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ORIGINAL PAPER

Discerning contextual complexities in STEM career pathways: insights from successful Latinas

Alejandro J. Gallard Martínez, et al. ***[full author details at the end of the article]***

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Abstract

This paper introduces the concept of contextual mitigating factors (CMFs) as a theoretical construct to help understand how Latinas who demonstrated success in STEM pipelines navigated the fluidly and dynamically shifting socio-historical-political contexts in which they found themselves. Further, understanding the ways in which CMFs contribute to the development of circumstances within fluid social fields is essential to understand the factors which Latinas both experience and create in their social interactions. We framed the development of CMFs within discussions of social place (Bourdieu and Wacquant in An invitation to reflexive sociology, University of Chicago Press, Chicago, 1992), social field (Swartz in Culture and power: the sociology of Pierre Bourdieu, University of Chicago Press, Chicago, 1997), and dynamic space (Tobin in Keynote address at 8th international congress on science teaching and learning, Barcelona, Spain, 2009). Given that CMFs appear as the result of social interactions within contextualized spaces, acknowledging the importance of place, be it physical or metaphorical, is essential in framing discussions on the sense-making of the participants' STEM successes. In accounting for our participants' positionalities and the materiality of their contextual experiences, we use CMFs as a theoretical underpinning to guide our methodological approach which we identify as CMF analysis. In each case, CMF analysis is used to explore how positionalities and experiences reflexively shaped each other, all while contributing to individual and social personhoods. Furthermore, the use of CMFs, by placing importance on both context *and* history, allowed us to discern not only the similarities of our participants' sociocultural, -economical, -historical and -political navigations toward success, but also the substantive differences between them. In presenting our discussion of CMFs, we present two of sixty case studies focusing on Latinas' successes in STEM fields using the intrinsic case study method (Stake, in: Denzin, Lincoln (eds) The SAGE handbook of qualitative research, 3rd edn, pp 443–466, SAGE, Thousand Oaks, 2005). This was the most appropriate method in analyzing our participants' experiences, because this allowed our participants to tell *their* stories of becoming and being successful in pursuing STEM pathways. Marrying this framework with intrinsic case study method provided internal consistency to the study. Ultimately, we want other researchers to see the benefits associated with CMF analysis, namely the provision of an additive framework in understanding the lived experiences of minority groups. By accounting for the role macro-, meso-, and microgenic CMFs play in the minority

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students' educational experiences, educators at all levels may play a substantively larger role in helping sustain their agency as learners.

Keywords Contextual mitigating factors · Resiliency · Latinas · STEM · Tactical understanding

Resumen

Este artículo presenta el concepto de factores contextuales mitigante (CMFs) como un constructo teórico para ayudar a entender cómo las latinas que demostraron el éxito en las líneas relacionadas con STEM navegaban por contextos socio-histórico-políticos fluidos y dinámicamente cambiantes en los que se encontraban. Además, es esencial entender las formas en que los CMF contribuyen al desarrollo de las circunstancias dentro de los campos sociales fluidos para identificar los factores que las latinas experimentan y crean en sus interacciones sociales. Enmarcamos el desarrollo de CMF dentro de las discusiones sobre el lugar social (Bourdieu y Wacquant 1992), el campo social (Swartz 1997) y el espacio dinámico (Tobin 2009). Dado que las CMF aparecen como el resultado de interacciones sociales dentro de espacios contextualizados, reconocer la importancia del lugar, ya sea físico o metafórico, es esencial para enmarcar las discusiones sobre el sentido y significado de los éxitos en STEM de los participantes. Al tomar en cuenta la posicionalidad de nuestros participantes y la materialidad de sus experiencias contextuales, utilizamos los CMF como un soporte teórico para guiar nuestro enfoque metodológico que identificamos como análisis CMF. En cada caso, el análisis CMF se usa para explorar cómo las posiciones y las experiencias se moldearon de forma reflexiva, al tiempo que contribuyeron a las personalidades individuales y sociales. Además, el uso de los CMF, al dar importancia tanto en el contexto como en la historia, nos permitió discernir no sólo las similitudes de las navegaciones socioculturales, económicas, históricas y políticas de nuestros participantes hacia el éxito, sino también las diferencias sustantivas entre ellos. Al presentar nuestra discusión sobre los CMF, presentamos dos de los sesenta estudios de casos que se centran en los éxitos de las latinas en campos de STEM utilizando el método de estudio de casos intrínseco (Stake 2005). Este fue el método más apropiado para analizar las experiencias de nuestros participantes, porque permitió a nuestros participantes contar sus historias sobre cómo llegar a tener éxito en la búsqueda de las líneas STEM. Casarse con este marco con el método de estudio de casos intrínseco proporcionó coherencia interna al estudio. En última instancia, queremos que otros investigadores vean los beneficios asociados con el análisis de CMF, es decir, la provisión de un marco adicional para comprender las experiencias vividas de los grupos minoritarios. Al considerar el papel que desempeñan los CMF macro-, meso- y microgénicos en las experiencias educativas de los estudiantes de minorías, los educadores en todos los niveles pueden desempeñar un papel sustancialmente mejor para ayudar a mantener su agencia como aprendices.

Palabras Claves Factores contextuales mitigantes · Resiliencia · Latinas · STEM · Conocimiento táctico

In this scholarly work, we introduce the concept of contextual mitigating factors (CMFs) as a methodological approach to understand how successful Latinas in STEM navigated the plethora of complexities associated with STEM pipelines. In particular, we present two case studies of Latinas who live in the USA. On a daily basis, these Latinas struggle to maintain a sense of balance between their professional aspirations in the STEM fields and

the multiple sociocultural, -economical, -historical and -political contexts within which their lives are enacted. We define CMFs as an infinite set of sociocultural, -economical, -historical and—political contexts, which are fluid and dynamic, simultaneously interweaving community, education, family, gender, identity, and other factors into the lives of the Latina participants highlighted in the study.

CMFs can help to create places which overlap and/or aggregate constantly, changing moment-by-moment by positioning and repositioning individuals within social places. Recognizing that CMFs contribute to the development of circumstances within social fields is key to understanding thematic factors that are both experienced by and created with Latinas in each case study. Pierre Bourdieu and Loïc Wacquant (1992) define social places as arenas of production, circulation, and appropriation of goods, services, knowledge, or status, and the competitive positions held by actors in their struggle to accumulate and monopolize these different kinds of capital. Fields may be thought of as structured *places* that are organized around specific types of capital or combinations of capital (Bourdieu and Wacquant 1992, p. 97, emphasis added).

David Swartz (1997) uses the concept of field to denote the invisible and underlying structures that shape practices within a scenario. Within the literature on social fields, fields have been referred to as subcultures, communities and/or ways of life (e.g., Goldring 2006). We view places as dynamic areas that are contained social fields of cultural enactment and representation which are basically made up of structures including space, time, individuals, goals, resiliency, imagery, material and social categories such as age, gender, race, and class (e.g., Sewell 1992, 1999, 2005). In this sense, places where culture gets enacted have temporal and physical qualities, as well as cultural resonances, and include examples such as the following: a home, classrooms, a basketball court, a dance hall, or a church. It is important to keep in mind that all places contain CMFs which can present conflicts which are the basis for legitimacy and access to different types of capital.

Given the multiple and increasingly complex forms of cultural enactment, it has become necessary to develop methodological strategies and concepts which allow social places to be studied systematically. For example, as new forms of globalized culture get enacted, such as a change in fulfilling STEM needs from a local to an international perspective, achievement standards are influenced by Program for International Student Assessment (PISA) standings of industrialized countries. This has had strong thematic influences on the social places in which STEM education takes place in both formal and informal settings. Our use of the terms *formal* and *informal* here differentiate between scripted or officially sanctioned curriculum standards and unscripted learning contexts. However, this is not to argue or suggest that the boundaries between formal and informal are consistently set. Within formal settings there can be moments of unscripted learning contexts that are purposeful in their occurrence.

Consequently, the stability and dynamism of social places can be explained through some of their key features and properties, leading to thematic understanding and methodological approaches. One of the key aspects necessary to identify and determine a social place is based on the specificity of its cultural productions. The specificity of the cultural production of each social place is largely defined by the relationships between the individuals involved and how human and material resources available are used (e.g., Tobin 2009), i.e., the capacity for action of individuals. All actions have to occur within social places in which the specificity of cultural productions, offers, demands, creates a repertoire of resources to be used by its participants either at the global, macro-, meso- or microgenic levels.

Painting a methodological landscape: using CMFs as an initial probe

When we started this research effort we were *perplexed* as to why few Latinas experienced success throughout the STEM pipelines. In order to gain contextual insight, our initial undertaking was to conduct interviews with successful Latinas. As we probed more deeply, it became apparent to us that their individual experiences, including overcoming adversity, assisted them in creating filters, such as resiliency, to make sense of their worlds both in and out of school. This led us to treat each person as an individual case with two surface commonalities: they identified as Latinas and were successful students in the STEM pipelines and as STEM professionals.

However, upon reflection we noted that we were employing reductionism by using adversity to understand resiliency. Using adversity as a probe did not provide us deeper insights as to how the participants maintained success in STEM pipelines and as professionals, or developed resiliency. It was not until we started making connections both to the sociocultural aspects of their lives and surveying the literature that it became clear to us that resiliency was not simply a function of hard work. Instead, their resiliency manifested as a complex composite of individual characteristics based on experiences. We are neither arguing nor suggesting that other filters, such as Critical Race Theory (Delgado and Stefancic 2012) and Standpoint Theory (Wylie 2003) would not be appropriate and useful. However, resiliency, as defined by overcoming adversity, did not seem to pay enough attention to the contextual influences that impact society (Arrington and Wilson 2000). We became curious as to why some individuals have to develop more contextually driven resiliency than others, and why this is not the central focus of the narratives describing resiliency. Our standpoint is that the hegemony of the status quo and the associated inequity and lack of social justice is treated in an acontextual and ahistorical manner. There appears to be little attention paid to the associative contextual factors that persist and position individuals throughout multiple sociocultural, -economic, -historical and -political landscapes.

Specifically, we had to understand or make explicit the CMFs that helped to create both the contextual elements of adverse situations as well as resiliency. We also had to understand that CMFs are not identified and coded as a property of an individual; instead they are coded simultaneously as both related processes and products of entering an array of socially constructed signifiers which we view as signatures of positionality. Moreover, it was also important for participants to identify how they were being positioned and had developed tactical understanding to overcome their limit-situations. As Freire (2014) notes below:

> As they separate themselves from the world, which they objectify, as they separate themselves from their own activity, as they locate the seat of their decisions in themselves and in their relations with the world and others, people overcome the situations which limit them: the "limit-situations." Once perceived by individuals as fetters, as obstacles to their liberation, these situations stand out in relief from the background, revealing their true nature as concrete historical dimensions of a given reality. (p. 99)

These revelations led us to look for other sociocultural filters to enable us to unpack resiliency as both process and product. One of the filters we used was Pierre Bourdieu's notions of reflective sociology and *sens pratique* (1976). This facilitated a deeper probe into the landscapes that create resiliency. In addition, Paulo Freire's (2005) ideas regarding tactical understanding and limit-situations were a strategic fit for probing the data. We argue that Freire's notions of tactical understanding and limit-situations are aspects of an analytical

bricolage (Kincheloe and Tobin 2006) which assisted us in identifying if a situation was limiting or not. We acknowledged that tactical understanding gave a more individualized and contextualized picture of the stories being told. Accordingly, by using tactical understanding as a probe, we came to realize that not only did the Latinas in the study read the sociocultural landscapes, but they also developed tactical understanding of limit-situations and the CMFs that helped contour their landscapes. This epiphany allowed us to see resiliency as a reaction to a set of sociocultural phenomena embodied in limit-situations.

First steps in sense-making of the data

Our approach became rooted in an emergent sense-making of the data, which included a necessity to complexify each individual case, anchored in our approaches to sociocultural theory, where teaching and learning is a form of cultural enactment. Additionally, driven by a deep commitment to reveal data not as *raw data* but as the stories of individuals (Connelly and Clandinin 1990), we then turned to intrinsic case study method (Stake 2005) as a way to tell their story about becoming and being successful in pursuing STEM pathways. Because "a case study is both a process of inquiry about the case and the product of that inquiry" (Stake 2005, p. 444), we choose the intrinsic case study as an overarching framework "because, first and last, one wants better understanding of this particular case" (Stake 2005, p. 445).

Participants

For the purposes of this paper, we present two of the research study's sixty cases as exemplars for how to use CMF analysis in understanding success in STEM. In selecting the participants, our starting point was to identify Latinas who were interested in continuing to pursue STEM—which we acknowledge might be partially motivated by receiving good grades in STEM courses. Having said this, we are pleased to note that all of the Latina participants continued to take STEM courses and have successfully graduated from high school and entered into a university as STEM majors and are working in STEM careers. Even though we have lumped our participants into one category broadly called Latina, they are all very different in their cultural, socio-historical, and linguistic backgrounds, as well as how they defined their identities. For example, one of the Latina participants, reported in this study, is from México, and she has strong indigenous roots. Another of the Latina participants is from Puerto Rico, a colonized territory of the United States of America.

We deliberately selected cases to present because the data explicitly revealed how each Latina used tactical understanding to deal with limit-situations. Each case, analyzed separately, provided important insights; however, analyzing both cases side-by-side provided additional instructive value. We believe it is critical to allow each Latina to tell her story. To that end, we are not interested in superimposing our world-views but to "represent the case" (Stake 2005, p. 460). We also use a cross-case analysis (Yin 2009) in which we examined common themes to identify similar trajectories as well as challenges or barriers across the cases. The case studies presented within are individual stories with general patterns.

These Latinas are exemplars of resilience because they have been able to recognize CMFs and develop appropriate strategies both to counter negative CMFs and to embrace positive ones. Some Latina readers might argue that there is no difference between their

stories and those we present in our narrative. Other non-Latinas may claim the same, and point to general patterns not only in their stories, but also to those of a handful of others. We reject either argument, because not to do so would discount the persistent individualized realities that Latinas must negotiate in the United States. It is important to recognize the success of individuals, but not at the cost of denying the connections between the collective and individual efforts to overcome the CMFs of institutional inequity. Our point is that while successful Latinas have stood at the crossroads of entering into the STEM fields, in spite of their successes, the pattern in the field continues to be a world which is still significantly dominated by their male counterparts, especially White men (Riegle-Crumb and King 2010).

The three-interview series

The primary goal of our interview series was for participants to reconstruct lived experiences related to the topic of the study, that is to determine how Latinas who successfully deal with limit-situations as they are studying or working within STEM disciplines, such as computer engineering and physics. We applied Irving Seidman's (2013) in-depth, phenomenologically open-ended three-interview series to examine the barriers encountered, as well as those factors facilitating Latinas' successive levels of educational attainment and securing successful STEM careers.

During the first interview, participants were asked to reconstruct their early experiences by speaking as much as possible about themselves. Instead of asking them *"Why is it important for you to complete your STEM program of study at either the secondary or tertiary levels?"*, the interviewer asked, "*How or why did you become motivated to enter a STEM field, and to pursue a STEM career?"*

The second interview focused on eliciting concrete details of the Latinas' present experiences as they relate to not only their limit-situations, but also to their academic and/or career successes. Specifically, they were asked to recount stories or to talk about their relationships with their campus administrators, their mentors, their peers, their teachers, their parents/guardians and other family members, and their academic and professional communities.

For the third interview, the goal was to focus on the context of the two previous interviews while reflecting upon the meaning of their experiences. In this case, meaning was solicited by addressing their experiences and their connections across academic, professional, psychosocial, and emotional trajectories in their individual and collective lives.

Organization, coding, and data analysis

The organization and analysis of the interview transcripts took place by utilizing a structured process described by Morrissette (1999) and suggested by John W. Creswell, William E. Hanson, Vicki L. Clark Plano and Alejandro Morales (2007). Also, as recommended by Strauss and Corbin (1998) and centrally necessary to our argument, the points of views and voices of Latinas were included in this study. Following are the six sequential steps we employed to synthesize participants' responses logically:

Steps 1 and 2 The interview as a whole and the interview as a text: These steps require transcription of responses to open-ended questions by a trained researcher who listened to all recordings, reviewed the transcribed text, and checked the accuracy of transcriptions. Also, in order to capture the full meaning and details of the participants' experiences, we

concentrated on the tone of voice, meaningful descriptions, and recalled participant body language during the interviews (Morrissette 1999). Data were organized, managed, and analyzed using NVivo9® qualitative research software. As suggested by Creswell et al. (2007), significant statements and keywords that described and defined participants' experiences were highlighted or coded as free nodes. All relevant statements to the topic under investigation were considered equally valuable.

Steps 3 and 4 Thematic extraction and first and second order clustering: First order statements and themes were grouped into corresponding nodes. During second order clustering, significant statements were identified and some were either reassigned under a new theme or reordered into an existing one. The identification of patterns and common sub-themes was facilitated through the visualized density of strip color-coding. Several combinations of clusters were considered, reworked, or discarded until the final categories were selected.

Step 5 Overall synthesis of the participants' protocols: Reflections on the identified themes and sub-themes, as well as on individual and group experiences, were compared and described (Morrissette 1999). Ultimately, in Step 6, we identified themes of all participants, providing a reference for a between-persons analysis (Morrissette 1999). Thus, inductively generating categories or patterns not labeled by the participants and prompted the creation of new terms. Ideas were tested all through the data analysis phase and emergent findings were either confirmed or disconfirmed as new data and additional information are processed (Patton 2002).

Step 6 Between-persons analysis was conducted to increase trustworthiness, the active participation of the researchers was made explicit and transparent throughout the information and data-analysis phases (Patton 2002). We used multiple sources of data, including archival information from the participants, interview transcripts, and field notes. The participants also contributed to the trustworthiness of the data through member-checking. Accordingly, participants received copies of their individual analysis for review and feedback, and follow-up interviews allowed for confirmation and clarification of points from previous interviews. In order to establish a fair and concise relationship or generalization of the findings to other settings/situations, all elements under investigation were carefully aligned with each other so that none was greater or lesser than the other (Patton 2002). Additionally, Margaret Eisenhart (2009) notes that "sites *[places]* in which context can be investigated and described in detail, in which the sites can be shown to be typical of other sites, and in which the context of the sites for generalization can be good candidates for establishing transferable relationships." (p. 57, emphasis added)

Making CMFs explicit in the transcript data

We acknowledge that when one reads the transcripts adversity can be the most apparent surface probe used to guide the analysis of resiliency in STEM. As such, in our initial analysis we probed the transcripts by focusing on the description of key situations within significant statements that are usually coded as adversity. For example, focusing on overcoming the adversity of a health and/or disability crisis or generating cultural capital to overcome institutional barriers (Trueba 2002). However, to gain deeper insights into the analysis of the power structures which continually (re)shape macro-, meso-, and microgenic CMFs, we looked to consider the ways in which these types of CMFs help to identify and interpret social locations or contexts. "What counts as a "social location" is structurally defined. What individuals experience and understand is shaped by their location in

a hierarchically structured system of power relations: by the material conditions of their lives, by the relations of production and reproduction that structure their social interactions, and by the conceptual resources they have to represent and interpret these relations." (Wylie 2003, p. 31).

Second, our methodological approach was not to privilege elements which normalize the types of academic achievement which disenfranchise and exclude underrepresented people as an effort to claim rigor and meritocracy in STEM. We are not calling for minimizing standards, but rather for a change in institutional commitments and practices that reward and pride weeding out individuals from pursuing STEM career trajectories. Accordingly, we made a conscious decision not to approach our case studies from either a deficit perspective or an essentialist perspective. In other words, we did not probe for how individuals in our case studies were able to overcome adversity to fit an exclusionary achievement trajectory for being successful in STEM.

We reconfigured our approach by first trying to understand the forms and functions of CMFs, which can be positive, negative or neutral, within the stories captured during the interview series. Methodologically, we felt that it was important to understand the relative contours of CMFs, as well as to understand how Latinas enacted culture in the pursuit of entering and/or sustaining their interests and careers in STEM. In our reconfigured approach, we reread the transcripts looking for CMFs and asked what their form and function were as the CMFs were being culturally produced. Our ensuing probe was to explicate and categorize the contours of these CMFs in the Latinas' pursuit of success in STEM. This is not to imply that our categorization of CMF contours is absolute, because what we view as positive, negative or neutral may be interpreted by others very differently.

Some readers may want to reduce CMF analysis to the discernment of existing patterns of academic achievement, thus homogenizing the analysis of our participants' experiences. This would be a misleading way of using CMF analysis and, as such, would ignore its potential. While indeed there may be general patterns of CMFs, it is their actualization which becomes comparatively individualized. In CMF analysis, the standard for positioning of all individuals should not be used to compare with "those who are comparatively privileged (socially, politically), by virtue of what they typically experience and how they understand their experience" (Wylie 2003, p. 26). For example, ethnicity can be considered a macro-, meso-, and/or microgenic CMF. In the US, how ethnicity is contextualized for a person from Mexican origin is very different when compared to other origins. Their social demarcations and experiences are different in accordance to the present day doxas and polity of immigration policies, race, class, economic privilege, and other socially constructed CMFs.

Considering how culture is produced, appropriated, and disseminated in STEM networks and pipelines, as well as through youth and adult networks, in urban, suburban and rural areas is important. The uptake of STEM culture in general, and by Latinas in particular, as with any other formation of culture, takes traction because it helps to structure encounters that are fluent, i.e., timely, anticipatory, and appropriate, among participants. This is a critical notion for understanding why high STEM failure rates occur in systems of education for some people and not for others. Cultures that define the self, and the self that is promoted within STEM fields, are often used as reference points to determine different social demarcations, in different location, which in many cases can create gateways of entry into the different STEM pipelines. In other words, to view STEM systems as a single pipeline where people get on and off based on the outcome of standardized achievement metrics is a very naive way of understanding the enactment of cultures which compete or clash amongst each other across intersecting STEM pipelines.

Accordingly, we pluralized *pipeline* to indicate that approaches to developing STEM exist within the systems of pipelines connecting to the social networks which permeate, extend, and overlap CMFs. For example, when the STEM community typically invokes the term *STEM pipeline*, it is only one pipeline of achievement that is being referenced. This is a historical and cultural reference point that has been well established within the STEM community. The notion of only one pipeline can be thought of as a part of limit-situations found in CMFs, defining the preferred or legitimate mechanisms that are necessary to perpetuate the established STEM fields. Furthermore, the promotion of only one STEM pipeline is a CMF because it is dismissive of the various social places and cultural reference points through which individuals' journey many of which are not considered legitimate parts of the repertoire of STEM disciplines or careers such as P-12 STEM teachers.

Identifying first order thematic CMFs

Methodologically, we began by identifying first order statements to cluster around thematic CMFs. In this initial step, we searched for transcript-based evidence of CMFs, which we subsequently used to probe for limit-situations. Our methodological dilemma is concerned with the formation of limit-situations, one of which can be adversity. The CMFs that make up limit-situations, as well as how they are shaped and reshaped by changing CMFs, are driven by who a person is and how they are positioned by their gender, race, and ethnicity, as examples.

Being able to read and act upon CMFs constituting limit-situations provides the potential to develop critical consciousness, something we consider both a milestone and a critical property of resiliency. Accordingly, we searched the transcripts for CMFs identifiable as individual themes, and subsequently clustered them into broader themes identified as limit-situations. In this phase, we used CMFs as the unit of analysis. Some readers may view using CMFs as a unit of analysis and as such reducing their awareness of other contributing factors. However, we define CMFs as an aperture to a complex host of connected sociocultural, -economical, -historical and -political mitigating factors helping constitute dynamic formations of limit-situations, and that focusing on CMFs as a unit of analysis provides a richer, deeper, and more contextualized examination of those limit-situations. Using the notion of aperture as a metaphor implies a polysemic approach to analysis because we are treating CMFs as representations of contextual factors that include and cut across all spectrums of the sociocultural, -economical, -historical and -political panoramas. Evidence found in analysis of the text of sociocultural, -economical, -historical and -political spectrums are representations of social places, or localized spaces, co-constituted by CMFs.

CMFs as systemic constructs

CMFs coexist in localized spaces with representations of past, present, and future sociocultural, -economical, -historical and -political positionings that can aggregate into limit-situations. As the unit of analysis, CMFs are also mitigated upon when they are positioned and re-positioned by hegemonic forces. Specifically, in order to unearth limit-situations, one must be cognizant of (1) the CMFs that make up a limit-situation and (2) the fluid dynamism that constantly changes the character of limit-situations which are situated in

localized spaces. It is important to recall that CMFs and limit-situations are not a distinct product of an individual, but rather are constituted by other limit-situations which exist as part of both agentic actions and representations of the sociocultural past, present, and future. Accordingly, a necessary step in CMF analysis is to make CMFs and limit-situations explicit. This implies that not only must individuals be able to read the landscape, *sens pratique*, (Bourdieu and Wacquant 1992), but so must the researcher in his or her approach to CMF analysis.

A critical task in using CMFs as the unit of analysis is to unearth tactical understanding. Evidence for tactical understanding found in textual data comes in the form of an explicit awareness (a) of CMFs, b) that CMFs *can* position or reposition an individual, (c) how CMFs position or reposition individuals, and (d) of the precursors to agentic action. For example, one of the Latina participants spoke English with a noticeable accent. According to her, her classmates made constant fun of her accent and would express doubt as to why she was placed in STEM classes. She recognized that the limit-situation was not solely about her peers belittling her accent, but their attitude that Latinas should not be in STEM classes. The awareness of limit-situations, which we define as tactical understanding, is necessary but not sufficient for the development of critical consciousness which can lead to agentic action. As such, in searching for evidence of critical consciousness, we are also looking for associated acts and representations. As mentioned earlier, we define resiliency as the act of developing critical consciousness that can lead to emancipation. This mean that when looking for expressions of resiliency in textual evidence, we are also probing for representations of emancipatory acts. The aforementioned set or host of complex factors locatable in textual data is also further justification for not using adversity only as the initial probe for resiliency.

CMFs as a probe for textual clues

The methodological approach that we outlined above is the blueprint we used for using CMFs as an initial probe. The obvious temptation is to use CMFs as direct evidence for the representation of resiliency. However, we argue that this temptation is problematic and ignores substantively the richness of CMF analysis in understanding agency in the face of limit-situations, as one may imagine or envision acts of resiliency but never act upon them. Thus, from a methodological perspective, one cannot account for what a research participant imagines. Rather, one should use CMFs as a probe for textual clues to indicate that there are cultural reference points which can lead to resiliency. This is why we used CMFs while probing for textual evidence which demonstrates the existence of limit-situations, and whether resiliency was enacted therein.

Regardless of whether textual evidence of resiliency exists or not, from an intervention perspective, the absence of evidence of CMFs is a signal that one needs to go back and probe both respondents and researchers. We suggest this in order to help make CMFs explicit to both researchers and participants. First, researchers need to acknowledge that possible offsetting worldviews may exist between researchers and participants. Further, researchers need to acknowledge that these can serve to obfuscate or make clearer the dormant or invisible CMFs which position individuals as evidenced within the contextual data. Here, we caution CMF researchers that indifference to making a particular theme of CMFs visible is an indication of cascading methodological bias, because it spills over clearly into the analysis.

Specifically, researchers need to acknowledge and make explicit those CMFs which influence their studies' methodological frameworks. This is essential because people, and particularly researchers, need to be helped in visualizing cultural reference points in landscapes, *sens pratique*, as well as the landscapes they share, so that they can make CMFs and limit-situations explicit. We are not advocating leading the participant or the researcher, but as Wylie (2003) suggests, "What individuals experience and understand is shaped by their location in a hierarchical structure of power relations, […material conditions, social interactions] and by the conceptual resources they have to represent and interpret these relations" (p. 31). As an example, in one of our cases which we present below, we had to ask the respondent three times what it meant to be Latina. Each time we asked the question anew, we would use past textual data from previous interview sessions to help her understand what it was we were asking and why we believed that the question was important. We suspected that she associated being Latina with not only having to confront structural problems such as systemic biases but also personally having to handle how she is (re)positioned by her gender, ethnicity, and other cultural demarcations. We knew that she was an extremely proud person. For example, she always insisted on handling her ownproblems. This led us to speculate that she purposely distanced herself from the question, because she would rather deal with the complexities and power relations of what it meant to be Latina by herself. If this was the case in fact, we empathize specifically because the cultural constructs of being Latina are neither linear nor monolithic, but rather create differentially unique socio-cultural, -economical, -historical and -political trajectories and positions. These trajectories and positions are simultaneously being (re)shaped across global,macro-, meso-, and microgenic formations of CMFs. In essence, we believe she refused to recognize that perhaps there were a plethora of cascading cultural reference points surrounding her being Latina.

In our approach to analyzing the textual data we identified thematic CMFs and categorized them as either macro-, meso-, or microgenic. From a methodological standpoint, one of the characteristics of using CMFs as the unit of analysis is that neither the insider nor the outsider views are privileged. We take this position because CMFs have exploitative and non-exploitative powers based on how an individual, or collective, is positioned. This established an explicit set of cultural reference point(s) which guide the use of CMFs as units of analysis. This sense-making process allowed us to probe for evidence of limit-situations, tactical understanding, and the development of critical consciousness as understood through representations of agentic actions from different perspectives and places.

The use of CMF analysis in case studies

Below, we showcase two case studies where we demonstrate how to use CMF analysis to examine textual data in looking for evidence of resiliency in the pursuit of STEM careers. Our goal is to demonstrate clearly how using CMF analysis can make explicit the intersections of contextual spheres of CMFs, which can be used to probe for resiliency in textual data sets.

Case #1: Dionisia. In the first case study, we showcase a high school student's experiences with the educational system while she participated in a physics class. We highlight not only the educational experiences she brings into the physics class, but also her cultural sensibilities associated with being a Latina to include ethnicity and gender.

In this case the student whom we will call *Dionisia* confronts the CMFs associated with the practices of classroom participation. In particular, we are interested in understanding why *Dionisia* has to develop strategies to counter her experiences in school to be successful in her physics and other STEM courses. These strategies are based on her situated knowledge of a limit-situation and a tacit tactical understanding developed from participation in a repeating limit-situation shrouded in varying contextual disguises. A second CMF that intersects and coheres closely to classroom participation is gender. In this particular case, it is the gender identity that is contextually mitigated, through internalized hegemonic forces and simultaneously (re)negotiated and played out in the classroom.

Why is it that in the social place called school *Dionisia* feels that she must develop strategies of resiliency if this social place encourages patterns of participation for all? Is this unique to STEM courses or just physics courses?

Asking for help in a STEM classroom. As a place of social, cultural, political, and historical interactions, the school environment is a set of complex intersecting and overlapping CMFs, providing opportunities for the researcher to identify limit-situations at a variety of interconnected levels of social construction, ranging from the micro- to the macrogenic. We do not consider CMFs as units of analysis, because to do so would necessitate ignoring the intersection of contextual spheres in which a CMF intersects with other CMFs. From a research perspective, we also do not claim to identify all CMFs at play in analyzing limit-situations, because all sense-making is experientially based and culturally produced. Thus, analytically, our approach was to identify CMFs and associate them with the formation of limit-situations. Doing so provided a much deeper structural picture of the implications of a CMF within a contextual setting.

This allowed us to contextualize positionality from various perspectives and probe for contextual indicators that limit-situations are being identified and that tactical understanding is being developed. For example, using school environments, a CMF, as a unit of analysis is to recognize that there exists a host of other complex CMFs localized within multiple places that co-create limit-situations as differential indicators across levels of social construction. Asking for help in school settings is an example of such a limit-situation.

It is the combination of all CMFs associated with school environments that represents and guides *Dionisia's* experiences in school one of which is seeking help. She has learned through direct or indirect experiences that asking for help may make her look unprepared or disruptive. For example, Silvia Lizette Ramos-de Robles (2016) discusses the notion of repetitive patterns in classrooms in school settings. It could be that *Dionisia* has picked up on a repetitive pattern throughout her educational experience in multiple school settings that have consistently resulted in the silencing students even those seeking help. Also, as Ramos-de Robles argues that it is important to recognize that students not only pick up on patterns of silencing, but that they also take agentic action through negotiating silence in the classroom along with negotiating knowing when and whom to ask for help. Based upon numerous prior interactions seeking academic help from teachers and having witnessed her peers do the same *Dionisia* seems to have perceived the limit-situation of the silencing of students. *Dionisia* has also perceived how students, herself included, are positioned when patterns of silencing are experienced. *Dionisia's* awareness of patterns of silencing helps us to identify the tactical understanding she developed in knowing how to deal with the limit-situation identified, enacted as knowing when and whom to ask for academic help. Teachers' attitudes toward student participation in class settings is an example of an intersecting CMF in the limit-situation of silencing students. Being selective as to which teachers have the attitude and the commensurate practice that encourages student participation

is an example of tactical understanding and agentic action based on critical consciousness resulting in the enactment of resiliency.

As mentioned earlier, some CMFs can lay dormant, which implies that limit-situations can also be dormant. Alternatively, some CMFs may be invisible, implying that associated limit-situations are also invisible. What is the difference? Dormant CMFs can be activated by contextual positioning and by other CMFs. We suggest that contrarily, invisible CMFs are embedded as doxas and usually are considered normative. As an example, the movement in the USA to allow women into combat roles was once an invisible CMF in a male dominated society. The recent development to begin allowing women to choose combat roles is an example of contextual positioning of CMFs. In other words, the CMFs associated with not allowing women in combat roles went from being invisible, or a doxa, to being potentially a recognizable part of limit-situations which influence and are contested in the career aspirations of a female soldier. Even though women can enter combat roles, some women who choose to apply for combat roles will continue to experience both hidden and visible attitudes and behaviors, CMFs, from both men and women who disagree with this new professional opportunity for female soldiers. This was particularly visible when Ranger School was opened to women. The first female Ranger School graduates were on the receiving end of numerous baseless accusations of benefitting from a reduced and less rigorous training experience, and that consequently their earning the Ranger Tab somehow diminished the value of the award for all those who came before them. Much like the racial integration of the armed forces, both were a result of orders and do not speak towards the plethora of CMFs associated with racist and sexist attitudes that exist both in the armed forces and society more broadly speaking.

This situation is highly comparable to a female student who has aspirations to become part of a professional STEM workforce. Likewise, she will face multiple limit-situations as she pursues her goal along STEM pipelines. Funding agencies and the private sector may invest billions of dollars, the academy may give scholarships, and companies may institute preferential hiring programs for female STEM professionals but these actions do not erase the negative CMFs women face in the STEM workforce. Reactions by some readers to the aforementioned may take several of the following forms, just to name a few: (1) things are getting better; (2) all women have an equal opportunity; or (3) they just cannot cut it. However, there are still extant CMFs that can remain dormant, invisible, hidden, and even unrecognizable by advocates of diversity to include more women in the STEM workforce that permeate limit-situations involving women who want to pursue STEM. The potential for change is not stagnant. As such, it does require constant vigilance because the nature of CMFs can cycle and assume new forms in and out of dormancy, invisibility, and recognizable positions of positive, neutral, and negative states.

From a methodological perspective, even when multiple CMFs are identified and coded by researchers, other CMFs may lay invisible, unidentified and/or unrecognized. These CMFs pose the largest methodological dilemma which is to say that in spite of a researcher's best efforts to associate meaning with CMFs, there are sociocultural contextual influences that are neither identified or cannot be accounted for but their influence remain. This situation is not unique to the research endeavor whether associated with qualitative and/or quantitative methodological approaches. There exist CMFs that are woven deeply into the fabric of methodological perspectives that become academic doxas. Accordingly, for all researchers who will use CMFs as their point of analysis, it is important that they must be aware of two limitations. The first is how researchers are biased by their worldviews, as these are shaped by their experiences and expectations. The second is that sociocultural ways of making sense creep into methodological frameworks.

Gender

The contours and characteristics of limit-situations as social places are co-created by a plethora of complex CMFs which intersect and provide the landscapes for individuals to enact resiliency. For example, in proceeding with our analysis of *Dionisia's* situation, we recognized that silencing is a negative CMF, but it could also be a positive CMF in the form of agency. Accordingly, silencing as a CMF can cycle into new forms, some which may become invisible and others dormant, as a researcher endeavors to make meaning in order to unearth and understand limit-situations. Taking the aforementioned into consideration, the data from the transcripts provide examples indicating the importance of unearthing one's gender as a macrogenic CMF within the STEM fields. Gender can (re) cycle across macro-, meso-, and microgenic formations of dormancy and invisibility, thus acknowledging the intersection of multiple CMFs that can serve as platforms for positioning students in STEM educational settings.

We found examples of this in analyzing *Dionisia's* transcripts. When *Dionisia* was asked the following question: "What is your perspective of being a girl compared to being a guy?", she responded thus: "I guess being a girl, I'm more caring. Girls are usually more caring than boys." Where did she get this idea that girls are more caring than boys? We were very specific in asking this question in this particular manner, because we were curious as to how she views herself in relation to her peers, particularly boys. We thought that perhaps this would give us insights into one of the reasons explaining the dearth of women in the sciences, further explaining why those few who make it have difficulties in male-dominated STEM fields (U.S. Department of Commerce, Economics and Statistics Administration 2011).

The absence and/or underrepresentation of women in STEM fields is a CMF that is part of a limit-situation which impacts and occurs in many STEM pipelines. In particular, women who recognize and face these limit-situations often experience a deep feeling from institutional and societal perspectives that they do not belong there (U.S. Department of Commerce, Economics and Statistics Administration 2011). The recognition of significant macrogenic structural barriers also help to support and prime overt meso- and microgenic barriers which can morph and recycle into doxas about women in the workplace, particularly in STEM fields. We found strong evidence in the data generated from *Dionisia's* transcripts that a powerfully negative microgenic CMF is that women believe that they do not belong in STEM fields. For example, when asked to explain why there are so few women in the STEM fields, *Dionosia* indicates: "I guess that they see that more men are there and that they don't feel like they can be there. Or then again people where they're from, some people view it as a wrong place where women should be." This notion is often reinforced in the processes and products of mesogenic CMFs associated with gender. *Dionosia* goes on to indicate how this mesogenic CMF cannot be compartmentalized. She states, "I guess society mainly would be a problem. Sometimes society doesn't accept women belong in some places." Upon further reflection, she notes: "It could also be that they don't, well if they don't have the support it means that they still scared. And they don't have enough courage to go into there." Indeed, notions of belonging and sense of place can exacerbate the idea that women do not belong in the STEM pipelines.

The criticalness of identifying intersecting CMFs helps us to understand that the problem is not the just the dearth of women in STEM pipelines, but also that powerful CMFs emit historical, institutional, structural, and political signals in the form of invisible societal and academic doxas indicating that women do not belong in the STEM pipelines.

In order to understand this, a researcher must make connections to negative macrogenic CMFs associated with gender. The negative CMFs help to form damaging dichotomies in society created along gender lines. The macro- and mesogenic level CMFs found in sociocultural institutionalized practices which promote and maintain a dichotomy along gender lines can also be found in the microgenic level CMF of female attitudes towards careers in STEM fields. The enactment of gender and gender representation are not a compartmentalized CMF. As such, the enactment of gender (re)cycles as meso- and microgenic CMFs along with other CMFs, such as silencing. By identifying gender as a macrogenic CMF, we realize the importance of understanding the enactment of gender in society. Similarly, by combining the CMFs of gender and silencing women's aspirations to become professionals in STEM, we are able to look at the intersectionalities that help to shape the complexities of limit-situations. These negative CMFs are antecedents that policymakers and research-sponsoring funding agencies must address in order to improve the number of women, to include young girls in STEM careers, otherwise, efforts to increase the number of women in STEM pipelines will only be as successful as negative CMFs allow. While there are some women who are successful in identifying and agentically combatting a disenfranchising limit-situation, thus resulting in success in STEM careers. This should not be taken as a sign of progress, but more as a sign that while some have made it, most did not.

Case #2: Karma. The formal and unscripted learning places and their intersectionalities. The manner in which learning experiences are situated help to form a spectrum of intersecting CMFs, which in turn assist in creating a range of intercontextual places that can form limit-situations. In Fig. 1 above, we display the multidimensional networks of macro-, meso-, and microgenic CMFs which can produce intercontextual places that theoretically have the potential to become limit-situations. Individuals both experience and help to structure the contours of these intercontextual places by creating explicit pathways for understanding how best they learn. For the purpose of this case, we identify and focus on two important sets of intersecting macrogenic CMFs, which we identify as (1) formal and

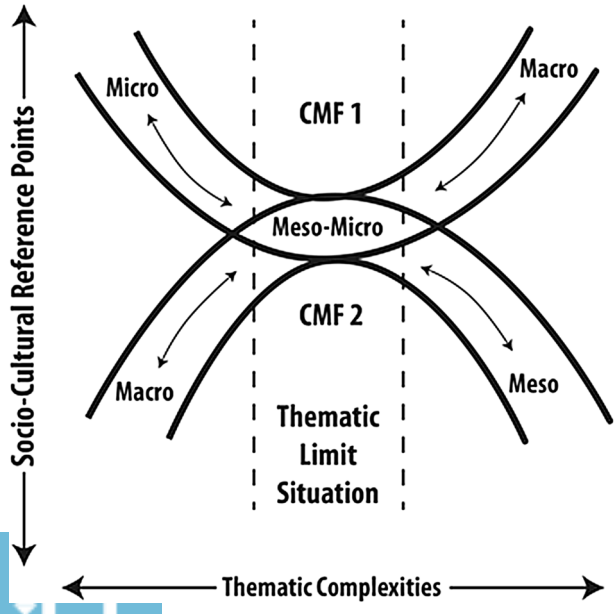

Fig. 1 This is a conceptual flowchart for CMF analysis which indicates how the spectrum of intersecting CMFs are formed. The multidimensional networks of macro-, meso-, and microgenic CMFs can produce intercontextual places we have theorized as potential limit-situations

unscripted learning places and (2) the resulting formation of their respective intercontextual learning spaces.

These intercontextual spaces have the potential to be disruptive towards how teaching and learning in STEM classrooms occurs. For example, when students take and enact responsibility for their learning needs, they facilitate the potential for disrupting STEM teachers' attitudes and beliefs which do not benefit their individual learning needs and curiosities. By doing so, students create competing tensions which disrupt the aforementioned beliefs and attitudes, often found in intercontextual spaces: asking a question and exploring for an answer versus worrying about getting the answer correct are some examples. What we identify are macrogenic level CMFs that are formed by similar or flanking intercontextual spaces with mesogenic level CMFs. These intersecting tensions have the potential to empower individuals to either reinforce or disrupt limit-situations formed by both formal and unscripted learning spaces.

Formal and unscripted learning experiences are types of macrogenic CMFs which can often intersect. Examining the intercontextuality of these spaces can shed insights on how tensions in learning situations can either be reinforced or be disrupted. The following excerpt from the textual data contains evidence of disruptive action that reinforces the idea that STEM students need learning spaces to satiate and increase their curiosity about STEM phenomena. During *Karma's* interview, she mentions that she developed a desire to go into a STEM field at an early age. She also documents several unscripted learning experiences that we consider to be part of learning STEM which occurred at home. These included playing with Legos, watching interior design shows, and exploring machines and computer programming. When asked about what motivated her at such an early age, *Karma's* response:

> Before I turned 8 because I had a Lego set, and I really loved building stuff with it, so I had gotten into the idea of being an architect and then from there I went into the idea of interior design and some people think the idea of interior design is what you see on HGTV but it's much more intense than that… Well I like to get my hands dirty; I used to take old stereos and VCRs and open them up and look at the stuff inside and I didn't understand what I was looking at, but now that I'm older I know what the different things are and I know how they make the components work and stuff like that.

Karma was curious and took the steps to satisfy her curiosity in a space in which curiosity was rewarded.

Karma's creation and participation in a learning space that met her curiosity needs could be considered both a process and a product of microgenic actions in the formation of curiosity as a microgenic CMF. A microgenic action for us is a generative form of agency that we associate with microgenic levels of cultural enactment and cultural reference points. In other words, she understood her learning needs. She was able to act *freely* and address her learning needs in order to fulfill her curiosity. Her actions became a pathway, cultural reference point, to develop understanding of STEM phenomena in a learning environment she helped to develop. The same can be said for macro- and mesogenic levels of cultural enactment. In order to dig deeper into the notion of intercontextuality as a cultural reference point, we asked ourselves: Has *Karma* been offered additional opportunities to create and experience intersecting intercontextual spaces of curiosity within formal educational settings? The answer is yes, but it is a rare and qualified yes.

During the exchange below *Karma* explicitly recalls that she was allowed to enact her curiosity in an unstructured manner once.

R: Okay, let me ask you another question. Did any of your teachers ever notice your curiosity?

Karma: I don't think so. The only person who might have was my first professor in the physics department. But I think she had the opportunity to notice by the way we did our labs. In her class, the way we did labs is we were given a box of stuff and a list of objectives and she said make it work. So we got to create our own labs. So it got to a point where myself and my group we usually did so well with what we did and there was 1 day where I was just like I don't understand what I'm supposed to do with this to make it work. And she said that's fine, go home. And I don't know if that was because she knows that I can get it and I normally can do it or what. But she's absolutely the only person who ever got the opportunity to truly see my curiosity in the classroom, everything else was so structured there was no room for curiosity.

As seen in *Karmas* response above, CMFs that help to structure the context in which learning experiences occur particularly curiosity and exploration become important to consider. This includes the development of imageries that can also help to contextualize STEM learning experiences, because they are simultaneously the product and the process of cultural enactment. Accordingly, imageries are a form of CMFs that can be associated with enacting STEM learning experiences: curiosity and exploration are examples. In both formal and unscripted learning spaces that allow for curiosity and exploration without consequences, imageries are coexpressed and combined with other multidimensional forms of CMFs that help to generate opportunities for learning throughout the STEM pipelines. Not allowing for the development of positive and meaningful imageries as a part of STEM learning spaces occurs when students are not allowed or encouraged to be curious and unstructured. This has severe implications for learning activities, such as problem-, project-, and place-based learning curricula in STEM classrooms.

Simply providing STEM students with opportunities to explore STEM phenomena, using a scripted guide to execute a set of learning techniques as well as learning how to confirm existing STEM knowledge neither creates opportunities for students to bring what they know to the learning table, nor promotes curiosity and exploration. This notion is seen in *Karma's* words as she discussed her experiences about learning physics in the formal setting: "In her class, the way we did labs is we were given a box of stuff and a list of objectives and she said make it work." While *Karma* was not explicitly asked about the learning model that her physics professor enacted during the lab, we inferred it to possess the features of project-based learning.

While there is value in providing well-articulated learning objectives, they should not be enacted by stifling student curiosity. Specifically, we are referring to the attempt to create exploratory spaces through educational policy, seen as cascading into positive mesogenic CMFs. Having said this, we view educational policy that promotes using scripted guides to execute a set of learning techniques as a set of negative macrogenic CMFs. These policies guide the context which creates systemic emphasis on meeting policy and assessment needs, as opposed to meeting the learning needs of the individual. The systemic nature of education policy, as CMFs, can provide intercontextual influences which help to shape limit-situations. We are not arguing that educational policy is the singular culprit or solution, however. It is simply a key CMF and it has to be understood how policy is enacted and shapes macro-, meso-, and microgenic culture associated with pedagogy in STEM classrooms. We want to underscore that approaching education policy with a checkmark mentality as opposed to the spirit of the policy is stifling and hyper-structures learning objectives in a fashion which promotes STEM content acquisition over individual learning

needs (Gallard Martínez and Antrop Gonzalez 2013). For example, in the learning situation described by *Karma*, when she indicated "that the teacher knew we would get it" and sent her home does not imply that there were no learning objectives established by the physics department. It simply indicates that the physics professor accounted for *Karma's* learning needs, and had faith that she would acquire the content. In this interaction, the physics content was secondary to *Karma's* learning needs.

However, what we describe above is at the tertiary level of education, in which state educational policy is limited in its reach into undergraduate STEM classrooms. This is very different from the primary and secondary classrooms, where the state has a substantively deeper reach into the daily functioning of the classroom. In P-12 levels, educational policy can be misunderstood, and thought of as dictating what STEM content to teach, and how. Making explicit another intersecting mesogenic CMF, the use of structured scripts may result from images that knowing STEM phenomena is best represented by enacting a set of discrete STEM scripts as facts. Both students and teachers can experience intercontextual CMFs which create limit-situations permeating both formal and unscripted learning settings. It is the recognition of these limit-situations that lead to critical consciousness, which then can lead to emancipatory learning actions as forms of resiliency. Emancipatory learning actions can be a function of place and agency when resources found within places are taken advantage of. *Karma* created a form of resiliency by exploring STEM phenomena in her home in unstructured and unfettered ways. For *Karma*, this was a form of unstructured learning that was fostered years later in a physics course. It also seems as if the seed of resiliency that *Karma* displayed in the physics course was developed in her personalized learning places. This was evidenced by her indicating that the instructor did not worry about her grasping the content and learning objectives, but allowed her and her lab partners to enact and create their own learning places. We believe that this is because at an early age, *Karma* enacted the means to create learning social fields which we think of as learning spaces conducive to her learning needs, and thus developed forms of tacit knowledge which helped her understand the kinds of learning opportunities she needs and does not need. This tacit knowledge is a CMF which laid dormant until she was given the opportunity to actualize it with others in a physics classroom. This makes us ask: How can structured formal settings, CMFs, be restructured to value exploratory experiences?

Exploratory experiences at a very young age are not only important in the development of a positive attitude for pursuing a STEM-related career, but they also are important to facilitate the focal points for learning STEM content. Digging more deeply into *Karma's* transcripts, we reanalyzed the following: "Well I like to get my hands dirty; I used to take old stereos and VCRs and open them up and look at the stuff inside and I didn't understand what I was looking at, but now that I'm older I know what the different things are and I know how they make the components work and stuff like that." It is not just learning experiences that are important, but the way these experiences are experienced (Dewey 1938). Accordingly, it was important for us to recognize that learning experiences can be influenced by learning fields across a spectra of macro-, meso-, or microgenic CMFs and, depending on the type, quality and focal points of the experience, can also create limit-situations.

The intersection of CMFs, one of which is the social spaces of home and the other unscripted inquiry, allowed *Karma* to create learning experiences driven by curiosity's sake. In creating these types of exploratory learning experiences, there was no right or wrong pathway to formalize inquiry. The emphasis was on learning through exploration and not to initially mimic the tenets of the nature of science. Additionally, in the process of maturing exploration that eventually led to conceptual development of inquiry of STEM

phenomena, there were no formal penalties or sanctions for *misconceptions*, or even the need to scientifically argue a position. This type of exploratory experience is often not perpetuated, or seen as valuable, in STEM classrooms, nor in educational policy guiding STEM instruction. Unfortunately, even when there is an explicit desire to guide students in this manner, the emphasis is on getting correct answers as opposed to allowing students to take responsibility for their learning by engaging in exploratory experience.

CMFs as pathways to further learning opportunities

If the learning environment as a CMF is critical to learning science content, then both formal and unscripted learning situations must have the potential to be imagery creators. The creation of imagery can facilitate conceptual development of STEM phenomena and offset teaching that is centered on lectures and note taking. Whether formal or unscripted, learning situations should be enacted in such a manner that imagery can be attached to existing knowledge and other sociocultural assets which STEM students bring to the learning table. In both *Dionisia's* and *Karma's* cases, we found examples of multidimensional CMFs, including imagery, associated with both formal and unscripted learning situations which helped them to negotiate the limit-situations they later encountered in STEM study. Also, in each case, *Dionisia* and *Karma* experienced CMFs that together not only created limit-situations, but also created opportunities for the development of tactical understanding that may have helped them achieve critical consciousness. And in addition, in each case, the development of tactical understanding and critical consciousness seemed to help them enact pathways to further learning opportunities. For example, even though they understood the importance of exploring for curiosity's sake, they also understood the systemic culture of teaching and learning in STEM classrooms through reading the landscape, or *sens pratique.* This became the basis for tactical understanding, which seems to be based on their further reflection on the intersections of systemic and local cultural images of teaching and learning. We suggest that how teaching and learning was enacted and experienced in their respective STEM classrooms became a CMF that contributed to their success in STEM.

Policy implications

There are many doxas surrounding teaching and learning as they relate to STEM content. Of the many that exist, we offer the following example of a cascading macro-, meso-, and microgenic CMF which is what teachers believe they must do. In this case, it is no accident that the chapters of a STEM textbook are closely aligned with the length of an academic year. A textbook's composition is an excellent example of how this macrogenic CMF can cycle to become a microgenic CMF. The problem for us is that educational policy does not specifically speak to covering all chapters in a text, but more so to the teaching and learning of concepts. This is not a matter of policy, but one of interpretation at the macro-meso-, and microgenic levels resulting in the following cascading logic: The test told me I had to cover all 12 chapters; it was not the Department of Education, superintendent, or principal. The end result is that the teacher has contributed to the creation of their own limit-situation. In many cases, the logic of covering subject matter with breadth instead of depth can easily lead to become part of doxas embedded in education and public notions

of both *local* and standardized testing. This is not a new criticism of education and testing, but it is an insightful example of what happens when results, which is an endpoint, are used as the basis of analysis while ignoring the complexity of macro-, meso-, microgenic CMFs.

CMFs aggregate to develop social spaces which can be populated by, or found within, limit-situations. Alternatively, CMFs can aggregate and as a body create positive situations within the same social spaces. In either case, aggregated CMFs help to create thematic compositions, such as standardized testing situations, embedded within social spaces. In other words, thematic compositions are both process and products and can position individuals along a spectrum of experiential continuities which can either be positive, negative, or a combination of both. Continuities of CMFs are socially constructed and can be exploited by individuals which in aggregation can form limit-situations. On the other hand, social spaces can be formed by a spectrum of CMFs that have the potential to emerge as opportunities based on positive experiences. Accordingly, within social spaces, one finds thematic features of experiential continuities that by their very nature (re)position individuals. These can, for example, be seen in formal and unscripted educational pathways into STEM.

Enacting critical consciousness and creating systemic change

The limit-situations which challenge Latinas in this study include racism, sexism, stereotyping, socioeconomic status, and not only being non-native English speakers, but having to deal with English-only assessments throughout the STEM pipelines. What we have found to be crucial is that identifying and overcoming adverse CMFs that comprise limit-situations through tactical understanding is required in order for Latinas to develop the ability to succeed in STEM pipelines, which they accomplish through the development of critical consciousness in the form of resiliency. Accordingly, an important aspect of systemic change is to consider resiliency as an enactment of critical consciousness, and to consider that learning environments are experienced as parts of multilevel CMFs characterized by intercontextuality. This encourages an approach to reimagining STEM pipelines that are inclusive of both formal and unscripted learning experiences to occur. By incorporating both formal and unscripted learning experiences, and by allowing them to shape Latinas' notions of critical consciousness to promote and sustain resiliency in the processes and outcomes of teaching and learning of science content, educators can create conditions which lead to further meaningful learning. Much of the resilience that the Latinas of this study have developed has been in social fields external to school. Accordingly, we believe that if science teachers want to improve students' performance in STEM they will need to understand the array and complexity of sociocultural factors, influencing the agency of their students. Without taking CMFs into consideration improvement efforts geared towards the teaching and learning of science may fail. One reason why they may fail is that these efforts are unattached to the other social fields in which student life develops. In the end, STEM teachers need to pay more attention to the contextual realities existing out of school thus making STEM education more pertinent. If it is important for underrepresented people and Latinas in particular to progress successfully in a STEM pipeline, systemic changes are both critical and necessary.

The structure of formal education, as often articulated in policy-generated notion of a STEM pipeline and achievement, needs to be addressed in systemic change. One of the systemic changes which could be enacted is a definitional shift in what constitutes learning

in STEM fields: instead of classifying it as the result of standardized tests which can contribute to the widespread notion of *having to* teach all of the chapters because students will be tested on them, learning instead could be defined as the mastery of scientific skills and modes of thought in a fashion which is contextually grounded and meaningful to students. The extant definition of STEM education provides examples of cascading CMFs found at the macro- and mesogenic levels which often manifest as CMFs at the microgenic level in the form of a checkmark approach to teaching STEM content. Checkmark approaches leave little room for other learning experiences, such as opportunities that are unscripted. Presently, when we assess what a student knows and is able to do, we assess what we know and what we are able to do, not necessarily student achievement. This pitfall of assessing student achievement as an intersectional CMF can lead to the creation of limit-situations if the intent is not to allow students to develop a sense of place in which they can engage in exploratory experiences and imagery associated with STEM. In attempting to foster curiosity as a transformative experience, should STEM students be provided an opportunity to explore STEM phenomena, using only a scripted guide that structures them in such a way that the concern is to execute a set of learning techniques as well as learning how to confirm existing STEM knowledge?

A first set of intersecting CMFs is the intersection of the space within which an individual takes responsibility for their learning and understanding their learning needs by moving freely within a space without negative consequences. This means that an individual is able to exploit the space they created, which is an agentic action. In doing so, they concurrently position their actions to re/shape CMFs as actions of their empowerment. For example, in *Karma's* and *Dionisia's* respective situations, it is important to consider that they were able to create the contexts necessary for their learning to take place. Taking control of their learning could be considered agentic actions and a stepping stone for facilitating the development of resiliency. In other words, they have developed a critical consciousness about what is necessary for empowerment when wanting to learn. The second intersection occurs where the CMFs involved in the development of teacher attitudes and beliefs about knowing and learning content in the STEM fields cross. It is reflected in the following student question: "I know what I need to learn; why am I not getting the opportunity to learn in this manner in school?" If this question is ignored, then another set of CMFs intersecting STEM pipelines and notions of STEM achievement have been created: STEM teachers' beliefs about what is content, and how one acquires this knowledge.

Challenging our thinking and status quo(s)

Like any other research methodologies using the concept of units of analysis, there is always an inherent danger that doxas which permeate methodological thinking will dismiss CMFs as forms of variables, asking: *So what? What's new?* Many readers might dismiss the notion of CMFs by implying that the authors of this paper are simply talking about contextual variables. We contend that to levy this criticism suggests an adherence to a methodological approach where the modes and processes of end-point analysis are privileged over the unfolding of the analysis throughout the method.

Additionally, many authors incorporate a context section in their research report that discusses in very discreet ways the *context* of their study. This discussion is often lacking and flat, because it treats the *context* almost as background noise that must be parked somewhere as a required part of a manuscript. However, as Bourdieu (1988) advocates, "let's

break with vague references to social world-through words such as context, setting, environment, social background" (p. 144). If one thinks about context as overlapping fields, then each field "has its dominated and dominant, his conservative and avant-garde, subversive struggles and reproduction mechanisms… in which all players entering the field are imposed" (p. 144). Bourdieu's notions that guide our thinking make it difficult for us to understand how research methodologies can treat context and related CMFs as background noise without losing sight of sociocultural enactments. To us, this seems impossible. Because individually and collectively the unique ability of CMFs is always to (re) position the sociocultural aspects of contextual settings, they cannot simply be considered variables that can be isolated from the context in which they are situated. CMFs can never be held in check when analyzing their influences on data collection and analysis, because they have a cascading effect.

Our standpoint epistemology is that in the context of using CMF analysis to support research designs an important goal is to incorporate avenues of analysis that acknowledge the existence of continuous contextual influences throughout the research process particularly in understanding data and answering research claims. As such, in any research genre, using CMFs as the initial point of analysis does not privilege insider knowledge and perspective over outsider knowledge and perspective. In the creation and analysis of data, it is important to understand that the theoretical frameworks used to create the data are a result of positional CMFs brought to the table by all stakeholders involved in the research. By implication, the evidence, the interpretation, and even the use of the same are always influenced by CMFs that continuously (re)position both the research agenda(s) and all stakeholders connected to the research. In this manner, CMFs are always in play and are never stagnant, either explicitly or implicitly throughout the entire research process.

Implications for planning interventions and final remarks

CMF analysis provides an additive framework that when incorporated throughout STEM intervention and programmatic designs points to CMFs which can implicate new forms of methodological design and structural approaches. As in research designs, intervention design and funding mechanisms are subject to doxas that surround teaching and learning including STEM education. This includes what constitutes *legitimate* perspectives on STEM pipeline(s) pathways and associated achievements metrics. CMF analysis demands that institutions and individuals associated with conceiving interventions, where the endpoint(s) are used as the only basis for the design of being more inclusive, not ignore the complexity and aggregation of macro-, meso-, and microgenic CMFs. For example, there exists multidimensional positive CMFs which can be found in a sense of places via social institutions, among these, family, church, schools, and groups of peers. A purposeful effort is required to help underrepresented people and institutions to build on the aforementioned positive CMFs in order to develop a strong sense of place in the STEM pipelines.

As we discussed, CMFs and STEM pipelines in a presentation at an international research conference, a tension was created between the notion of STEM pipelines and academic achievement during the question and answer period. We believe the ideas of STEM pipelines and achievement are applicable to this paper. The idea of closing the achievement gap seems to be a notion isolated from many CMFs associated with STEM learning. The exclusion of CMFs such as those who decide who should or should not be in a STEM profession as well as the socioeconomic status (SES) of students are critical aspects that must

be aggregated with achievement. As such, Baker's, Farrie's, and Sciarra's (2016) assertion that to close the achievement gap, one must first close the resource gap is a prime example of how to make CMFs explicit and included in the analysis of data. In addition, while SES as a macro CMF provides a well noted framework for designing interventions that help to address the STEM access and achievement gaps, these interventions struggle to sustain significant impact.

In closing the resource gap, there are associated CMFs that can be macro-, meso-, and/or microgenic simultaneously, because closing the learning achievement gap is a political, neoliberal objective, and is not necessarily the responsibility of the student. If the CMF of closing the achievement gap cycles cascades from a macrogenic level through to meso- and microgenic level CMFs, then an individual must necessarily be concerned with closing the achievement gap. However, students have nothing to do with closing the achievement gap pragmatically, because they do not have the political or social power to enact these changes.

We suggest that in order for an intervention approach to impact individuals, it must make negative CMFs explicit when situated at the level of the funding agency, and institutional levels, such as the classroom and informal learning settings. By making negative CMFs explicit, one assists students in the development of tactical understanding and agency through the identification of hegemonic cultural forms which facilitate the creation of limit-situations. Additionally, we recommend that positive CMFs in localized places need to be made explicit. For example, there are many doxas such as frameworks for standard literacy acquisition or those associated with families of underrepresented people that are built into intervention programs. These doxas need to be challenged and understood differently. Taken together, when CMFs are made explicit they can contribute to the development of goal-directed pathways that emerge as critical consciousness or resiliency. In other words, understanding and/or acknowledging resiliency alone, or even in conjunction with socioeconomic status, as an intervention, resiliency will not lend itself as a useful tool to impact the underrepresented people in the STEM fields unless CMFs are made explicit.

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Alejandro José Gallard Martínez is Professor, Goizueta Distinguished Chair and Director of the Georgia Center for Educational Renewal at Georgia Southern University in the Teaching and Learning Department. The platform for his research is to explore equity and social justice in education in general and in science education specifically. Through the lens of Contextual mitigating factors (CMFs) his foci are to understand teaching and learning science and education policy is contextually situated in relation to differences associated with ethnicity, gender, race and SES. His frameworks include global perspectives on differences, otherness, polyphony of voices and meaning making that reflects categories used to situate people in social life.

Wesley Pitts is an associate professor of science education in the Department of Middle and High School Education, School of Education, Lehman College, CUNY. Dr. Pitts also holds a joint appointment in the Ph.D. Program in the Urban Education Program at the CUNY Graduate Center. His research uses frameworks from cultural sociology to investigate how encounters in urban secondary and post-secondary education settings and science teacher preparation programs create success in science education.

Silvia Lizette Ramos de Robles is a professor and Director of the Masters program of Biology and Environmental Health Sciences in the Department of Environmental Sciences at the University of Guadalajara. Her research focuses on sociological and cultural aspects of discourse in the teaching and learning of science, especially in multilingual contexts. So that she may understand more deeply scientific literacy she uses sociocultural and sociolinguistic perspectives. In addition, her research also focuses on socio-environmental aspects related to Environmental Health, specifically climate change literacy.

Katie L. Milton Brkich is an Associate Professor of Early Childhood Science Education in Georgia Southern University's College of Education. Her current areas of scholarship interest are reconceptualizing success in STEM fields, increasing underrepresented populations' access to quality STEM education, and justice-oriented preservice and inservice elementary school teacher education. She has numerous peer-reviewed publications in national and international science education journals, with audiences ranging from the science education researcher through to the classroom practitioner.

Belinda Flores Bustos is Chair and Professor, Department of Bicultural-Bilingual Studies at the University of Texas, San Antonio. Her research focuses on teacher development including self-concept, ethnic identity, efficacy, beliefs, teacher recruitment/retention, and high stakes testing. Flores is lead editor for Teacher Preparation for Bilingual Populations: Educar para transformar and for Generating Transworld Pedagogy: Reimagining La Clase Mágica. Dr. Flores was recently selected as the recipient of the 2015 Hispanic Research Issues SIG Elementary, Secondary, and Postsecondary Award.

Lorena Claeys is the Executive Director and Research Associate for the Academy of Teacher Excellence in the College of Education and Human Development at the University of Texas at San Antonio. Her research focuses on teacher recruitment, preparation, retention, and teachers' motivation to teach culturally and linguistically diverse students; including school-community-university collaborative partnerships.

Affiliations

Alejandro J. Gallard Martínez[1] · Wesley Pitts[2] · Silvia Lizette Ramos de Robles[3] · Katie L. Milton Brkich[4] · Belinda Flores Bustos[5] · Lorena Claeys[5]

✉ Alejandro J. Gallard Martínez
agallard@georgiasouthern.edu

[1] Department of Teaching and Learning, College of Education, Georgia Southern University, P.O. Box 8013, Statesboro, GA 30460-8013, USA

[2] Lehman College, Brooklyn, NY, USA

[3] Universidad de Guadalajara, Guadalajara, MX, USA

[4] Georgia Southern University, Statesboro, GA, USA

[5] University of Texas at San Antonio, San Antonio, TX, USA