environment, cite specific textual evidence to support analysis of issues

Art: Creative writing, participation in collaborative discussions, possibility to express yourself verbally through video.

Math: Recognize and analyze problems, construct viable arguments, and analyze arguments of others

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction: 20 minutes

The teacher begins the session with a brief discussion of what is heard when the Sun rises and sets.

What is the first thing you hear when the Sun begins to rise?

When they pass under a tree in the morning or in the afternoon/evening, what is there?

The discussion aims to start having a recognition of the birds in the environment. No more than 5 minutes, it is just a warmup.

After that, the group is divided into pairs and trios, depending on the number of students. The activity will be as follows: a student will describe a bird to his partner so that he can draw it. Assuming it is a couple, one student is sent to the Breakout room and the other stays with the teacher to see the images of the bird in question: Cassowary. After seeing them, the student who stayed in the main room joins the other to discover the bird in question. While the other student is drawing, they should not show their modelling process to the describing partner. It is sought that based on previous knowledge; the drawing is the closest to reality.

After 10 minutes they return to the main room and the teacher asks those who drew to show their work. The discussion about the similarities of the drawings with the real bird is created. The teacher mentions the characteristics of the bird and that it is found in Australia and New Zealand. It introduces the question of which are the most common birds in Monterrey. Participation of the class in contributing with birds or bird names.

Development: 60 minutes

The group splits into two, reading about the crane and reading about pigeons, I think. The reading will be 15 minutes, in teams or individually. It is recommended that notes be taken on important points.

At the end of the 15 minutes both teams return, and the next instruction goes, return to the teams, and discuss the reading so that the important concepts are safe. Guiding questions for team discussion:
What human actions affected the bird population?
What was lifelike for birds before human actions?
What actions did the human try to do to repair his damage?

Upon returning from the teams, rooms are made with the two mixed teams so that they share the readings. The teacher goes to the rooms to supervise the discussion of the groups of students.
What are you looking for among the teams?
compare the stories
find common ground
Discuss how the events of the story happened.

The teacher collects information that the students were saying in the discussions and highlights some information or hard concepts.

The teacher introduces the concept of bioindicator. Here is the problem. How do scientists analyze birds to investigate the environment? How have humans affected bird populations? What actions can we take to help scientists, birds, and the environment? For the last question, introduce the eBird platform.

Closing: 10 minutes
To conclude, the teacher acknowledges and recapitulates the students' ideas. Mention name works. Example: As STUDENT A said, birds help scientists to know what is happening in the environment. And give the instructions for the subsequent activity.

Post-session: 10 minutes
Through Teams, send a reflection on how birds are bioindicators and what humans do to affect them and how to form a commitment to the environment. The reflection is in a free format, video, writing, drawing, comic.
Drawing: large and that the elements can be appreciated
Comic: 2 sheets
Video: 3 minutes minimum
Written: 150-200 words

V. INDICATORS

List how an outsider can identify components of dialogue in the session

In transformative learning the student:
Prior knowledge is applied in the description of and modelling of the Cassowary
Recognizes new possibilities in common things: birds and actions to preserve the environment
Internalizes a commitment to caring for the environment
Space for reflection of activity and learning

Regarding dialogic learning:
Student voice recognition
Collect the thoughts and opinions of the students
Students share knowledge between the two teams
The teacher is a guide with questions that encourage students to participate
Students have different options to express themselves
Plurality: different things that are done at home to take care of the environment
Sequentially: when there is the description of the Cassowary, there is a follow-up of the idea that ends up represented in the drawing

Appendix D.6: Oceanography in a cup

HIGH STEAM SESSION # 6	
	
I.INFORMATIVE DATA	
Unit: [2] Environment	**Lesson:** [6] Oceanography in a cup
Objective: Understand how foam forms in the oceans, density, and the effect of wind-driven waves	
Based on: https://www.noaa.gov/education/photos-images/oceanography-in-mug	
II. MATERIALS *List all the materials that students will need for the session*	
• 1 litter of milk • chocolate powder • A large glass cup or some glass container, it must be transparent to observe the phenomenon The milk will be used for: • Warm chocolate milk, almost warm • Hot milk Optional: • instant coffee • hot water for coffee	
III. STEAM CONTENT	

Identify the STEAM Areas used during the session

Sciences: Oceanography, Density, upwelling, Proteins, sea foam, plankton
Technology: 3D models about El Niño and La Niña
Art: Gastronomy

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction: 10 minutes

A little music that would normally be heard on a beach and as the students would arrive in class, they could request some songs. The music can stay for the rest of the class, but, if necessary, it is removed.

The person in front of the group starts the discussion by asking if any of the students have been to visit the beach. Here the discussion is more open and less controlled. The teacher can tell his own experience to motivate students to participate.

Questions:

How was the water on the beach?

It was very windy?

Did you see foam?

Did you feel cold below the body, but warm above?

Development: 60 minutes

Since there are more materials, and the preparation time would take a lot of the class, only two of the experiments that have the requested materials will be done. The other two concepts will be explained with multimedia.

Density: 10 minutes

The concept of density is demonstrated with practice in the cup. The teacher ensures that they have the materials at the right temperatures. Once the materials are ready, the teacher gives the floor to a volunteer student to read the instructions and together they guide the group.

The experiment itself is short, but it has a few small intervals in which the liquids must settle. During these intervals, the teacher first explains the concept of density and guides the students to relate what happens in the cup to what happens in the ocean. The concept of "thermocline" is introduced, its relationship with La Niña and El Niño example: if you were to stick your finger in the drink, you would feel hot milk, a “transition” zone, and less hot chocolate

Upwelling or outcrop: 10 minutes

Once the concept of density is finished. The second part of the experiment comes to show the "upwelling". As the students begin to blow, the teacher explains that the same thing happens on large scales in the ocean and lakes.

Sea foam: 10 minutes

Finally comes the latest concept of sea foam. Guide students to the answers: Proteins break down and the molecules can trap air, forming the foam

What happens to a sugar cube when it crumbles?
What nutrients does milk have?
What happens to those nutrients when milk is shaken?
Where could the proteins of the sea come from? What organisms could there be?
What churns the sea that causes proteins to break down?

Closing: 10 minutes
At the end of the session, a 15-question Kahoot will be asked with the key concepts.

Post-session: 10 minutes
Send an email with the photos of the activity and a reflection that answers the following questions.
What did I think about the experiments?
Did you spark any particular interest?
What lessons am I left with?

V. INDICATORS

List how an outsider can identify components of dialogue in the session

In transformative learning the student:

- With past experiences, build new concepts. Past experience: visit to the beach, learning about what happens on the beach in future visits; related to conviction
- Internalize concept of density for future experiences
- Analyze events to find answers, exploration of upwelling in the ocean
- Space for reflection on activity and learning

Regarding dialogic learning:

- Class begins with the experience of the students
- Seeks to create the feeling of home with the use of music
- Reflective questions to seek discussion on some topics

Appendix D.7: Eco-audit

HIGH STEAM SESSION # 7	
	
.INFORMATIVE DATA	
Unit: [2] Environment	**Lesson:** [7] Eco-audit
Objective: Raise awareness about the use of resources and determine the impact of decisions	
Based on: https://drive.google.com/file/d/1n_irovB5F68_1R0AIo1N6kBGcENryWzB/view?usp=sharing	
II. MATERIALS *List all the materials that students will need for the session*	
• Worksheets • Colours • Pencils	
III. STEAM CONTENT *Identify the STEAM Areas used during the session*	
Technology: Prototype that applies technology at your fingertips. Engineering: Prototype Design Mathematics: Calculation of daily, weekly, and annual consumption. Answer: How	

many litters of water does my family use per day, per week, per year?

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction

Asynchronous
In TEAMS:
Discussion about water consumption
Fill in the first three columns of the table “Personal Water Eco-Audit Data Collection”

Developing

Presentation with analysis of drought, shortages, SDG 6
Fill in the last three columns and get the total litters.
Share a survey* where they place sex, and total consumption.
Observe the graph.
With the recycled leaves they will generate a drawing, model, mock-up about an idea that can be implemented in your home to save water and make others aware of its care. (20 minutes)

Closing

Final thoughts
In Teams, post a photo of your prototype.

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Dialogic space | Historicity, Positioning
Cooperation | Willingness to find solutions to problems
Meaningful and rewarding experiences | connecting to the future

Appendix D.8: Climate change

HIGH STEAM SESSION # 8	
	
I.INFORMATIVE DATA	
Unit: [2] Environment	**Lesson:** [8] Climate change
Objective: Express their thoughts on climate change through music and design a poster that represents the song they created	
Based on: https://www.nytimes.com/interactive/2020/05/21/climate/songs-about-climate-change.html	
II. MATERIALS *List all the materials that students will need for the session*	
• Computer	
III. STEAM CONTENT *Identify the STEAM Areas used during the session*	
Science: Research on concepts and context of Global Warming Technology: Use of sound bases for composition Art: Song writing	
IV. SESSION SEQUENCE *List all the steps that teachers need to follow to develop the session*	

Introduction
Place the following resources in Teams:
choose two videos
https://www.youtube.com/watch?v=8UqBuUSn3hY
https://www.youtube.com/watch?v=tMwFNMfjFuU
https://www.youtube.com/watch?v=HufPb_j7UE4

Explore NASA Earth Science Division page
https://earthobservatory.nasa.gov/world-of-change

Specific songs to listen to:
before the flood
Full playlist on Spotify:
https://open.spotify.com/playlist/4VcE7DJu4Lz7oLfWNw1YZU?si=7c39da6abd0e405f
https://www.youtube.com/watch?v=VeX2T2IP0_I
Minutes:
Dust Bowl: 8:05
The Melting Pot: 31:26
After the flood: 33:33

Smash Mouth- All Star https://www.youtube.com/watch?v=N2QxDxzMGa8
Billie Ellish- All the good girls go to hell https://www.youtube.com/watch?v=-PZsSWwc9xA

In the same conversation in TEAMS, each student will post a brief reflection of 50 words related to the material seen. In addition, you will make a list of 10 keywords on the topic "Global Warming"

Developing
In the zoom session:
The facilitator will introduce the topic of the session by presenting the following:
Data and statistics of problems related to global warming
Pick up songs from [The New York Times "The Climate "Hot 10 songs""];
documentary soundtrack “Before the flood”. Emphasize the message
Dialogue on key messages of songs (hope, conscience, sadness)
Basic elements of a song [melody, rhythm, harmony]
Maximum presentation time 30 minutes
After presenting the data (brief 1-2 slides), share Mentimeter code, in which students will type the 10 keywords. At the end, the objective is discussed: Compose a song with the theme of the session and make a poster.
The presentation continues, with an analysis of some Top 10 songs and the Before the Flood soundtrack. Open conversation.
Explain basic elements of a song.
Form teams. Open random breakout rooms.
In the rest of the session, they will have to compose a song.

Closing
After the session:
Publish your audio on TEAMS accompanied by a flyer explaining your song. 1 per team

V. INDICATORS
List how an outsider can identify components of dialogue in the session

Dialogic space | Historicity, Positioning
Cooperation | Facilitate group discussion, Openness to new ideas on how to proceed
Meaningful and rewarding experiences | Connect Hobbies to Manufacturing

Appendix D.9: Jelly that glows

HIGH STEAM SESSION # 9	
	
I.INFORMATIVE DATA	
Unit: [3] Gastronomy and Chemistry	**Lesson:** [9] Jelly that glows
Objective: Apply chemistry concepts in the kitchen	
Based on: https://www.instructables.com/Glow-in-the-Dark-Jello/	
II. MATERIALS *List all the materials that students will need for the session*	
• Tonic water • Jelly powder • Silicon mould • UV light	
III. STEAM CONTENT *Identify the STEAM Areas used during the session*	
Science: Fluorescence Concept Technology: Preparation and use of lamp	
IV. SESSION SEQUENCE *List all the steps that teachers need to follow to develop the session*	

Introduction
Start the class with the concept.
That? What have I heard? What have I seen?
Use presentations to deepen the topic.

Developing
Make the demo based on the league: https://www.instructables.com/Glow-in-the-Dark-Jello/
The student will oversee doing the activity at home and will encourage the young people to do it asynchronously, later the creation of WhatsApp groups is proposed with each group where these students send the photos of their activities, and each SS student uploads them to TEAMS as evidence.
Guide the activity through the inquiry methodology

Closing
Close the activity; show jelly to the refrigerator.
Conclude with what will happen.
What can you do with a jelly lamp? What problem can you solve?

In TEAMS place photos of your lamps and observations.

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Dialogic space | Historicity
Cooperation | Facilitate group discussion
Meaningful and rewarding experiences | Learning

Appendix D.10: Greasy chips

HIGH STEAM SESSION # 10

I. INFORMATIVE DATA

Unit: [3] Gastronomy and Chemistry	**Lesson:** [10] Greasy Potatoes

Objective: Create awareness of the concepts of fat, calories, and estimations through the comparison of the oiliness of several varieties of French fries

Based on: https://www.sciencebuddies.org/science-fair-projects/project-ideas/FoodSci_p048/cooking-food-science/how-greasy-are-your-potato-chips#background

II. MATERIALS

List all the materials that students will need for the session

- Tape
- Chips
- Graph Paper Bond
- Worksheets

III. STEAM CONTENT

Identify the STEAM Areas used during the session

Sciences: The study consists of experimenting with the fat of a variety of potatoes through a measured and observed process.
Technology: lucidpark, canvas
Math: Measuring the amount of fat that is detected in each attempt.

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction 15 min (10 min)
Begin by introducing the topic to the students, mentioning the objective of the class and the activities that follow (Intro is in the prompts). After doing so, enter Lucid Spark, the student will have the opportunity to answer each question by adding a stickynote. Between questions, discuss and encourage students to share responses.
Intro Questions

Development 45 min
Open the presentation and demonstrate the activity that will be done during the class, demonstrating the importance and why they will be doing the activity. Do the project with them, step by step
activity instructions
Exercise
Change all the links to oneself to speed up access:
https://docs.google.com/document/d/1SIixBxvr7O5Esv4-AaTiB5IuJrr6iqNFuZ9WaTwjNiY/edit?usp=sharing

Closing 15 min 10 min
In closing, encourage students to reflect on the activity they have done in class and how they can improve, as well as what they think they have done well.

V. INDICATORS

List how an outsider can identify components of dialogue in the session

- Start the class by answering the questions that will be seen in the Lucidspark
- Encourage students to participate and discuss what they answered in the first activity at the beginning
- Show instruction video
- Conduct the activity together with the students, step by step
- After the first attempt, pause and ask how the students feel.
- Discuss the first findings and continue with the second test
- Do this repetitively until you finish each potato and try
- At the end of the activity, comment on the general findings
- Conduct individual reflection and self-assessment
- Comment on reflection

Appendix D.11: Do it like Pollock

HIGH STEAM SESSION # 11	
	
I.INFORMATIVE DATA	
Unit: [3] Gastronomy and Chemistry	**Lesson:** [11] Do it like Pollock
Objective: Create a safe space for the expression and development of creativity, an opportunity that can be turned into business	
Based on: https://www.scienceofcooking.com/chocolate/science-of-chocolate.htm https://www.tate.org.uk/kids/make/paint-draw/make-chocolate-painting	
II. MATERIALS *List all the materials that students will need for the session*	
• Inspireka Pinta Frut pen or similar	
III. STEAM CONTENT *Identify the STEAM Areas used during the session*	
Art: Jackson Pollock and his works, abstract expressionism, a new form of expression	
IV. SESSION SEQUENCE *List all the steps that teachers need to follow to develop the session*	

Introduction: 5 minutes
Then it presents an image of the work Number 23 and Yellow islands by Jackson Pollock. Here begin the teacher's questions to the students:
Have you seen this painting?
What do you think it represents?
Do you know the author?
From what era could it be?
Could it be art?
Is art good business?

Link for more information: https://www.unprofesor.com/ciencias-sociales/jackson-pollock-obras-mas-importantes-4589.html
Link for more information about the location of Jackson Pollock's works: https://www.viveusa.mx/destinos/10-museos-que-honran-jackson-pollock

Development: 25 minutes
Video talking about Jackson Pollock 5 minutes: Pollock and abstract expressionism
Facts to highlight about Pollock, Abstract Expressionism and Business: 3 minutes
Activity: Video showing the technique Pollock used and which will be replicated during the activity: Jackson Pollock Action Painting
Place the wafer as if it were the canvas
With the Caramel, paint like Jackson Pollock
Keep in mind, what are the feelings that you want to represent in the work
Do you think it serves to be able to truly express emotions?
What is abstract for you?
What could Pollock have expressed?
How different is abstract expressionism from verbal expression?
What is abstract for you?

Closing: 10 minutes
To end the session, the teacher makes a list of art and business and gives the instructions for the post-class reflection activity.
Clarifies doubts and dismisses the group.

Post-session: 10 minutes
Through Whatsapp, the students will record a video in which they will show their work of chocolate art and answer the following questions:
What feeling or feelings does your work express?
Do you think people would be willing to buy your work? What would be the price you would put on it?
The next time you must express your feelings, would you do it with some abstract expressionism technique? Cause Yes or not?

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Transformative learning:

- Recognize art as a form of expression
- Knowledge of the past about the works of Jackson Pollock starts the discussion
- Applying the idea of abstract expressionism to chocolate painting
- Final reflection that seeks to create awareness about the expression of feelings and a business possibility

Dialogic learning:

- The teacher is a guide so that the two sections of students share the knowledge acquired in the previous activity.
- During discussions, students take on a greater role as the voice of the class
- Inviting potential learners who do not communicate enough through targeted questions to participate
- Students internalize knowledge from previous activity to be able to express it in their own words

Appendix D.12: My digital footprint

HIGH STEAM SESSION # 12

I. INFORMATIVE DATA

Unit: [4] Digital Literacy	**Lesson:** [12] Digital footprint

Objective: Raise awareness of the individual digital footprint (favourite apps, websites visited, messages sent, videos downloaded, pictures uploaded, music downloaded, games plated, comments posted) and how businesses use that information

Based on:
https://www.teachhub.com/technology-in-the-classroom/2019/10/technology-in-the-classroom-what-is-digital-literacy/
https://www.teacherspayteachers.com/Product/Computer-Digital-Citizenship-Digital-Footprint-2188504
https://www.commonsense.org/education/lesson-plans/whats-my-digital-footprint

II. MATERIALS

List all the materials that students will need for the session

- MDF 30x30cm
- Worksheets

III. STEAM CONTENT
Identify the STEAM Areas used during the session

Technology: Understand the impact that we can generate today with the behaviours that are reflected in social networks and learn to identify risk and benefit factors in social networks.

IV. SESSION SEQUENCE
List all the steps that teachers need to follow to develop the session

Introduction - 20 minutes
Begin with a brief introduction of the participants.
Ask the students for their preconceptions about the digital footprint (what is it? what is it for? what does it consist of?) and write it down on this board if the session is remote, otherwise, empty these ideas on sticky notes and stick them on a board, or, depositing them folded inside a box.
We will proceed to share these preconceptions aloud and comment on the findings.

Development - 55 minutes (total)
Explanation - 30 minutes
Proceed to explain with the presentation the meaning, implications, benefits, consequences, and usefulness of the fingerprint. Likewise, explain how behaviours in the different social networks are
Activity - 25 minutes
Distribute the following template and each student will fill it out individually.

Closing - 15 minutes
Discuss conclusions, reflections, findings and if, with the help of the session, it was possible to develop a short/medium/long-term action plan to improve with respect to the footprint they leave.

V. INDICATORS
List how an outsider can identify components of dialogue in the session

- Understanding the digital footprint in broad strokes and what it entails.
- Self-reflection on the matter to generate a change, impact, or transcendence with your digital footprint.
- Finished template.
- Proper verbal interpretation of the fingerprint

Appendix D.13: Microsoft Office and Power Point

HIGH STEAM SESSION # 13

I.INFORMATIVE DATA

Unit: [4] Digital Literacy	**Lesson:** [13] Microsoft Office and PowerPoint

Objective: Explore learning Microsoft office Word and PowerPoint intermediate level

Based on: https://support.microsoft.com/en-us/office/word-for-windows-training-7bcd85e6-2c3d-4c3c-a2a5-5ed8847eae73
https://support.microsoft.com/en-us/office/powerpoint-for-windows-training-40e8c930-cb0b-40d8-82c4-bd53d3398787

II. MATERIALS

List all the materials that students will need for the session

- Computer

III. STEAM CONTENT

Identify the STEAM Areas used during the session

Technology: By developing and adapting this new machination and landing of ideas within these softwares instead of resorting to traditional physical media; in addition to building their knowledge based on this digital methodology.

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction - 25 minutes

Introduce yourself to everyone

Subsequently, the teacher will briefly introduce what is possible to do in these softwares, this by way of introducing shapes, playing with figures, positioning, colors, formats, etc. Within this first phase, students will be asked if they were already familiar with these tools from some other software or these in particular; as well as their opinion about it and finally, ask on a scale of 1 to 5 how capable they feel of manipulating content in said programs. Compare responses to briefly discuss findings.

Development - 50 minutes

Proceed to a segmented explanation of the elements of the interfaces of both software, showing what each menu is for, what kind of information will be found to facilitate the objectives with the software. As a support resource, present some videos, if necessary, from these official Microsoft pages.

Next, conduct the activity included in said presentation.

Closing - 15 minutes

At the end of the dynamic activities, proceed to explain in a summary way what was seen in the session, without going into depth, just mentioning key aspects.

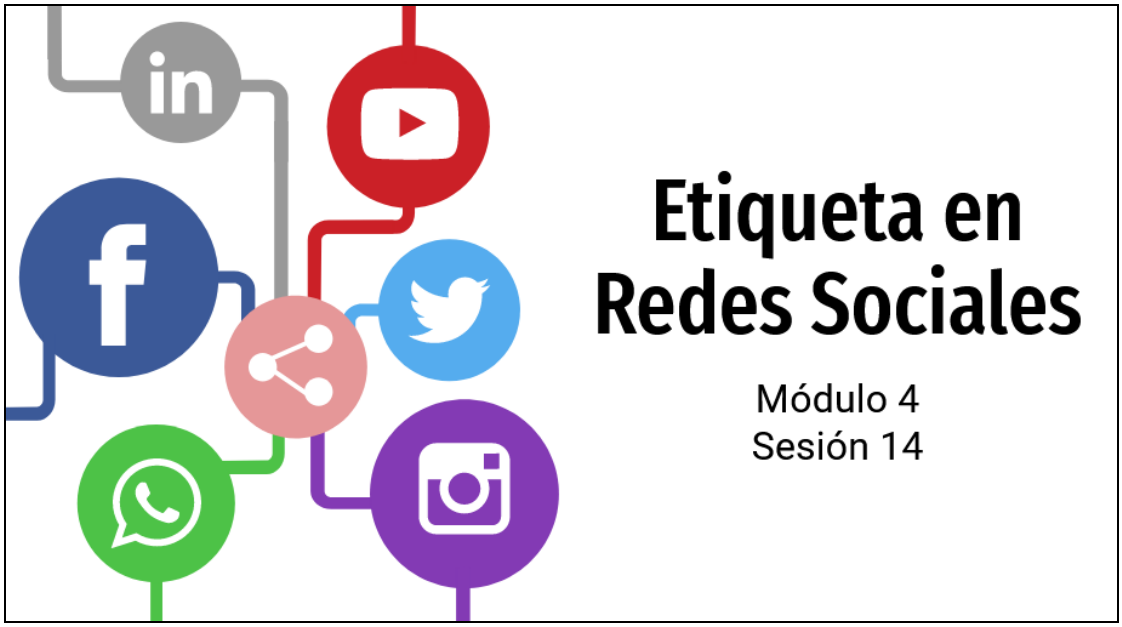
Close with questions about what you have learned based on the same scale from 1 to 5 but applied to more direct questions, for example: how do you see yourself using these resources in your classes? and request opinions on the usefulness and learning gathered in the session.

V. INDICATORS

List how an outsider can identify components of dialogue in the session

- Understanding of interfaces (their implications, recognition, functionality, and location)
- Ability to justify the selected tool(s)
- It manages to land the ideas with the resources of these software’s.

Appendix D.14: Social Networks Etiquette

HIGH STEAM SESSION # 14	
	
I.INFORMATIVE DATA	
Unit: [4] Digital Literacy	**Lesson:** [14] Social Media Etiquette
Objective: Promote a culture within social networks that allows clear communication bridges to be built	
Based on: https://domain.me/10-social-networking-etiquette-rules-your-children-have-to-know/ https://www.govtech.com/education/why-educators-must-teach-students-social-media-etiquette.html	
II. MATERIALS *List all the materials that students will need for the session*	
• Worksheets	
III. STEAM CONTENT *Identify the STEAM Areas used during the session*	
Technology: paddle, Awesomely, Lucidpark Art: Poem Math: Add up how many rules you already follow and how many are missing	

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction 15 min

Start by asking how the students feel, have them identify which character they are, and have them verbally express their feelings (This is especially important, make the student heard, help them understand that every feeling is correct).
mood board
Open the pallet and first discuss your personal responses to each question. After doing so, encourage students to answer each question. As you answer, ask for volunteers to discuss each question and their perspective on it.
paddle

Development 45 min

Throughout the presentation, encourage students to read each rule and how they personally feel about it, give a small space between the rules for other students to share their thoughts on the given rule.
Mention the 9 rules in the presentation
After the presentation, ask if they have questions about any rules. The next activity is simple, write the rule and mention if they are currently following it or if they are still working on it. This activity is individual, it gives them time to fill it out on their own.
Nine rules, add how many you already follow and how many are missing
Based on the questions at the bottom of the worksheet, create a short discussion. Go question by question and have students express their feelings and thoughts about each question. This is a good time to encourage students who have not participated.
discuss rules

Closing 15 min

Finally, as a closing, open and share the link with the students. Each student must create a poem on the topic they have learned. At the end, they ask for at least 5 volunteers to share the poem they have created.
Create Poem about what they learned
At the end, I asked how they feel about the lesson and if they would change anything.
express new discoveries

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Always encourage students to help them want to do the activities on their own, not as an obligation.
Create a healthy environment, knowing that not one answer is bad, if there are mistakes, they can be corrected
Help raise doubts, make students want to participate and say how they feel
Answer concerns

Appendix D.15: Fake News

HIGH STEAM SESSION # 15

I.INFORMATIVE DATA

Unit: [4] Digital Literacy	**Lesson:** [15] Fake News

Objective: Promote the topic of "Fake news" through the collaborative use of "Google Suite" documents

Based on:
https://www.bbc.co.uk/teach/young-reporter/lesson-1-real-news-vs-fake-news/z899vwx/
https://www.govtech.com/education/why-educators-must-teach-students-social-media-etiquette.html
https://www.nytimes.com/2017/01/19/learning/lesson-plans/evaluating-sources-in-a-post-truth-world-ideas-for-teaching-and-learning-about-fake-news.html

II. MATERIALS

List all the materials that students will need for the session

- Worksheets

III. STEAM CONTENT

Identify the STEAM Areas used during the session

Technology: lucid charts, kahoot

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Pre-session preparation:
Ask students and teachers to access from a computer or laptop.

Introduction 15 min
To start the class, I encouraged the students to decorate and wear the mask during the session. The mask will represent how behind a screen, one can be someone with a mask, that is, not their true self. This will connect with the material that will be seen during the class.
Decorate Mask
After decorating and wearing the mask, they will have to get into lucid charts to answer questions related to today's topic. These questions will help the student already know what will be discussed and prepare mentally on the subject.
intro questions

Development 45-50 min
At the end of the intro questions, he will introduce himself and talk about the topic of fake news, this will be presented through a presentation.
After reviewing the presentation with support on how to identify if news is false, an activity will be conducted.
worksheet one
The activity is accompanied by a help page with quick tips to identify if a piece of news is false.
help identifies
To conclude the activity, students will have to share the story of their classmates and explain which parts they think are false and which are real acts. The owner of that story will have to announce if their partner got it right or wrong.

Closing 10 min
Review on what was learned through Kahoot
Questions:
Fake news is NOT...
Honest reporting errors
Journalism you do not like
Disinformation for profit
Piracy
We do not have to determine the authenticity and reliability of the sources to establish their usefulness.
Real

Fake
Which of these is NOT a way to determine the reliability of news
Identify the author of the source
We do not like the author
Read skeptically and critically
See multiple points of view of the same historical event
fake news is
Uncritically reporting a hoax as fact
satire websites
Disinformation for political gain
It is important to know if a story is true or false
true
Fake

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Always encourage students to help them want to do the activities on their own, not as an obligation.
Create a healthy environment, knowing that not one answer is bad, if there are mistakes, they can be corrected
Help raise doubts, make students want to participate and say how they feel
Answer concerns

Appendix D.16: Designing my future

HIGH STEAM SESSION # 16

I.INFORMATIVE DATA

Unit: [5] Employability	**Lesson:** [16] Design my future

Objective: Design a prospective future to recognize areas of opportunity and strengths. Students will imagine their future and put their ideas on a poster, where they can draw, past images, objects that represent the things they want for the future.

Based on: https://en.unesco.org/futuresliteracy/about

II. MATERIALS

List all the materials that students will need for the session

- Sticky notes different colors
- Flipchart

III. STEAM CONTENT

Identify the STEAM Areas used during the session

Technology: We will see work outside the traditional ones to increase the prospects of traditional jobs specifically in the STEAM area with a focus on technological positions that will be presented soon.

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction (15 minutes)

At the beginning of the session, a series of icebreakers will be made in an introductory way calling for dialogism by the teacher, generating a relationship of trust with the students who will voluntarily comment on the striking topics about companies and their job aspirations in their future.

It is recommended to comment on large companies such as Google, Apple, Oracle, among others, giving interesting and striking data such as their facilities, the importance of their existence, their contribution to society and the job opportunities within them.

Development (30 minutes)

Giving continuity to the comments made by the students and the data presented, a space will be created to share what the students have in mind or expect as a future job opportunity and their projections. In this activity the teacher will take note of the workplace preferences of the students.

Explain the components of Ikigai and the operation between its four sections such as What you love, What the world needs, what you can get paid for, and What you are good at. It is recommended to review both videos by the teacher to have a guide. Students will be able to write their ideas on the post-it provided.

Finding your IKIGAI with innovation | Carlos Alvarado Dumas | TEDxUSAC (Spanish)
https://www.youtube.com/watch?v=GTmeDrNQB8c&ab_channel=TEDxTalks
How to Ikigai | Tim Tamashiro | TEDxYYC (English)
https://www.youtube.com/watch?v=pk-PcJS2QaU&ab_channel=TEDxTalks

The result will gradually change to the fulfillment of life goals. Therefore, another space will be opened to comment on the opinions of the students to learn about this Japanese method. The teacher will take notes to get to know the students better and if the teacher considers it appropriate, he can also present his opinion to empathize with the students.

It also comments on the objectives that the students have in the future to be able to take advantage of this Japanese method and fulfill their expectations and dreams. Likewise, the processes that they must follow to fulfill those goals and objectives that they have planned.

Closing (15 minutes)

Closing the activity, consensus is generated with the students about what they learned on the day about the activities in an open way for the students. An asynchronous activity will be left that will be uploaded to the Teams about making a collage of the

2025 planning. This collage must have elements from the following areas: Personal, Couple, Finance, Health, Social. This activity will need to be done digitally, but you can make your sketches on flipcharts.

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Number of students responding per activity
Student responses
Activities delivered

Appendix D.17: Excel and Database analysis

HIGH STEAM SESSION # 17

I.INFORMATIVE DATA

Unit: [5] Employability	**Lesson:** [17] Excel, database, and data analysis

Objective: Develop database analysis for decision making

Based on: https://www.coursereport.com/blog/how-to-use-microsoft-excel-like-a-data-analyst

II. MATERIALS

List all the materials that students will need for the session

- Worksheets

III. STEAM CONTENT

Identify the STEAM Areas used during the session

Excel is a tool that covers these four sections of STEAM by science and technology, we are talking about the use of science and the management of databases that can contain billions of data collected from the internet or from companies. On the part of

engineering, the bases for data management are like those of programming, in addition, the functions that will be shared with the students will be simplified mathematical formulas and calculated by computers, facilitating people.

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction (15 minutes)

Icebreakers and big data from data science and excel by the teacher. The use of data such as the uses for managing information within excel, generating reports with graphs, daily use in all companies, etc. is recommended. Students will be invited to share their knowledge of tools such as excel (If this is not the case, success stories of the optimal use of these tools and their applicability in work will be shared with them)

Development (60 minutes)

Teach the video about the basic elements of excel
Activity 1
Create a list of items seen in the video
Show an excel table, five volunteers point to a function, and say why it works.
Show a table already made
Mention how a table can be created to be able to manage finances and numbers, not only in large companies but to be able to undertake and create tables.

Activity 2
Based on what they learned, students will be asked to perform the following operations on the Excel file:
A micro-enterprise, dedicated to sending packages to any part of the world in the shortest time, wishes to study the shipments made in 2011, which generated profits of more than $200,000 USD. As an analyst, you are asked to present a study that allows the management team to identify the number of packages sent according to their type, as well as the most frequent places of origin and destination.

Initial tips:
Use the Save As function to rename the file and save a copy of it.
Apply a filter to the table to easily organize the data. Invest as little time as possible

Calculate the data in column F ($/unit) by dividing E by D.
Account for the number of shipments according to their modality and enter them in cells G26 to G28, as appropriate.
Count packages according to their priority
Use conditional formatting to color column C (priority) based on the value of each cell.
Apply accounting format for columns E and H.
Like the number of submissions, view the cases by target audience in cells J26 through J29.
Get the sum of the data in column E.

Sort the table by date, from oldest to newest.
Obtain the name of the country to which the most shipments have been made.

Closing (15 minutes)
Generate dialogue between students
For what would you like to use this app?
The topic will be closed, and doubts generated by the students will be resolved.
The teacher will offer support and resolution of doubts through topics.

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Number of doubts generated
Number of uploaded files vs correct files

Appendix D.18: My Curriculum

HIGH STEAM SESSION # 18	
	
I.INFORMATIVE DATA	
Unit: [5] Employability	**Lesson:** [18] Curriculum
Objective: Build skills to design resumes based on the position to apply	
Based on: https://www.idtech.com/blog/futuristic-stem-jobs-and-career-list-for-students	
II. MATERIALS *List all the materials that students will need for the session*	
• Worksheets	
III. STEAM CONTENT *Identify the STEAM Areas used during the session*	
Art: Design of CVs in an innovative way and adapting them to the tastes of the students.	

IV. SESSION SEQUENCE

List all the steps that teachers need to follow to develop the session

Introduction

The importance of a CV will be discussed, what it transmits, its uses, its varieties, and potentials by the teacher. After this induction, insights about Canva and the tools offered to facilitate the work of generating a cv there will be given. The teacher is recommended to review Canva in advance of the class to learn about the tools it offers and for the design of presentations, reports, CVs, etc.

Developing

Students will be invited to create accounts and enter Canva to discover everything it can offer them as a tool. It is also recommended that the teacher, having made a previous entry, initially guide the students with prominent tools within the platform. Examples of CVS made in Canva will be presented to take them as a reference. (Two examples are shared, one formal and the other adapted for a learning place. After this presentation, the students will be released so that they can start with the realization of the same and that they can upload to the team's platform.

Closing

Doubts about the creation of CVs generated by the students will be resolved and the opening of the teacher to resolve doubts by teams will be presented during the week. The generated CVs will be requested to be uploaded to the group of teams

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Resumes received
Student satisfaction

Appendix D.19: Looking for a job

HIGH STEAM SESSION # 19	
	
I.INFORMATIVE DATA	
Unit: [5] Employability	**Lesson:** [19] Looking for a job
Objective: Open the range of available professions especially in STEM careers through the experience of interviews with mentors from the STEM field.	
Based on: https://www.idtech.com/blog/futuristic-stem-jobs-and-career-list-for-students	
II. MATERIALS *List all the materials that students will need for the session*	
• Worksheets	
III. STEAM CONTENT *Identify the STEAM Areas used during the session*	
Technology: Demonstrate the tools for searching for non-traditional job offers and managing your account in one of the largest employment networks used by large companies in search of talent	
IV. SESSION SEQUENCE *List all the steps that teachers need to follow to develop the session*	

Introduction (25 minutes)
It will begin with a dialogue about the tastes and interests that the students have. With this we will know the possible designs that can be presented to attract the attention of the students. A survey will be made on the knowledge of job searches in general. From this start the teacher should take note of the information collected.

Development (20 minutes)
The LinkedIn platform will be presented, a profile will be presented, and they will be invited to create an account in which they can add things that attract the students. Students should take note of those main elements to have a complete and striking profile. Items such as Name, biography, friends, place of studies, etc.

Closing (15 minutes)
Solve general doubts about the operation of the platform. To close the session, students will be encouraged to create an account on the LinkedIn platform asynchronously. These profiles must be posted in a team space to be reviewed by the teacher and give feedback.

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Shared Profiles
Profiles with the elements established by the teacher.

Appendix D.20: Closing ceremony

HIGH STEAM SESSION # 20	
	
I.INFORMATIVE DATA	
Unit: [5] Employability	**Lesson:** [20] Closing Ceremony
Objective: Deliver recognition to participants of the project	
II. MATERIALS *List all the materials that students will need for the session*	
• Certificates • Transportations: round trips • Snacks	
III. STEAM CONTENT *Identify the STEAM Areas used during the session*	
• The speakers will aim to recap all the High STEAM process giving voices to participants involved.	
IV. SESSION SEQUENCE *List all the steps that teachers need to follow to develop the session*	
1. Receive participants at Garza Sada's entrance 2. Campus tour	

3. Take them to library sixth floor
4. Description of the project and its progress (Dr. Juan Fernández)
5. The linking processes of the DGETI with science, technology, and art (Prof. Felipa Longoria Gaytán, head of the DGETI State Office in Nuevo León)
6. The agenda of the EHE School of Humanities and Education on issues of social justice and social innovation (Dr. Judith Aurora Ruiz Godoy Rivera, Dean of the EHE, Tecnológico de Monterrey)
7. Teacher and student experience (Karla Martínez)
8. TEC students experience (Pablo Arreguin, TEC student)
9. The research groups of the Tecnológico de Monterrey and their impact on the social agenda of our communities (Dr. Francisco Díaz Estrada, Associate Dean of Research at the EHE, Tecnológico de Monterrey)
10. Empowering communities through technology and education (Jill W. Dietrich, United States Consul for Culture and Press in Monterrey)
11. Delivery of certificates
12. Snacks and sharing time
13. Closing of the event

V. INDICATORS

List how an outsider can identify components of dialogue in the session

Give voice to participants to share the impact of the project

Appendix E: Main – Study Data Collection Instruments

Appendix E.1: Semi-Structured Interviews for high school teachers

Estudio principal: Entrevista a los docentes

Por favor, cuénteme más sobre usted como maestro (¿Por qué eligió enseñar)? ¿Cuáles fueron tus motivaciones? ¿Cuánto tiempo has sido profesor? ¿Qué te hace un excelente maestro? ¿Qué metodologías utiliza en su práctica?
Describa su experiencia en High STEAM. (¿Cuál es el impacto de High STEAM en sus prácticas educativas? ¿Qué aprendió de High STEAM? ¿Cómo puede usar lo que aprendió en High STEAM en el futuro?)
Describa la experiencia para sus estudiantes. ¿De qué manera las actividades que tuvo con sus alumnos fueron fuente de diálogo? ¿Qué vio en sus alumnos en cuanto a la reflexión sobre sus trayectorias y posibilidades para un futuro con esperanza?
¿En qué medida las actividades High STEAM eran diferentes a las actividades que habitualmente realizabas en tus clases? Si ese fuera el caso, ¿qué fue diferente?
[Si tuvieras que elegir tu sesión High STEAM favorita, ¿cuál elegirías? ¿por qué? ¿Podría darme detalles de algunos aspectos de la libertad, la creatividad y el juego que fueron parte de esa sesión? ¿Podría darme detalles de reflexión derivados de esa sesión, en función de sus circunstancias actuales y como parte de un futuro posible con esperanza? (Presente y futuro)

Appendix E.2: Semi-Structured Interviews for high school students

Estudio principal: Entrevista a los estudiantes de CBTIS/CETIS

Cuéntame más sobre ti (¿Quiénes son tus padres y qué hacen? ¿Qué te gusta hacer? ¿En qué eres bueno? ¿Cuál es tu sueño para el futuro?)
Describa su experiencia en High STEAM. (¿Cuál es el impacto de High STEAM en tu vida académica? ¿Notaste alguna diferencia con estas actividades en contraste con otras clases? ¿Qué aprendiste de High STEAM? ¿Qué crees que puedes hacer con lo que aprendes en High STEAM en ¿el futuro?)

Appendix E.3: Semi-Structured Interviews for social service students

Estudio principal: Entrevista a los alumnos del servicio social

Cuéntame más sobre ti (¿Quiénes son tus padres y qué hacen?) ¿Qué te gusta hacer? ¿En qué eres bueno? ¿Por qué estudias tu carrera? ¿Cuál es tu sueño para el futuro?)
Describa su experiencia en High STEAM. (¿Cuál es el impacto de High STEAM para tu vida académica y personal? ¿Notaste alguna diferencia con las actividades que diseñaste e implementaste en contraste con lo que usualmente vives en tus clases? ¿Qué aprendiste de High STEAM? ¿Qué opinas? puedes hacer con lo que aprendes en High STEAM en el futuro? (Tanto como competencias disciplinarias [STEAM] como transversales [diálogo])

Appendix E.4: Field notes

1. INFORMACION GENERAL

Nombre del investigador:
Escuela y nombre del docente:
Número de sesión:
Número de estudiantes:

2. NOTAS DE CAMPO

1. **Describir la sesión**
   (¿Qué observas en la clase? ¿Cómo se comportan los alumnos y profesores? ¿Cuál fue tu participación)

2. **Describir cómo se produjeron las interacciones entre los alumnos y entre profesores y alumnos.**
   (¿Hay confianza entre compañeros para discutir criterios, identificar objetivos? ¿Se ofrecen los estudiantes para responder a las solicitudes de los miembros del grupo? ¿Hay retroalimentación?)

3. **Describir la comunicación entre alumnos y entre profesores y alumnos**
   (¿Respetaron las ideas y los compromisos? ¿Usaron un lenguaje y un comportamiento socialmente apropiados? ¿Se turnaron para hablar o hubo interrupciones constantes?

4. **Describir las múltiples rutas de consulta**
   (¿Se fijó si consultaron o remitieron a otras fuentes de información? ¿Qué otros conocimientos aportaron?)

5. **Describir el enfoque transdisciplinario**
   ¿Existen relaciones con problemas locales o globales a resolver? ¿Existen resoluciones colaborativas? ¿Existen herramientas para cocrear y completar tareas? ¿Hablan de otras disciplinas?

3. REFLEXIÓN

Reflexiona sobre lo que llama tu atención
(¿Qué pasó o dijeron los estudiantes que les llamó la atención? ¿Por qué?)

4. EVIDENCIA

Coloca fotos de la sesión

Appendix E.5: Focus group for social service students

Grupo focal con los estudiantes de servicio social

1. Describe la experiencia de diseñar experiencias científico-tecnológicas dialógicas en este contexto de pandemia. (¿Qué sentimientos, pensamientos y acciones despertó en ti?)
2. Describa su relación con los estudiantes y el maestro. (¿Qué aprendiste de ellos?)
3. Describa qué conocimientos/habilidades de su carrera transfirió al proyecto y viceversa
    a. Justicia social: ¿Cuál fue el impacto de este proyecto para los estudiantes y sus profesores?
    b. Dialogismo: ¿Qué espacios de diálogo se crearon a través de las actividades? Evaluar las oportunidades de diálogo creadas en términos de su impacto para profesores y estudiantes.
    c. Transformación personal: ¿Cuál fue el impacto de este proyecto en tu vida personal? ¿Trabajar en High STEAM te ha hecho pensar en tus propios estudios de una manera diferente o cambiar la forma en que abordas tu trabajo?
    d. Valores del Servicio Social: ¿Cómo refleja este proyecto los valores del servicio social (reconocimiento y empatía, argumentación ética, integridad y compromiso ciudadano y ético)?

Appendix F: Main Study – Ethical Forms

Appendix F.1: For High School Teachers

Consentimiento Informado Profesores de CBTIS/CTIS| Estudio Principal de A01683423

Mi nombre es Lay-Wah Carolina Ching Chiang, soy estudiante del programa de Doctorado en Innovación Educativa del Tecnológico de Monterrey. Como parte de mi programa me encuentro realizando el estudio principal para mi disertación titulada *"Prácticas educativas dialógicas: Casos de estudio en contextos no formales"*. Por tal razón, me gustaría invitarte a ser parte de mi estudio. Tu experiencia en el proyecto HIGH STEAM es de mi interés. A través de mi estudio quiero conocer el impacto que dicho programa ha tenido para ti. Este proyecto de investigación ha sido revisado y ha sido aprobado por Dr. Juan Manuel Fernández. En caso de cualquier duda lo puedes contactar a través del correo j.m.fernández@tec.mx

Por favor señale si está de acuerdo o en desacuerdo	Sí No
Se me ha leído la información del estudio de fecha. He sido capaz de preguntar sobre el estudio y mis preguntas han sido respondidas con satisfacción.	□ □
Consiento voluntariamente a ser un participante en este estudio y entender que puedo rechazar el dar respuesta a pregunta y que puedo retirarme del estudio en cualquier momento sin tener que dar razones, siempre y cuando esto sea antes de que la información se haya anonimizado.	□ □
Entiendo que formar parte de este estudio implicó tomar parte en actividades de creación creativa y compartir los resultados y la percepción de las actividades con otros en el proyecto de High STEAM.	□ □
Entiendo que formar parte del estudio implica responder a solicitudes breves de retroalimentación usando mensajería instantánea, como Whatsapp, y una entrevista audio grabada por teléfono.	□ □
Estoy de acuerdo con que se tomen notas de campo de mis actividades.	□ □
Estoy de acuerdo con la grabación y almacenamiento de mis breves retroalimentaciones en un archivo de registro.	□ □
Estoy de acuerdo con el audio grabación y transcripción de la entrevista	□ □
Entiendo que la información proveída será utilizada en talleres, reportes, publicaciones y en la página web del proyecto.	□ □
Entiendo que la información personal recolectada sobre ti que permita identificarte, como nombre o donde vivo, no serán compartidos	□ □
Entiendo que la información anonimizada será almacenada en una carpeta compartida protegida por 10 años [30/06/2032] después de los cuales la información será destruida.	□ □
Estoy de acuerdo con que mi información sea citada en los resultados de la investigación.	□ □

Nombre Completo y Fecha

Appendix F.2: For High School Students

Consentimiento Informado Estudiantes CBTIS/CTIS| Estudio Principal de A01683423

Por medio de la presente queremos invitarte a participar en un estudio que estamos realizando sobre prácticas educativas en ciencia y tecnología. Somos parte del programa de la Escuela de Educación y Humanidades del Tecnológico de Monterrey. Se espera que en este estudio participen 130 personas.

Si tú decides aceptar esta invitación, tu participación consistirá básicamente en asistir a 20 sesiones sincrónicas en línea, así como interactuar durante 30 semanas en actividades asincrónicas en ciencia, tecnología, ingeniería, arte y matemáticas (STEAM) de septiembre 2021 a junio del 2022 bajo la dirección y acompañamiento de un docente de tu institución y de personal del Tecnológico de Monterrey. Para estas actividades se te enviarán los materiales que requieres usar para cada sesión. Se espera que como resultado de tu participación construyas habilidades en diferentes áreas que fortalezcan tu perfil laboral. Se grabarán las sesiones sincrónicas, se tomarán fotos de los materiales producidos y de los participantes en varios momentos. También se aplicarán al inicio y al final del proyecto una escala de competencias de pensamiento crítico.

Toda información obtenida en este estudio será estrictamente confidencial. Los datos serán respaldados en una unidad de almacenamiento en la nube y se guardarán por 20 años. Si los resultados de este estudio son publicados, los resultados contendrán únicamente información global del conjunto de las personas participantes. Tu identidad será protegida por pseudónimos, anonimizando en todo caso las referencias a participaciones personales.

Tu participación en este estudio es voluntaria y de ninguna forma afectará tus relaciones con tu escuela ni con tus maestros. Si tú decides participar ahora, pero más tarde deseas cancelar tu participación, lo puedes hacer mediante una carta dirigida al director del programa High STEAM, el Dr. Juan Manuel Fernández Cárdenas. En caso de suspender tu participación te pediríamos la devolución de los materiales que te fueron entregados.

Si tienes alguna pregunta, por favor hazla escribiendo a localizarnos Lay -Wah Carolina Ching lay.ching@tec.mx o a Juan Manuel Fernández Cárdenas j.m.fernandez@tec.mx Si deseas conservar una copia de esta carta, solicítala y te la daremos.

Si tú decides participar en este estudio, por favor anota tu nombre, firma y fecha en la parte inferior de esta carta, como una forma de manifestar tu aceptación y consentimiento a lo aquí estipulado.

Nombre del participante:_____
Nombre de la escuela:_____
Firma:_____**Fecha:**_____

Nombre del Padre o tutor (para el caso de menores de edad):
_____
Firma: _____**Fecha:** _____

Appendix F.3: For Higher Education Students

Consentimiento Informado Profesores de CBTIS/CTIS| Estudio Principal de A01683423

Mi nombre es Lay-Wah Carolina Ching Chiang, soy estudiante del programa de Doctorado en Innovación Educativa del Tecnológico de Monterrey. Como parte de mi programa me encuentro realizando el estudio principal para mi disertación titulada *"Prácticas educativas dialógicas: Casos de estudio en contextos no formales"*. Por tal razón, me gustaría invitarte a ser parte de mi estudio. Tu experiencia en el proyecto HIGH STEAM es de mi interés. A través de mi estudio quiero conocer el impacto que dicho programa ha tenido para ti. Este proyecto de investigación ha sido revisado y ha sido aprobado por Dr. Juan Manuel Fernández. En caso de cualquier duda lo puedes contactar a través del correo j.m.fernández@tec.mx

Por favor señale si está de acuerdo o en desacuerdo	Sí No
Se me ha leído la información del estudio de fecha. He sido capaz de preguntar sobre el estudio y mis preguntas han sido respondidas con satisfacción.	□ □
Consiento voluntariamente a ser un participante en este estudio y entender que puedo rechazar el dar respuesta a pregunta y que puedo retirarme del estudio en cualquier momento sin tener que dar razones, siempre y cuando esto sea antes de que la información se haya anonimizado.	□ □
Entiendo que formar parte de este estudio implicó tomar parte en actividades de creación creativa y compartir los resultados y la percepción de las actividades con otros en el proyecto de High STEAM.	□ □
Entiendo que formar parte del estudio implica responder a solicitudes breves de retroalimentación usando mensajería instantánea, como WhatsApp, y una entrevista audio grabada por teléfono.	□ □
Estoy de acuerdo con que se tomen notas de campo de mis actividades.	□ □
Estoy de acuerdo con la grabación y almacenamiento de mis breves retroalimentaciones en un archivo de registro.	□ □
Estoy de acuerdo con el audio grabación y transcripción de la entrevista	□ □
Entiendo que la información proveída será utilizada en talleres, reportes, publicaciones y en la página web del proyecto.	□ □
Entiendo que la información personal recolectada sobre ti que permita identificarte, como nombre o donde vivo, no serán compartidos	□ □
Entiendo que la información anonimizada será almacenada en una carpeta compartida protegida por 10 años [30/06/2032] después de los cuales la información será destruida.	□ □
Estoy de acuerdo con que mi información sea citada en los resultados de la investigación.	□ □

Nombre Completo y Fecha

Biography

Lay-Wah Carolina Ching Chiang

E-mail: lay.chingchiang@gmail.com
CVU: 1018876 || **ORCID:** https://orcid.org/0000-0002-1211-2128

Lay is a Ph.D. candidate at Tecnologico de Monterrey for the program of "Educational Innovation", which she enrolled to back in 2019. She also earned her master's degree from Tecnologico de Monterrey and her Bachelor's in Business Administration from Texas Christian University. Her research interests are related to dialogic educational practices in the scientific and technological field, teacher training, critical thinking, critical consciousness, designing cultural and educational experiences, and discernment tools. She has been leading internationally funded projects in non-formal contexts of education that have contributed to the reduction of marginality. Her academic, cultural, and work experiences have caused a profound impact on her in a cosmopolitan vision. She holds a passion for serving and caring for others which fuels social justice agenda in education. She would love to continue designing educational experiences that encourage the shared practice of recognizing others and oneself through these relationships.

You can find more information about her work in the following networks:

Escuela de Humanidades y educación:
https://escueladehumanidades.tec.mx/dee/users/lay-wah-carolina-ching-chiang
Google scholar:
https://scholar.google.com/citations?user=7TQuKR0AAAAJ&hl=es
LinkedIn:
https://www.linkedin.com/in/laywahching
Research Gate:
https://www.researchgate.net/profile/Lay-Wah-Ching-Chiang