Learners' Engagement in Transdisciplinary STEAM Activities:

A Mixed Methods Analysis of Perceptions, Self-Efficacy, and Self-Determination Within

an Out-Of-School Science Program

by

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ABSTRACT

In this three-article dissertation, I explore how ten Palestinian fifth and sixth-grade students perceive and engage with science, technology, engineering, mathematics, and art (STEAM) activities within an out-of-school context. I collaborated with a local organization, Al-Roward for Science and Technology which developed the programming for the four-day program (about 2 hours each day). Each day of the program students completed a hands-on science activity that integrated technology, engineering, mathematics, and art. Under a sociocultural and political lens, I study learners' perceptions of their engagement with transdisciplinary STEAM, examine shifts in learners' self-efficacy, and analyze moment-to-moment interactions of learners as they engage in the learning setting.

Across each chapter I used a different method to examine students' perceptions and engagement. In the first chapter I examine students' perceptions using an interview instrument to understand ways students conceptualize their experiences with STEAM. Findings show that students have varied ways of describing their perceptions, such as normative views about STEAM and values that shape their experience. In the second chapter, I use a mixed-methods design to explore if and how students' self-efficacy shifts as an outcome of participating in the program. The findings demonstrated that students' conceptualization of science varied between instruments. In the third chapter, focusing on the case of one learner, I examine moment-to-moment interactions with peers, educators, and materials as the student navigates his learning trajectory during the third day of the program. Findings show varied ways in which the learner enacted self-determination across the learning activities to assert his positionalities, engage with others, interact with the educators, and use materials.

In doing this analysis of students' experiences in transdisciplinary STEAM, this dissertation contributes to the ongoing research of sociocultural and political dimensions of learning, examining learning as a complex phenomenon. In addition, this work contributes to critical STEAM education that examines science learning and practices while taking into consideration that learning is a relational and ethical process. Implications for future research on learning, methodological approaches in the learning sciences, and critical STEAM pedagogy are considered.

DEDICATION

إلى أمي وأبي.

To my mom and dad.

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CHAPTER 1

INTRODUCTION

Overview

The goal of this dissertation is to examine Palestinian children's perceptions and engagement with transdisciplinary science, technology, engineering, mathematics, and arts (STEAM) activities in an out of school, community-based organization setting. Specifically, this dissertation is structured as three studies conducted in a collaborative and participatory research project with Al-Rowad for Science and Technology. Al-Rowad is a non-profit organization led by Arab educators and scientists in Israel. Al-Rowad creates infrastructure for transdisciplinary science education for Arabs and historically marginalized learners in Israel. Ten children participated in a four-day winter program at Al-Rowad, led and designed by Al-Roward educators. For this three-article dissertation, I conducted a fieldwork research within a winter program in 2019 to explore the perception of ten 5th and 6th grade children of their STEAM related activities in everyday life and their perceptions of the activities they did within the program. I also examined the students' self-efficacy shifts from participation in this program. Finally, in order to better understand the students' engagement in the learning environment, I studied a case of one learner's interactions in this space, focusing on his enactment of self-determination as a way to navigate his learning trajectory.

Broadly, in this work, I build on interdisciplinary literature from education, learning sciences, and sociocultural and political theories of learning (e.g., Vossoughi et al., 2020; Esmonde & Booker, 2017; Philip et al., 2018a; Philip et al., 2018b) to connect the analysis and findings to broader sociocultural and political implications this work reflects. Learning sciences studies suggest that learning can be understood through diverse lenses (Sfard, 1998). That is, learning is not a matter of cognitive processes in the mind solely; rather, it is part of the interactions of sociocultural, political, emotional, and ethical dimensions (Sfard, 1998; Vossoughi et al., 2020; Nasir et al., 2006). From this perspective, attending to the complexity of learning as a phenomenon challenges existing frameworks that often study the learning experiences of nondominant learners, historically oppressed populations, and marginalized groups through deficit lenses (Gutiérrez & Rogoff, 2003; Nasir et al., 2006). Discourses that attribute learning gains to learner characteristics like ethnicity, socioeconomic status, or gender to generate generalizable conclusions about nondominant learners and their communities exist in education research (Bang, 2017; Nasir, 2011). While such discourses have been prevalent for years in education research, policymaking and reforms, there is a paucity of literature with a critical view of the systematic oppression and historical economic exploitation nondominant populations have been facing (Bang 2017; Medin & Bang, 2014; Nasir, 2011). Such deficit models also ignore the heterogeneous ways of knowing and doing that learners bring to learning settings and their cultural practices as they negotiate their learning experiences (Nasir et al., 2006; Rosebery et al., 2010). Through learning sciences literature that examines learning as a sociocultural and political phenomenon, there is a shift in conceiving the design and pedagogy of equity-oriented approaches (Esmonde & Booker, 2017). These approaches examine how power manifests and reproduces in learning settings, through micro-interactions in these spaces, curricula, pedagogy, and artifacts with which educators and learners engage (Esmonde & Booker, 2017). Such an understanding of power issues in learning settings enables the design and study of transformative educational possibilities and futures for historically oppressed and marginalized learners beyond normative frameworks (Bang & Vossoughi, 2016; Gutiérrez & Vossoughi, 2010; Gutiérrez & Jurow, 2016). Therefore, a growing body of literature in the learning sciences, science education, and cognition attends to the nature of learning as sociocultural and political (e.g., Davis et al., 2020; Pinkard et al., 2017; Tzou et al., 2019). That is, such work considers existing dynamics in STEM environments not focusing only on content knowledge or conceptual understanding of scientific knowledge and practices, rather, such work calls for examining the dynamics within such spaces, relations between actors in such spaces, and ethics, values, and ideologies that shape learning (Bang & Vossoughi, 2016; Bang, 2017; Kimmerer, 2013; Krist & Suárez, 2018; Philip et al., 2018).

In this three-article dissertation, I focus on the experiences of Palestinian learners reflected in their perceptions and engagement in STEAM activities. These activities took place in an Arab town with ten Palestinian children in Haifa District in Israel. In this dissertation, I build on prior work to demonstrate the importance of understanding the complexity of learning and learners' engagement in a learning setting within the context of science learning. Through these three separate articles, I illustrate the varied ways the learners describe their perceptions and engagement, showing that these complexities are a form of heterogeneity that is important for understanding and enhancing their learning experience. Studying these experiences requires attention to historical and sociocultural forces that come at play in this context within the education system. Often, Palestinian learners in Israel are described through a deficit lens and in ignorance of the settler-colonial structure mediating their learning experiences from early ages to higher education (see more, Awayed-Bishara, 2020; Rouhana & Sabbagh-Khoury, 2015; Shalhoub-Kevorkian, 2019). Studying the learning experiences of Palestinian students in Israel is understudied in education research in general and the learning sciences in particular. As a nondominant and historically marginalized population, studying learners' experiences within an out-of-school setting, can offer insights into the ways of knowing and doing in which Palestinian learners conceptualize their learning activity.

In order to better understand this work, I also describe here the sociopolitical macro context, the site of activities at Al-Rowad for Science and Technologies, and my positionality.

Broader Context: Palestinians in Israel

To understand the modern history of the education of Palestinians in Israel, one needs to understand the political and historical background of this context. While it is challenging to go into detail, I center the history around events that shaped the lived experiences of Palestinians in Israel as a Native population in their own homeland.

Beginning of the 20th century. Prior to 1917, during the Ottoman era, education took multiple forms in Palestine; examples include Western-based missionary schools established later in the 19th century, schools within religious groups (e.g., like Al-Kuttab at mosques for learning basic literacies, religious text interpretation), and institutional education that serves the purposes of the Ottoman empire (e.g., administration, military) (Mar'i, 1978). During this era, from the late 19th century to the early 20th century, private missionary Christian schools driven by Western institutions were considered to be the first form of formal schooling in the region as Mar'i (1978) described. Because of the political tension that these schools brought, Arab nationalists recognized the need to establish different forms of schools. For example, Khalil Al-Sakakini established a nationalistic Arab school in Jerusalem, al-Dusturiyya between 1909–1917 (Moed, 2014). The school emphasized Arab identity and embraced a humanizing approach to schooling, connecting students to the land using a series of pedagogies that acknowledge learners' culture (Moed, 2014). These strategies included walking in nature, abolishing exams, assessments, homework and punishment, encouraging students to do sports, and teaching Arabic literature and poetry.

During this era, Jewish people in Palestine could also establish their own schools autonomously. Similarly, foreign Jewish bodies in autonomy provided education for the Jewish community in Palestine (Great Britain, 1946). Additionally, in 1914 the Zionist Education Council was formed to provide education for the growing Jewish community in Palestine. Politically, during this era, it is important to mention that waves of Western Zionists began to immigrate from Europe to Palestine in preparation for establishing settlements. The formation of Zionist schools also expanded to higher education and institutions like Technion and the Hebrew University of Jerusalem, which were founded in 1912 and 1918 respectively.

The British Mandate of Palestine. When World War I ended in 1918, the British Mandate of Palestine began. This mandate was due to the Sykes-Picot agreement between the United Kingdom and France to divide and control the partitions of the Ottoman Empire. Schneider (2018) describes that during the British Mandate, there was a shift in schooling systems from schools being managed by religious communities to a central system administered by state institutions. Importantly, the Department of Education used versions of religious education for the local communities that aimed to preserve traditions in separation from nationalistic politics (Schneirder, 2018). Schneirder (2018) argues "far from accepting a colonial view of religion, politics, and education as discrete practices that were best kept separate, educators from both Palestinian and Zionist communities sought to use new and dynamic forms of religious education as a means of advancing their nationalist projects." (p. 3) During this period, however, educators like Khalil Al-Sakakini described in his diaries that the British discriminated against Palestinians in favor of Zionists.

A new reality, 1948. A new state of Israel was established in 1948 ushering in a new reality for Palestinians referred to by Israelis as the year of Independence Declaration, what Palestinians call the Nakbah. The Palestinians began living through what is known for Palestinians as the Nakbah - the Palestinian Catastrophe. During the Nakbah, Palestinians experienced an ethnic cleansing (Pappe, 2007) that led to the destruction of about 400 Palestinian villages and the displacement of thousands of Palestinians as a result of the war. This created a new reality in a new divided geography: a new state of Israel within the 1948 borders, West Bank and Jerusalem, and Gaza.

Palestinians in Israel existed under Israeli Military Governorate that lasted until 1966. The Palestinians in Israel have Israeli citizenship and currently represent about 20% of the population in Israel. Education in Israel has been dominant by Western Zionist ideologies within curriculum and cultural practices (e.g., Peled-Elhanan, 2008; Shohat, 1997).

Education after 1948 for Palestinians in Israel. Since its establishment in 1948, Israel saw education as an important development tool for the Palestinians in Israel in agricultural rural areas and cities; however, the education system was political and served

Zionist policies and agendas that are dominated with Western settler-colonial ideologies (Rouhana & Sabbagh-Khoury, 2015). Despite continued reforms, Mari (1978) and Al-Haj (2012) argued the education system was an attempt to control the Palestinian minority within Israel and isolate them from their cultural-historical interactions with who they are as Arabs.

From 1949 to 1966, Palestinians in Israel lived under a military government. This political situation shaped the role of teachers and schooling. Schools and education became tools for control that the state of Israel imposed on Palestinians (Rouhana & Sabbagh-Khoury, 2015). Under this control, education de-emphasized Arab history and disconnected learners and teachers to their Palestinian roots. Furthermore, education was a tool for systematic erasure of Palestinian culture, heritage, and ways of knowing. Rouhana and Sabbagh-Khoury (2015) argue that despite the hegemonic narrative imposed by the state, the control of Palestinians, and the state view of Palestinians in Israel as a security threat, Palestinians used their private spaces to challenge the settler-colonial narratives through "poetry, folksongs, literature, fine arts" (p. 210). Such practices also involve explicit and implicit decolonization practices that Palestinian teachers and learners used as practices to face cultural erasure in educational settings (Rouhana & Sabbagh-Khoury, 2015; Shalhoub-Kevorkian, 2019).

This situation has been dynamic over the years, because, eventually, the Israeli government saw an economic potential for the development of its Palestinians citizens. Notably, due to the colonial mindset, Palestinians were viewed as less developed, homogeneous, living in rural areas, and in need of a process of modernization. These deficit views not only ignore the Palestinian heritage and cultural practices, but also ignore the destruction that the Nakbah and political situation did to Palestinians' lives. Such ideologies represent a settler-colonial mindset that views the colonized through a deficit lens that positions the Native as "primitive" that need "to be saved" (Bang, 2017; Shalhoub-Kevorkian, 2019; Medin & Bang, 2014). Unfortunately, these notions of the Native populations were also adopted by Arab scholars in the past. For instance, Mar'i (1978) referred to Palestinians in Israel in a generalizable statement as "the Arab population in Israel forms a rural society, which like all other rural communities in the world, is homogeneous, traditional, and relatively static" (p.5). The political dynamics impacting education for Palestinians in Israel continued over the years with Palestinians in Israel continuing to challenge the hegemonic narratives and connections with their Palestinian Arab identity through collective actions in events like the Land Day in 1976, the First Intifada in 1987, and the Second Intifada in 2000.

The Second Intifada, however, was a turning point in the lives of Palestinians in Israel. As described by Kayyal (2020), the uprising in October 2000 led to the death of 13 Palestinians (who are also Israeli citizens), killed by Israel police. The protests during that time resulted in increased lack of trust with the Israeli institutions and government. The events, as Kayyal (2020) described, led to a committee called "Orr Committee" by the Israel government to investigate the police actions. In addition to the investigations, among the agenda of the committee were political decisions that suggested an investment in economic development, inclusion in the Israeli society and in education (Kayyal, 2020). However, these actions have been implemented through neoliberal projects and mainly for the benefit of the state economy and its politics, rather than uplifting the Palestinian society in Israel or creating transformative social, political, economic, and educational reforms. Such tensions come into play when we look at the increased numbers of Palestinians in higher education and increasing numbers of them in STEM fields. Yet, at the same time, Palestinians are increasingly continuing to live in a reality brutally rooted in violence, segregation, systematic inequality, and discrimination (Adalah, The Inquality Report, 2011). For instance, at the surface, these discourses are often illustrated as form of development and support for the "Arab minority" in Israel, however, such development forms contradict with the systematic erasure of Palestinian culture, heritage and Arab language from education system and public spaces (e.g., Awayed-Bishara, 2020). Furthermore, such reforms ignore the many forms of colonial violence Palestinians in Israel experience in social infrastructure, land exploitation, racism, and violence that are also reproduced in the education system (Rouhana & Sabbagh-Khoury, 2015; Shalhoub-Kevorkian, 2019).

Despite these challenging realities, Palestinians' engagement in education expanded beyond formal institutional learning. For instance, learning and educational activities took place in community-based forms, out-of-school settings through intergenerational learning, and through social and political activism. These out-of-school activities also included informal learning settings such as youth centers and non-profit organizations. These organizations included grassroot community-based organizations that worked on addressing educational issues in the Palestinian society in Israel. For example, a human rights organization called Adalah - The Legal Center for Arab Minority Rights in Israel - organizes educational camps for Palestinian law students who study at Israeli universities to expose students to issues of power, injustice, and human rights violations in their history and realities as Palestinians (Adalah, 2017). A growing body of educational organizations include a focus on science, technology, and entrepreneurship within the Palestinian society in Israel. An example of a grassroot community-based organization that was established to address issues around science and technology literacies is Al-Rowad for Science and Technology.

Given the historical context and current political and educational climate in this context, one can not ignore that such work in science, technology, and entrepreneurship comes in a climate that is impacted by neoliberal economic development reforms in education, where encouraging Arab students to pursue such careers becomes beneficial to the state economy (e.g., the integration initiatives in higher education, see Hager & Jabareen, 2016). And where the "achievement gaps" of Arab students in science and math literacies (like in PISA tests) compared to Hebrew speaking students persist in education and public discourses. The two examples are places where questions could emerge about the history and consequentiality of such economic development and educational reforms towards what ends they are being conducted (Philip et al., 2018b). These questions in dialogue with viewing STEM practices through sociocultural, political and ethical lenses (e.g., Harding, 2006; Medin & Bang, 2014; Said, 1993) led me to think about what it means to learn science in relation to others and society. In search of a way to address such questions, I connected with Al-Rowad for Science and Technology.

Specific Context of this Study Setting:

Al-Rowad for Science and Technology and Science Activities

In this work, I collaborated with a community-based non-profit organization that focuses on science and technology education called Al-Rowad for Science and Technology. The organization is led by a group of scientists, science educators, community educators, and volunteers in Israel. The organization develops and leads interdisciplinary science outreach programs, hands-on activities, workshops, and public participation in science activities (like science shows, talks) in schools, community centers, and their own center.

The community emphasizes the importance of supporting access to high-quality hands-on science activities and increasing learners' motivation to engage with science for marginalized communities in the country. The major goals of these science activities include engaging Arab learners with high-quality science activities, changing attitudes and aspirations towards science, helping learners see science in their everyday lives, feeling successful as they engage in doing science activities, developing science inquiry practices, and building a future generation of Arab learners who pursue science-related careers in Israel as a way to bridge economic and societal gaps.

For the purpose of the study goals, I chose to work and collaborate with Al-Rowad because we both identified a need to conduct research that bridges the gap between research and practice in education research (Mawasi et al., 2021). The conversations with Al-Rowad led us to understand that we have a common ground in thinking about the sociocultural dimensions of community-based work and ways it connects to the learning of science and technology. We also thought this research work could create a dialogue between the work I have been doing around learning, design-based research, educational technology, and STEM education and the work Al-Rowad members are doing as science and technology educators and community activists with Arab students, parents, and educators in Israel.

In this work, Al-Rowad provided a space to conduct the research activities within a four-days program led by two educators of the organization where ten learners participated across the four days. In addition to discussions with educators, during the four days activities the students engaged in doing four hands-on science activities designed by Al-Rowad. The ten learners registered to the program through Al-Rowad. The organization pedagogy counselor facilitated communication with parents, to invite children to the program and interviews. As part of the collaboration (not included in the dissertation chapters), six educators of Al-Rowad participated in co-design sessions as a way to learn about the work they are doing and think together about educational possibilities for the context of their work (Mawasi et al., 2021). I also interviewed four educators in different positions from Al-Rowad to have a better understanding of their organization structure.

Positionality

During this research fieldwork, I identified myself as a researcher from the local community in which this study took place. Across all fieldwork activities, I emphasized the collaborative and participatory approach I was taking in my education work with the organization. That is, while I engaged in my own interpretation of the data analysis and observations, I also sought to understand the pedagogy of the organization from their perspective. To understand the organization perspectives, I did co-design sessions during field work with educators which established my understanding of the organization structure, work, and pedagogy.

Within this research project, I conducted fieldwork for data collection with the organization, facilitated conversations with the organization community members and participants, designed instruments for the study, conducted interviews with students, parents, and educators, and organized and analyzed data. Additionally, I engaged in what

I consider a culturally sensitive transcription and translation processes during the interpretative phases of data analysis. Throughout my analysis I was engaged in thinking about the social, cultural, political, and ethical aspects this work represented to me as a Palestinian educator and researcher. I am multilingual and fluent in all major local languages used in the space: Spoken Palestinian Arabic, Academic Arabic, Hebrew, and English.

I view my role within the work as dynamic, fluid, and unsettled (Said, 1999), across the field work, data analysis, and writing phases. This fluidity was shaped by geography, language, time, and space (Said, 1999) as I engaged in the setting as a researcher, learner, and part of the broader community in which the organization functions (e.g., Said, 1999). This fluidity made me in some cases feel outsider and in others as an insider (Erickson, 2012). As a researcher who is not part of the organization, I needed time to build trust between the organization and me to learn about their work and to share my expertise. The feeling of being insider comes from me growing as a Palestinian in Israel. It also came from the goals and trust I shared with the organization.

The feeling of being an outsider comes from me studying since high school out of my hometown, then pursuing higher education in universities that are Western-oriented and Euro-centric. The outsider feeling also came from the geographical distance I have been living from my own community since 2015, as I was pursuing my graduate studies in the United States. Within the context of the study, it was especially with my departure to the United States in January 2020, right after the field work. At the same time, these experiences across space and time, were also generative in how I learned to examine and view the realities of Palestinians in Israel through a critical lens. For instance, my experience in the United States exposed me to critical discourses of minoritized and Indigenous Peoples experiences in a way that I was able to identify overlaps between cases I learned in the United States and experiences of Palestinians. Another component that shaped this fluidity is the language (e.g., Said, 1999). The split between my academic education in Hebrew and English, and my native language in Arabic made it challenging for me across different moments of this work to express myself. I was simply engaged across different tasks in this work with all these languages, yet, mainly producing, talking, and thinking about writing in English.

Road Map of the Dissertation

In the first chapter of this three-article dissertation, I studied the learners' perceptions of their STEAM activities in everyday life and in the program. This chapter, "Students' Perceptions of their Transdisciplinary STEAM Activities in an Informal Community-based Learning Setting", offers an understanding of the diverse ways of knowing, doing, and being students perceived about their STEAM practices. Such an understanding provides insights into the children's' worlds of connecting their school activities and out-of-school activities. I explored these perceptions through a series of interviews conducted with all ten students who participated in the four-day program. Then I engaged in a qualitative inductive analysis followed by a deductive analysis of these interviews to identify major themes these perceptions reflect about the students' experiences. I find that students have varied ways of conceptualizing STEAM practices and activities. Such conceptualizing in some ways is expansive, as it allowed learners to see themselves in different roles and doing diverse practices rather than only centering it on science. And in others such perceptions reflect a broader systematic structure of normative, narrowed schooling definitions of what counts as learning, and wrestling with ideologies and ethics when doing STEAM activities. I close the chapter by discussing the implications of these findings on the design of equity-oriented STEAM environments for nondominant learners.

In the second chapter, I examine the potential of students' engagement in this out-of-school community-based program on their self-efficacy, titled as "Exploring Learners' Self-Efficacy Shifts within a Community-Based STEAM Program". I ask if and how this engagement results in self-efficacy shifts for the ten learners who participated in the winter program. Using a mixed methods approach, I analyzed the shifts by doing t-test analysis and then following it with an inductive analysis of students' responses to items during an interview conducted after they completed the program. I identified that there was a shift in the students' self-efficacy, however, this shift can not be understood in statistical terms as they were only descriptive. Following the analysis of an inductive coding, I identified students did not follow the same learning trajectory, this is reflected in varied answers within and across items for how each learner conceptualized the context of science for each item. I close the chapter with suggestions around methods and implications to better understand such trends.

In the third manuscript, through a moment-to-moment interaction analysis in the learning environment, I examine one case of a learner as he interacts with peers, materials, and educators in the space. The chapter is titled "Enacting Self-Determination as a Form of Participation in STEAM Activities in an Out-of-School Setting". Specifically, I look at the enactment of self-determination as a form of participation in STEAM activities in the learning environment. In this work, I build on Davis et al. (2020)

conceptualization of self-determination as a contestation and moving to elsewhere in the learning process. I used a moment-to-moment analysis approach (Chinn & Sherin, 2014; Vossoughi et al., 2020; Vygotsky, 1978), to examine the learning trajectory of one student as he participated in varied activities on the third day of the program. During this day, the educators introduced concepts of light and engaged learners with discussions and hands-on activities that included building an illuminating board artifact, testing materials like paper filters, and drawing with light. Across different moments, I find that the student enacted acts of self-determination in the space in varied forms and in alignment with findings of Davis et al. (2020), that is, moments where the learner enacted resistance and moved elsewhere in a way that was generative for his learning and others. These acts of self-determination in the forms of "resistance" and "moving to elsewhere" contributed to the student to position himself in different ways across the activities as a contributor, knowledgeable, helper of others, and also a joyful person. These forms of self-determination enacted by one learner were also generative to the learning of others in space. That is, these acts also helped the student to contribute through his acts to the learning processes of other students as well, as he actively sought to involve others across different moments. I discuss the implications of such moments on the learning experiences of nondominant learners at micro and macro levels.

Finally, I close the dissertation by providing a summary of this work and possible future research directions for related studies. Specifically, I conclude by suggesting future directions that include theoretical approaches for understanding learning, thinking methodologically about studying and understanding learning in similar environments, and pedagogically attending for approaches that may help in bridging between theory, methods, and practice.

Contribution

Overall, the dissertation work contributes to education research and the learning sciences in the following ways: conducting research in an understudied context, exploring varied methodologies to understand student experiences, and thinking about learning as a relational process with others and materials, where such relationality is shaped by sociocultural, political, and ethical dynamics enacted by learners. In identifying these dynamics, there is a possibility for researchers to learn about the ways children negotiate their learning experiences to assert their childhood and their positionalities. This research is conducted in an understudied context with a population that is often represented through hegemonic academic work. In doing this research within this context, with Palestinian learners and community-based educators, this work offers insights on ways of knowing that shape the experiences and perceptions of these learners within an out-of-school context as they engage in transdisciplinary science activities — contributing to our understandings of the consequential roles of historicity and epistemic multiplicity in human learning. Such insights offer theoretical, methodological, and pedagogical perspectives on working with nondominant learners. Finally, in using varied methods, I was able to demonstrate that the individual learner experiences are connected to the context in which they conduct their learning activities and in which the methodological instrument being used.

Across each chapter I am engaged in different research questions that aim to understand the learner experience while also identifying it through different lenses

(Saldaña, 201). The first a macro-level lens where I tried to connect between the students' perceptions and activity they did in the program, the second is examination of shifts of their self-efficacy as reflected in pre-posttest self-report across two different moments of time, and the third a micro lens where I am examining moment-to-moment evolvement to understand the student learning processes as reflected in moments of self-determination. I illustrate how learners' interactions with others in learning environments and with materials carry evolving dynamics across time and activity type. This requires an attention to that studying learning and designing for learning should take into consideration the ways learners enact actions beyond the constraints of structured designs or participation forms that design for them what counts as useful participation or desired behaviors. In doing so, the dissertation offers a lens through which researchers can use varied methodological approaches to understand the complexities of learning when designing "for" or "with" educators and learners, acknowledge the limitations of real-world education research methodology, and position themselves not only as researchers but also learners with participants.

At a pedagogical and instructional level, this work provides insights on the perceptions that shape learners' understanding of their science learning, ways these perceptions are expanded or constrained by adults, and ways may be connected to dynamics in the classroom. In doing so, it offers teachers and educators insights to engage learners with understanding their assets, creating space for learners to enact their self-determination, and nurture learners' diverse ways of participation in learning settings. It also illustrates how important it is to engage learners with thinking about science ethics and values beyond dominant discourses shaped by Western scientific practices and neoliberal economic based approaches.

Finally, while I attempted to attend for the macro political context in which these activities taking place, future work, may explicitly examine this work through settler-colonial framework that aims to provide decolonizing approaches for understanding children experiences and their learning of science and suggestions within this context to tackle such complexities pedagogically. Overall, this work is an initial step in which I am attempting to engage in dialogue with different disciplines to understand learning in a context that means a lot to me as a researcher and educator.

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CHAPTER 2

STUDENTS' PERCEPTIONS OF THEIR TRANSDISCIPLINARY STEAM ACTIVITIES IN INFORMAL COMMUNITY-BASED LEARNING SETTING

Abstract

Informal settings can provide learning possibilities for nondominant students to engage in STEAM related activities in diverse ways. Prior work has investigated learning in these environments in the context of minoritized students and historically marginalized populations and assessed the effects of interventions on STEAM learning processes and outcomes to develop students' interest and agency towards STEAM. Such environments help students develop interest, gain access to these activities, and potentially increase students' self-efficacy in STEAM. Only a limited number of studies have investigated students' perceptions of their STEAM activities. Understanding students' perceptions of their STEAM activities opens opportunities to identify the expansive ways in which students conceptualize their learning. Such an understanding also helps in designing learning environments and instruction that nurture learners' assets and cultural ways of knowing. Towards this end, this qualitative study aimed to explore students' perceptions of transdisciplinary STEAM activities after they participated in a four-days science program run by a community-based organization. The study provides evidence to the complex ways in which students perceive their engagement in STEAM activities, reflected through tensions between schooling and learning, transdisciplinarity, presumed normativity, and values. I conclude by suggesting that the diverse ways of thinking, being, and doing in which students are engaged in, in their everyday life in and out of school are central to the study and design of meaningful learning environments that

support nondominant learners to engage in STEAM activities in heterogeneous ways. Such consideration may help students see how their own ways of knowing and everyday activities already incorporates STEAM practices.

Introduction

Recent scholarship in informal education for STEM highlights the importance of expanding sociocultural learning theories in work with nondominant learners to attend for the political and ethical nature of learning (e.g., Booker et al., 2014; Philip et al., 2018; Nasir, 2011). Within sociocultural scholarship, there is emerging attention to the design of STEM informal learning environments that broaden the participation and engagement of nondominant and underrepresented learners in STEM (e.g., Barton & Tan, 2010; Pinkard et al., 2017; Stewart & Jordan, 2017). This work asserts that informal learning settings have benefits towards the engagement of learners, such as, supporting learners' agency (e.g., Barton & Tan, 2010), interests (e.g., Pinkard et al., 2017), and engagement in diverse ways of knowing and doing STEM that inform their literacies (e.g., Parekh & Gee, 2019). At the same time, work in the field also examines ways in which the participation in informal STEM activities does not always mean learners' cultural assets and ways of knowing are supported. For example, Vossoughi et al. (2016), examined the sociopolitical and historical context in which informal environments like Makerspaces were created and argue that such environments privilege certain dominant ways of knowing and practices that do not necessarily align with the cultural assets of learners from historically oppressed and marginalized populations. In the same line, Tzou et al. (2019) take a decolonial approach towards families engaging with STEAM making and show that making and technology are historically embedded in Indigenous ways of knowing. Additionally, recent scholarship in learning sciences asserts that the engagement of learners within discourses of STEM education should expand from centering around epistemological and conceptual learning, to include axiological and ideological ways of learning (Bang et al. 2015; Krist & Suárez, 2018; Philip et al., 2018). This expansion includes considering the power and hegemony that historically shaped scientific discourses through designing for transdisciplinary engagement that attends for ethics and historicity in STEM education (Takeuchi et al., 2020).

The attention to both the affordances and constraints of informal learning environments for nondominant learners' engagement in STEM activities offers an opportunity to examine learning within these spaces while considering the sociopolitical context in which these activities are situated. Such examination is essential for the design of equity-oriented learning environments that acknowledge the cultural assets of learners and to design environments that disrupt and transform power and oppression reproduced within existing environments and curriculum (e.g., Warren et al., 2020). I build on the understanding of these affordances and importance of attending for the sociocultural and political nature of learning within informal learning settings to study students' perceptions of their engagement in STEAM related activities. I draw on prior scholarship in informal STEM environments to explore ten Palestinian children's perceptions of their STEAM related activities after they participated in a science program at a community-based organization called Al-Rowad for Science and Technology in Israel.

In this article, I discuss what I learned through a culturally sensitive analysis of interviews that I conducted with ten students who were 5th and 6th grade during the time of the interviews. Specifically, I discuss what I learned by attending to the sociocultural and political framing of this work as reflected in what students' perceptions reflect. Specifically, I address students' perceptions of informal STEAM activities and practices and what these perceptions reflect about students thinking, doing, and being in relation to the sociocultural and political context.   In this study, I aimed to understand how students who attended the four-day science program developed and conducted by Al-Rowad for Science and Technology perceive STEAM activities and engaged in meaning making about their STEAM related experiences in and out of school. Drawing on qualitative data from interviews analysis memos, I illustrate how students make meaning with STEAM activities as reflected in the ways they describe their everyday experiences, their engagement with program activities, and their perceptions of STEAM activities and experiences.

In this study, I used interviews as both an instrument and a pedagogical tool. Namely, I use interviews to understand students' perceptions, at the same time, engage students with thinking about their own STEAM activities through questions that purposely design to support such a process. I conducted an interpretive analysis, guided by the following questions, (1) what are students' perceptions of informal STEAM activities? (2) what do students' perceptions of scientists, artists, engineers, and inventors reflect about their STEAM related experiences? And (3) what do these perceptions reflect about the ways students conceptualize their thinking and doing of STEAM activities?

In this chapter, I discuss these perceptions through four findings: tensions between learning and schooling, transdisciplinarity, presumed normativity, and axiological ways of thinking, being, and doing. I first present relevant literature which I build on to understand students' perceptions. Then, through an interpretive analysis of the interviews, I illustrate the emerging themes. Finally, I close the chapter with discussing these findings and implications for creating more equity-oriented environments that consider students perceptions.

Literature Review

In this section I outline prior literature and work that informed my understanding of students' perceptions in this context as well as the analysis and interpretations of findings. I discuss how I draw on sociocultural and political perspectives of learning to understand students meaning making reflected in their perceptions. Then, I describe the ways I build on my understanding of transdisciplinarity to identify ways in which students' meaning making during interviews reflects expansive and complex ways of thinking, being, and doing science. Finally, I describe the benefits of learning in informal settings for nondominant learners.

Learning beyond participation in a practice

Penuel (2016) asserts that education research needs to go beyond school contexts as ways to learn science and engineering for "transforming cultural and economic production." (p.96) That is, school learning is separated from "meaningful activities" for learners and constrains learners' access to engage in subject matter practice (Penuel, 2016, p.93). Schools from this sense are centered on knowing, rather than supporting learners' diverse identities or doing activities associated with practices of a given field (Gee, 2017). Specifically, Penuel argues that engaging in science and engineering practices provide ways for learners to "access and make use of science knowledge" (p.90) and engage in their practices. From this perspective, learning is reflected through an increased participation in an activity (Wenger & Lave, 1991), learners' participation in such practices creates possibilities for them to imagine themselves doing activities within these practices (Penuel, 2016). However, these definitions do not take into consideration two things, first science and engineering practices are historically defined through existing sets of power dynamics, normative and hegemonic terms that shape practices, and participating in them does not always mean a learner participation is legitimized (e.g., Harding, 2016; Mawasi et al., 2020b). Therefore, they risk reproducing inequities in what Penuel (2016) refers to as "transforming cultural and economic production." (p.96) Second, despite the learning opportunities engaging in STEM practices offer, increased participation in a practice as a measure for learning, can be problematic in context where learners participation patterns do not align with such paradigms or in contexts where participation has multiple forms that also indicate learning (e.g., refusal to participate, Davis et al., 2020). That is, what if participation in an activity was defined by axiological means, like values? For instance, ways of knowing and being associated with ethics, values, and aesthetics (Bang et al., 2015) that shape a learner world. For examples, ideological beliefs of a learner could expand or constrain engagement in certain science and engineering practices (e.g., Philip et al., 2018).

Accordingly, researchers and teachers should acknowledge the diverse "repertoires" that learners bring to learning environments ("routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions or concepts" (Wenger, 1999, p.82)) and they should work to nurture learners diverse ways of knowing and being (Nasir et al., 2006). In other words, achieving equity through diversity from this perspective means, to support diverse learners' varied practices, challenge deficit views of learning to situate learners' diverse practices and identities as an asset, support the inclusion of non-dominant learners, support heterogeneity of practices, experiences and assessments in the learning environment, acknowledge learners' linguistic and cultural differences, and respect learners' social, cultural, historical, and intellectual learning trajectories (Nasir et al. 2006; Gee & Hayes, 2010; The New London Group, 1996; Uttamchandani, 2018). For instance, engagement of nondominant learners in practices as defined through hegemonic structures and dominant ways of knowing can reproduce forms of violence and oppression towards learners, this includes erasure, stereotypes production, testing and assessments designed through normative lenses, and hegemony in curriculum and pedagogical practices.

From an asset perspective of learner differences, equity is not about access to presumed normative resources or about "sameness", an asset perspective acknowledges that learning achievements and outcome differences consist of diverse histories, talents, and interests that shape the learning trajectories of learners (Gutiérrez, 2007). Therefore, diversity in achievements and outcomes among learners should be expected and viewed as a strength rather than a deficit (Gutiérrez, 2007; Nasir et al., 2006; Uttamchandani, 2018). This approach does not ignore that nondominant learners in the 21st century should be prepared to participate in economies, public life, and practices that can be oppressive to them (The New London Group, 1996), rather, the researchers recognize that learning environments should prepare nondominant students for addressing issues of power and inequity reproduced in contexts they engage in (Esmonde & Booker, 2017) towards liberatory and transformative futures. This requires approaches to designing equitable learning environments that "connect in deep ways to the life experiences of all students" (Nasir et al., 2006, p.700). In other words, even when learners gain dominant knowledge associated with power and institutionalized knowledge, the learners will have the knowledge that enables them to examine and evaluate their learning process critically, to challenge what counts as knowledge and be able to transform their realities (Gutiérrez, 2007, p. 49). Learning is mediated by cultural tools, including language, symbols, ways of thinking, everyday life experiences, and histories that shape the trajectory of how learners make sense of their worlds and their learning experiences (e.g., Vygotsky, 1978). Therefore, expanding the theoretical tools to attend for the complexity of learning is essential for understanding ways students make meaning of their learning (Davis & Schaeffer, 2019; Zittoun & Brinkman, 2012 cited in Davis & Schaeffer, 2019). As Davis & Schaeffer (2019) assert, understanding meaning making of learners creates the opportunity to attend for the complexities of children's engagement with socio-scientific activities. In their meaning making, learners engage in making sense of situation, events, objects, or discourses building on their prior knowledge, engagement history, and their experiences (Davis & Schaeffer, 2019; Zittoun & Brinkman, 2012 cited in Davis & Schaeffer, 2019; Zittoun & Brinkman, 2012). This process of making sense, I argue, is both political and contextual (e.g., Sengupta-Irving & Vossoughi, 2019). It is also shaped by the available cultural resources and structures that define terms for learners to make sense of their experiences.

Therefore, to bridge between the importance of introducing learners to practices beyond school and sociocultural theories, the discourses in which learning theories are discussed, should be also situated within political context and historicity. Expanding the understanding of the political and historical aspects of learning, creates an opportunity to understand the tensions and possibilities for intervening in a particular context, and ask major ethical questions about the consequences of such implementation on local communities (Mawasi et al., 2020b). The importance of this understanding aligns with development framework that stress that multi-dimension understanding of contexts in which an intervention is implemented can possibly shift top-down hegemonic interventions towards a participatory form of collaboration for transformative and sustainable change (e.g., MacGinty & Williams, 2016). One way to address such complexity within informal learning environments is through the sociopolitical analysis approach Vossoughi et al. (2016) describe for makerspaces and making movement. That is, analyzing educational injustice within educational systems and learning environments with an attention to cultural-historical dynamics and values systems that shape learning activity within educational contexts.

Therefore, I stress that through children's ways of meaning making, if we consider their perceptions through a sociocultural and political lens, it is possible to learn what their stances reflect about hegemonic structures and forms of colonialism that possibly mediate their perceptions of their experiences. For this study, I also draw on literature that grounds this case in a settler-colonial lens (e.g., Rouhana & Sabbagh-Khoury, 2015) as a way to view the experiences of the Palestinians in Israel as an ongoing form of colonialism. Such forms are reproduced in ways students come to learn and understand their learning experiences (Sabbagh-Khoury, Year; Fasheh, 1990). The education system has been a political tool for power and control of the Palestinian minority in Israel (Rouhana & Sabbagh-Khoury, 2015; Awayed-Bishara, 2020). This settler-colonial reality has been creating a reproduction of injustice within education systems and mediates learning in diverse settings and environments in curricula and other aspects of education (Rouhana & Sabbagh-Khoury, 2015). In this way, similarly to other settler-colonial societies, hegemonic narratives define normative ways of knowing, being, and doing for teachers and learners for Native populations (Bang, 2017).

Learning in informal environments

Informal learning environments are out of school spaces where students can engage in diverse learning activities through varied instructional approaches (Hofsein & Rosenfeld, 1996). Such spaces include libraries, zoos, public spaces designed intentionally for meaningful play, makerspaces, youth programs, and community-based learning environments (Hofsein & Rosenfeld, 1996). As Hofsein and Rosenfled (1996) described definitions of what counts as informal learning environments are varied in the literature, particularly, that learning can take place across diverse settings, in and out of school. For the purpose of this paper, I view informal learning environments as spaces where students engage in learning activities that are not centered around schooling approaches for assessment purposes (Hofsein and Rosenfeld, 1996).

In the past decade, literature in education research has focused on the affordances of informal learning environments to engage students in a diverse set of STEM activities. Through the range pedagogical approaches within these environments for individual learners or families or groups, students are able to participate in activities that contribute to their STEM learning, agency, identity development, and affective engagement. Such activities include, hands-on experiences (e.g., Mawasi et al., 2021b), real world practices with STEM such as tinkering in makerspaces (e.g., Blikstein & Krannich, 2013; Petrich et al., 2013), exposure to materials and tools in public learning spaces, fabrication tools like 3-D printers or e-textile or robots (e.g., Bar-El & Zuckerman, 2016; Tzou et al., 2019), culturally-relevant activities designed to engage nondominant and underrepresented learners with STEM (e.g., Pinkard et al., 2017; Tzou et al., 2019), decolonial STEAM practices in making (e.g., Barajas-López & Bang, 2018), and opportunities for developing literacies and identities (e.g., Gee & Parekh, 2018). The epistemologies guiding such work are diverse, from constructionism (e.g., Blikstein & Krannich, 2013; Bar-El & Zuckerman, 2016), to sociocultural theory (e.g., Calabrese Barton & Tan, 2010; Gee & Parekh, 2018; Pinkard et al., 2017), to decolonial approaches in the design of learning environments for STEAM engagement (e.g., Barajas-López & Bang, 2018; Tzou et al., 2019). Within this scholarship that focuses on STEM learning in informal settings, there is also an attention to including art as a way to expand the opportunities for learners to engage in transdisciplinary learning (Gee & Parekh, 2019; Mawasi et al., 2021a; Pinkard et al., 2017). Examples of this work include involving design within STEM learning (e.g., Petrich et al., 2013; Tzou et al., 2019), dance and hip-hop (e.g., Champion, 2018), and creating e-textiles (e.g., Kafai et al., 2014).

Within the literature on informal STEAM learning there is a growing emphasis on the sociocultural and political dimensions of learning in such spaces by examining learners' experiences, designing equity-oriented learning spaces, and going beyond discourses of access for nondominant and underrepresented learners in STEAM. Such work asserts that simply providing access to informal learning spaces does not mean learning opportunities are equitable. It is through careful design of pedagogy and instruction and careful attention to dynamics within space that one can expect learners to shift their meaning making within such contexts. For example, Vossoughi et al. (2016)

assert that the discourses in which MakerSpaces were established within are designed to serve dominant participants. Vossoughi and colleagues (2016) emphasize that making practices have a long history across cultures (e.g., Barajas-López & Bang, 2018), and their current centricity on practices associated with neoliberal economy erases the diverse ways of knowing and doing learners from nondominant populations can engage in making (Vossoughi et al., 2016). In another example, drawing on ethnographic analysis of an after-school robotics club, Stewart & Jordan (2016), illustrate that despite the learning opportunities provided in the space, Nina, a fifth-grade girl, “was unable to make sense of her experiences in ways that could serve her to make better scientific decisions in the club and in the future.” (p. 151) The authors argue that explicit instruction from instructors and peers would have made a difference for the student. They suggest that, in contrast to common beliefs about learning in informal environments where teachers are more often seen as facilitators, instruction is open ended, interest driven, and learner-centered, some students like Nina, need other pedagogical approaches to find their participation in such environments beneficial. Specifically, when existing structures like school learning define what counts as learning for students. Therefore, the attention to different elements within informal learning environments, such as pedagogy, design of space, artifacts design, dynamics and interactions, creates an opportunity for examining diverse elements in which learning activities within such spaces occur and the ways they mediate learning processes.

These diverse elements within informal learning environments may vary across settings and be different than what students are used to in schools (e.g., Stewart & Jordan, 2016). Therefore, understanding learners' perceptions of their activities and engagement in STEAM learning environments through their own terms, can help understand the ways in which existing structures are reflected through their perceptions and conceptions of learning and experiences (Sengupta-Irving & Vossoughi, 2019). Such an understanding helps in examining ways in which existing power structures, hegemony, and dominant practices manifest in learners' understanding of what counts as learning, and therefore shape how learners perceive themselves and make meaning of their experiences.

Methods

This study is part of a larger research project within a community-based organization. To answer the research questions, I conducted semi-structured interviews with ten participants who participated in a community-based organization program for science during Winter Break in December 2019. This specific study aimed to understand students' perceptions of transdisciplinary science within this context. I explored these perceptions by focusing on the major research questions: (1) learners' perceptions mediated by the activities they used in the program; (2) perceived characteristics of scientists, artists, inventors, and engineers; (3) perceived their own thinking, doing, and self-being in relation to these activities and perceptions of scientist, artists, engineers, and inventors. I use interviews as the main tool of data collection for this study, however, I build also on field notes from observations of the setting during my field work.

Participants

For the purpose of the study, the organization planned a Winter Break program for 5th and 6th grade children. Recruitment of the participants was conducted by Al-Rowad. The organization announced the Winter Break program and shared the information with their local community through social media announcements, such as, posts on the director's personal social media accounts which are open to the public as this is their major means of communication with the local community. Additionally, the pedagogy and education counselor shared details of the program with her network of educators. I also shared the ad on my own personal social media account as I have a network of parents and educators from the town where the activities took place. The ad included an announcement that observations would be conducted during the program and participants might be invited for interviews. Fees for the program were waived to enable broader accessibility. The registration process was conducted through Al-Rowad and I was not involved in the registration process and selection process for the program. Parents who were interested in the program contacted the organization. I asked the organization representative to make sure the students were in 5th or 6th grade, there was equal representation of boys and girls, and different schools were represented. In addition, close family members of the organization directors were excluded.

All participants (5 boys, 5 girls) were Palestinians, from two Arab towns in Israel (Table 1.1). These participants were from 5 different schools in two towns. All of these learners attend state public schools in the Haifa District in Israel. All participants spoke Palestinian Arabic as their native language but were also exposed to English and Hebrew as these are taught in school. The activities and interviews were conducted mainly in Spoken Palestinian Arabic. However, this learning environment was a diglossic environment, meaning that both Spoken Palestinian Arabic and Academic Arabic were used throughout the activities and measures.

Table 1.1

The Participants' Pseudonyms Names, Gender, and Grades

Pseudonyms	**Grade**	**Gender**
Faris	5th	Boy
Rami	5th	Boy
Yousef	6th	Boy
Fadi	6th	Boy
Rana	6th	Girl
Noura	6th	Girl
Beesan	5th	Girl
Lina	5th	Girl
Lara	6th	Girl
Karam	5th	Boy

The program activities

Winter Break Program with Children

The Winter Break program consisted of four days of activities (approximately 100 minutes each day). In these activities, children engaged in transdisciplinary science hands-on activities designed for informal learning of diverse topics related to science. These hands-on activities are designed as models to engage learners with scientific phenomena, such as diffusion, light and color, illumination, volcanism, and density.

Each day, learners engaged in one activity. While the program was promoted as a science program, these activities integrated features that combine science, engineering, art, technology, and mathematics. This transdisciplinary approach was emphasized during the program discussions with students by the leading teacher and also reflected in the diverse ways in which learners perceived the activities (Mawasi et al., 2020a; Mawasi et al., 2021a). Here is a description of hands-on activities with an image that illustrates the major artifact students built for each activity.

Activity 1: Super Absorbent Polymer (SAP)

Figure 1.1: *Super Absorbent Polymer (SAP) Final Artifact*

Learners build this activity in the setting, but observation of changes to the chemicals happen at home. The teacher introduced the topic with a series of slides about the concepts. This introduction included a discussion with learners about the concepts and questions to engage them in discussion. Then the teacher gave instructions for students to complete the activity. In this activity, students used multiple tools such as test tubes, pipettes, and a wood stand to build their own take-home hands-on artifact (see Figure 1.1). To build the artifact, students added to the tube the three primary colors sequentially and separated each with a white substance (the SAP), then learners began to observe the diffusion process and how the colors merge. The final outcome of this activity that all substances blend and turn black, however, this takes weeks. The teachers encouraged the students to continue observing how the tube changes from the three distinct primary colors and white, to a blended rainbow of colors, and finally, to black.

Activity 2: Newton's disc

Figure 1.2: *Newton's Disc Final Artifact*

The second activity, Newton's disc, taught light and color as well as mechanical motion. The Newton's disc was attached to a smaller wheel, which was attached to a bigger wheel (see Figure 1.2). When the student rotates the big wheel using a handle, the smaller wheel rotates fast. This activity built on knowledge of primary colors (from the previous day's activity) helped differentiate them from the light colors (green, yellow, red, indigo, violet, blue) on the current wheel. When it turns fast, the colors merge and the disc appears white. In this activity they learn about both motion and colors. Particularly, this activity allows students to wonder and question about additive and subtractive colors as well as compare and contrast with their experience with colors in the first activity. Mixing in the first activity leads to black while the "mixing" in the second activity leads to white. This paradox can be resolved by understanding how colors are produced and perceived.

Activity 3: Illuminating Board

The third hands-on activity was building an illuminating board where light can be used as a "pen" for drawing (Figure 1.3). This activity exposes learners to diverse sources of light, where they learn about light, how it works, and materials that light-up in the dark. Specifically, in this activity, students learned about phosphorescence and the characteristics of these materials characteristics in the dark.

Figure 1.3: *Illuminating Board Final Artifact*

Activity 4: Oil & Water

The fourth activity focused on volcanism and density through characteristics of oil and water and their reaction with other materials. Initially, the teacher introduced volcanos to explain the concept of effusive eruption. Then, learners created a mixture of oil and water and observed the reaction when other solution of colors and acid are added to the mix turning it into a solution. This reaction was a model of how volcano magma erupts into lava. Finally, in this activity, students used their knowledge of color mixing from previous activities to determine what color they wanted their final outcome to be (Figure 1.4). The product of this activity is a liquid hand soap the learners could take home and use.

Figure 1.4: *Oil & Water Final Artifact*

Data sources

Interviews as a Method

In this study, interviews as an instrument were used as a tool to study learners' perceptions of transdisciplinary STEAM activities. I recognize the affordances and constraints of interviews in mediating participants responses and meaning making in the data analysis (Vossoughi & Zavala, 2020). I conducted semi-structured interviews with all participants (n=10) after they completed the program's activities. Here I describe the major procedures taken during interviews and examples of questions we asked.

The interviews were conducted following the four-day program. I interviewed five participants on the day after the program, 4 participants the following day, and 1 participant on the third day after the program. I conducted the interviews in Spoken Palestinian Arabic. The interviews were 40-60 minutes long (average time = 48.4 min, SD=8.9 min).

I began the conversation by thanking participants for joining, providing an overview of the goal of the interview, clarifying that there are no right or wrong answers, that their participation is voluntary, the interview is confidential, and asking consent for recording.

The interview questions consisted of several topics that aimed to address the overall research questions I am raising in this study, around learners' perceptions. The sequence of questions varied across interviews, depending on the flow of conversation with each individual participant. I displayed photos of the final artifact from each day of the program activities, namely, the activity of the day. These photos were displayed using a laptop and were used to help learners remember the activities and provide context for the conversation. I asked these questions to most of the students, depending on the activity they chose to talk about or the flow of the conversation with the students. Some students talked more than others. I used different variations of the questions structure to acknowledge the diversity of their language assets, therefore the questions had varied wording and structure given the richness of the Arabic vocabulary.

Here I describe the major emerging topics that guided the questions and examples of variations of questions that were asked. This list of question variations emerged as an outcome of the interview process itself.

- **General questions** about their in and out of school activities, such as everyday life at home, engagement with siblings, activities they do with technology, favorite topics at school, going to spaces like libraries and museums. Examples include: w*hat is your favorite topic at school? How often do you go to the library? Have you visited a museum before? Did you share these activities with your family, siblings, or friends?*

- **Questions about the artifacts** created during the program by walking through the activities. On average, learners discussed approximately 3 of the 4 activities artifacts (Mawasi et al., 2020a). Examples of conversation flow and questions included: *What was your goal joining this program? How would you describe what you did in this activity to your friends at school? What was your favorite activity? What was your least favorite activity? What was your favorite part of this activity? What would you improve in the activity design? Did you feel successful doing this activity? How do you see this activity in your everyday life? How would you use it? What do you think you learned doing this activity? What challenges did you have doing this activity? Do you think this activity is art or science?*
- **Learners' perceptions of scientists, artists, engineers, and inventors (SAEI)** as a way to understand how learners perceive their characteristics, roles, and if and how they connect these to their own identities. I focused on these four professions because they present interdisciplinarity. The conversation with participants included, describing the characteristics of SAEI, talking about SAEI through the activities, and using possible selves prompts to engage students with thinking about diverse identities they could have. We acknowledge that constraining learners with these four roles may constrain their thinking about possible

identities. At the same time, during the interview, there were multiple examples where learners had an opportunity to share about other interests (e.g., animals, knowing more about space), hobbies (e.g., drawing, playing videogames), and future possible self (e.g., becoming a teacher, becoming a lawyer). In many cases, using a possible self-question as a prompt helped learners to think through the roles. For example, asking a student "imagine you are a scientist" versus "what are the roles of a scientist?". One benefit of structuring this question using "imagine" is that it creates an opportunity for the learner to see themselves in different roles (Gee, 2017). Imagination allows a possibility for learners "to try new identities and new roles and grow into new ways of being human." (Gee, 2017, p.34).

Examples of questions that addressed SAEI include: *what do you think the characteristics of scientists, artists, engineers, and inventors are? (Learners were asked one role at a time.) Among these four, what did you feel doing this activity? Or When you did this activity did you feel like a scientist, artist, engineer, or inventor? Let's imagine you are an inventor, how would you improve or enhance this activity? Which one of these activities made you feel like scientists, artists, engineers, or inventors?*

- **Responsibility** in doing activities to understand their ethical thinking. Example of a question: *Imagine your invention caused an issue in your house. Who would be responsible for that*?
- The final stage of the interview was allocated for walking through items from the pre-post survey that students answered during the four-day program. Students

were not asked to recall how they answered previously but were asked the questions anew in order to elicit explanations for their answers and further explore their perceptions of the pre-posttest items (see the second article in the dissertation for more information and see APPENDIX B for examples of examples of science self-efficacy items).

Other data sources

While the major data source of this paper is interview data, I also refer to general observation notes from the overall study. Specifically, I refer to notes summarizing the field work that included, noticeable actions in the setting, logistics considerations, pedagogical practices, activity flow during observations, summary of activities, and summary of initial impression from participants and activities.

Data Analysis

I employed an interpretive analysis approach to account for the meaning making of students' perceptions during interviews (Erickson, 1986, 2012; Saldaña, 2015). I also did what I refer to as culturally sensitive analysis. That is, paying attention to the sociocultural context in which the language is used and to ways broader sociocultural conditions affect students' reactions (Erickson, 2012; Saldaña, 2015). The analytical procedures are discussed in three phases: first cycle, second cycle, and interpretative cycle.

First cycle

The interviews with children were audio recorded and then transcribed by professional services that specialize in Spoken Palestinian Arabic transcription. I reviewed all transcriptions line by line, and identified only minor typos, none of the typos were disruptive to the text meaning. The codes and memos were in English. I wrote them in English to allow feedback, discussion, and communication about them with my committee members. I coded the data in English because that is the major communication language in my academic education.

The primary goal of this study was to understand students' perceptions of their engagement in STEM activities through the program activities, characteristics of scientists, artists, engineers, and inventors (SAEI), and values they reflect. I did an open coding for all interviews following (Saldaña, 2015).

First, in order to understand what might be present in the data, I did an initial coding by reading all interviews (Charmaz, 2006; Saldaña, 2015). This initial coding was for major categories that stood out to me for what might be present in the data (Saldaña, 2015). For example, I noticed learners talking about their engagement with their family, so I highlighted signs for “intergenerational interaction”. I also noticed that learners' perceptions about their experiences varied, meaning some perceived the activities within the program as non-science only while others talked about them as science activities. This variety was across students and activity type too, that is, in some cases even if a student talked about one activity as a science one (like Oil and Water), they might refer to the SAP as art. Finally, reading all the interviews was also one step to decide the next coding steps to take for a deeper coding procedure.

In the second part of the coding cycle, I used two coding analysis approaches to analyze the data qualitatively (Saldaña, 2015). First, I used a process of structural coding to generate codes based on the semi-structured questions asked to students. I used this method because I wanted to capture the major stances of students reflected in their answers. In this step, I used the software MAXQDA to highlight the major codes. For example, I coded questions I asked on responsibility as “values”, I coded questions I asked about characteristics of SAEI as "characteristics of SAEI”. Second, I coded data in segments through a holistic approach (Saldaña, 2015). This approach allowed for developing a meaningful initial coding of segments instead of looking at data as line-by-line. The structural coding allowed me to identify major categories of responses for semi-structured questions. The holistic coding also allowed for deriving new codes. Examples of such coding include, students describing a “design related process” such as improving the artifact design, aesthetics, testing their artifact, and expanding how students talk about values beyond responsibility.

During this coding cycle, I coded each interview on its own. I also returned to previously coded interviews when a new code was created from later data. Upon completing coding for each interview, I created a memo that summarized major insights about what I learned from coding each interview. All codes and memos were written in English with a combination of the spoken language when needed.

Finally, I combined codes that had similar definitions and were addressing the same topic. For example, initially I had a separate code for when a student talked about “describing an activity to others” and “mentioning specific activity features during the interview." Upon reflection, I decided that both of these codes were sufficiently similar and combined them under "Program Activities".

Within the end of this coding cycle, I printed all the codes and organized them in eight major categories that I grouped together. To group the codes, I printed all the subcategories and grouped and organized them using an Affinity Diagraming method (Hartsonm & Pyla, 2012). It is important to mention that there are overlapping codes within segments. For example: there are segments that were coded under the "Program activities" and had within them codes related to "Values" or "Everyday life". Another example, segments that were under a General code category, yet, included family related codes. Additionally, rather than taking a frequency approach for these codes, the procedures taken were focused on identifying major themes, codes, and categories this data highlights throughout the interview conversation with students.

I describe the eight categories constructed in this coding cycle process. I illustrate these categories through examples from interviews with students (see Table 1.2).

(1) **General:** A category used for subcategories that represents introduction, learning about students' interests like hobbies, talking about school favorite topics, using technology, out of school activities, going to spaces like libraries or museums. This category was used as a way to highlight general conversation questions with students. Such questions were mainly used to get to know students, not only to ask them about the program itself.

(2) **Everyday life**: A category used for subcategories that represents engagement with family or friends, resources at home, play and fun, using activities out of program, and intergenerational interaction. Examples include, students talk about

engagement with family, students addressing questions on how activities connect to their everyday lives.

(3) **Program activities:** A category used for categorizing segments such as students goals doing activities, walking through activities, features of activities, describing activities to others.

(4) **Processes category** for subcategories that describe processes students engaged with in relation to programs or activities they do at home. For such processes, subcategories include observing changes in an artifact they did, describing a challenge they faced and how they addressed the challenge, describing a design process where they suggest improvement for their artifact, describe testing their artifact, materials they used to design an activity, describing creativity process like imagination.

(5) **Knowledge:** Procedural and declarative knowledge (e.g., students describing procedural knowledge for what steps they did in an activity, declarative knowledge like mentioning a phenomenon or fact they discussed within the program).

(6) **Values:** A category for subcategories that connect to students ethical thinking, values, and morals. Examples include students addressing the question of responsibility, talk about harm, ethics, design aesthetics, and utility.

(7) **STEAM perceptions** through: Scientists, Artists, Inventors, Engineers (e.g., students describing characteristics of SAIE) and general perceptions of STEAM.

(8) **Self-Identity category** that describes stances or segments where student talk about themselves as a certain type (e.g., good student, patient, being like an artist,

or inventor, being careless student). These were in relation to questions around activities or in general.

Table 1.2

Codes Used in Initial Coding Pass with Descriptions and Examples from Interviews

First Cycle		
Coding category	**Description of Example**	**Example from Interviews**
General	A general conversation where a student talks about interests (e.g., an activity at home, using a computer).	Lara: **Usually, I do not read like these things, I read more about space**. Areej: Do you like space? Lara: yes, I love it a lot. So, **I read more about it, meaning, many things about planets or so.**
Everyday life	A student talks about having a conversation with his relatives about one activity he did during the program. He describes the engagement with his relatives as one way he used the artifact.	Fadi: **When my relatives came over, I showed them this…** that there is the SAP substance and water, also Red Sap, and Water SAP and these things and it became this product.
Program activities	A student describes an activity students did in the program	Rami: **It is difficult and requires a lot of precision and beautiful**
Process	A student describes his imagination process, after he talked about imagination as one of the characteristics of inventors.	Areej: What made you feel like you have imagination? How do you mean you felt you had imagination? **Yousef: for example… I do a move in my head.. Meaning one is talking in front of me, they tell me a story, mmm.. If I do not how forms/shapes look like, I imagine some**

		forms/shapes, and I imagine all…
Knowledge	A student reflects declarative knowledge from the activities they did within the program.	Fadi: I will tell them, **it absorbs the light, and it saves it, because.. When it is night.. It lights, and one can draw using this light of the bulb.**
Values	A student talks about the behavior of an engineer (her father in this case) in response to a question on characteristics.	Noura: They should love buildings first and… be nice in **the way he treats others.**. For example if someone tells him… **he can engineer in a correct way.** That he does not build to someone, something that will be damaged. That that he has trust and integrity.
STEAM perceptions	A student describes what he perceives as characteristics of a scientist	Areej: What characteristics you should have to **become a scientist?** **Faris: Smartness, Ethics, and Patience.** Areej: How do you mean smartness? **Faris: meaning mmm.. That I know how to put things and their quantity and take things not recklessly.**
Self-Identity	A student describes herself as an artist when she describes the characteristics of an artist.	Noura: mmm… **for example when I want to draw, there are little things things and I want.. I should have a patient spirit for example when I start coloring, so i do not damage the drawing.**

Second cycle

The eight categories offered an initial means to identify similarities and differences across students' responses. Then, I conducted a second cycle review of these codes and categories towards identifying general cross-cutting patterns in students' perceptions. This review and analysis led to the constructions of three initial major themes, (1) tensions between in and out of classroom science; (2) transdisciplinary ways of thinking; and (3) axiological ways of thinking, being, and doing. For each one of these themes there were categories that reflect the ways in which tensions, transdisciplinarity, and axiologies are reflected in students' stances. Within the completion of these themes and categories I engaged in a deductive analysis, where I discussed the themes with senior researchers and consulted existing literature. The discussions yielded to construct one theme by itself after it was a subcategory under transdisciplinary ways of thinking, presumed normativity. Thus, the final four themes which will be discussed in more detail below are, (1) tensions between in and out of classroom science; (2) transdisciplinary ways of thinking; (3) presumed normativity; (4) axiological ways of thinking, being, and doing. In the results section I will expand on the ways in which each theme is reflected across the interviews.

Beyond coding: interpretation and translation as an act of interpretation

I grounded my analysis in a culturally sensitive interpretative approach that attends to the sociocultural and political context in which these activities are situated. Therefore, in the transcription and translation processes I paid attention to these dynamics too.

To illustrate each one of the four themes and subcategories I selected excerpts from interviews with students. Despite the connecting theme for examples, these excerpts reflect subjectivist experiences for each learner. The excerpts were used as examples with my interpretation of the excerpts. I reviewed the excerpts examples and interpretation while connecting them to related literature. The examples could represent multiple themes, however, each interpretation provided for examples representing the theme and category in which it is positioned in. I built on my multilingualism and cultural knowledge as a way to also engage these interpretations of interviews. This particularly led me to do in depth thinking of the meanings as I was engaged in during the translation process.

As Lapadat & Lindsay (1999) describe, transcriptions enact theories and mediate interpretations of data, therefore, transcribing becomes an interpretative act and should be carefully paid attention to in multilingual studies. As previously mentioned, transcription of the data was not isolated from interpretation. As I engaged in translation, I paid careful attention to the meanings of the text and their interpretation.

After selecting excerpts from interviews I engaged in careful translation of these excerpts. By careful, I mean paying attention to meaning making reflected in students' articulations, culturally sensitive meaning and vocabulary, attention to accent and dialect, and an understanding of the social and political implications of the language locality. Translation also entails an understanding of contextuality and requires an act of interpretation of meanings (e.g., Shammas, 2017). In this sense, translation is not a technical procedure rather an integral part of the analysis process. This also led me to select excerpts (n=14) across interviews and ask a professional translator who is familiar with this Palestinian Arabic context dialect to translate them. This translation exchange yielded multiple questions about some words that were resolved in communication between the translator and me. For example, I wondered when and how to use words like "pretty" and "beautiful" and if words like "improvement" reflect a holistic meaning of words like يحسن (Fasheh, 2012, 2014; Mawasi et al., 2020). When I did a final review of the excerpts within the full interview again, I kept the translation as close to the meaning of the context.

The importance of cultural sensitivity of translation made me and the translator pay attention to important stances that reflected situated meaning making. For example, in one excerpt, we wondered if the child said عالم (Aalam) as people or world. The translator referred to it as people, then I realized in this specific Palestinian dialect, *Aalam* عالم is world and *Nas* ناس is people. This exchange within the context of the interview was essential for capturing that a child was wrestling with science as human centric versus science as targeted to benefit the world. Additionally, viewing languages, and Spoken Languages as a tool for meaning making, it is important to acknowledge that English vocabulary in many cases is not reflective of different meaningful words, verbs, phrases, and nouns in other languages, like Arabic or Indigenous languages (e.g., Kimmerer, 2013; Fasheh, 2012, 2014).

Findings

Drawing on interviews as the primary data source for these questions, I discuss major findings from the analysis process in four organized themes in which I see the categories in coding cycles connect: (1) tensions between in and out of classroom science, (2) STEAM transdisciplinarity (3) presumed normativity, and (4) axiologial ways of thinking, doing, and being.

I illustrate these themes and subcategories through examples from data. Despite the unique learning trajectories of each participant, these examples reflect ways learners' experiences are bound through the themes I discuss. I use these findings to discuss students' perceptions of STEAM activities, perceptions of scientists, artists, engineers, and inventors, and ways these perceptions reflect students' STEAM thinking, doing, and being.

Tension between in and out of classroom science

Students reflected an engagement with the activity through describing knowledge they had learned from the program and activity descriptions. However, this engagement does not always reflect how an activity's artifacts could be used or seen in their everyday life as science related.

Learners expressed knowledge and engagement with activities they did in the program at different levels. This knowledge is reflected in learners' descriptions of activities (e.g., concepts, phenomenon) they discussed with the organization instructor reflecting (i.e., declarative knowledge), learners' description of procedures they did (i.e., procedural knowledge), learners' narrations of how they would describe these activities to others and expressing ways they might be using or not using these activities at home. Building on Fredricks et al. (2004), the data shows there was engagement within the context through in varied ways, including, emotional, behavioral, and cognitive. Through their stances, the learners reflected engagement in this context through their emotional affective stances in both interviews (e.g., describing activities as beautiful or joyful, describing the learning environment as fun), descriptions of how they did the activities, describing the knowledge they learned in the program, and using activities with their siblings or family. I take these examples as forms of engagement.

However, there were variations in the ways learners described this engagement and knowledge; this variety was reflected in the depth of what they described, details they paid attention to, ways they engaged with activities out of the program, or simply their conceptualization of what counts as science. Additionally, even though students may describe engagement with the program and activities, it does not necessarily mean that they perceive themselves as doing science. Additionally, various tensions were reflected in examples where some learners position themselves as engaging in science as school students or in relation to the program. How a student describes engagement with the program and activities does not necessarily mean that a student perceives themselves as doing science. For example, Faris, described himself as a good science student or loving science class, yet there was a struggle for him to see how he is engaged in science related activities in an out of school context. Similarly, a learner like Lina might describe herself as not “a science person”, yet, mention different ways in which she does STEM related activities with her family members when they draw like an engineer. Finally, there were stances across interviews where the interview itself offered opportunities for deep engagement, reflected in their thinking about activities. Examples include a student comparing between activities, a student describing possibilities for building on these activities to create something new or improving the design, and a student describing details in the design of artifacts. In these descriptions, some students were able to identify ways to engage with these activities at home, for example, by engaging in science-related practices such as observing and documenting changes, communicating about the program activities with their families, and thinking creatively about possible uses of the activities. Despite these affordances, in different situations, the students did not necessarily see these practices as science related or even perceive all activities as science activities. This disconnect or challenge of alignment creates tension with ways learners expressed engagement in learning about science and excitement about the program and activities they did.

The tension between learners' engagement as interpreted through their stances and perceptions of what counts as science, unearths the complexity of engaging nondominant learners with STEM activities (e.g., Sengupta-Irving & Vossoughi, 2019). An important aspect of the program activities is that it creates an entry for learners to engage with STEM that affords diverse ways for students to engage with transdisciplinary STEM activities within the program and once they take the artifacts home. Yet, I see that in different examples, the narrowed ways in which STEM is conceptualized in students' everyday life through channels like school creates a challenge for them to see ways existing cultural resources out of school entails science related practices and ways to perceive the assets of their cultural resources and local knowledge (e.g., Erickson et al., 2008).

I will illustrate examples of tensions through one student excerpt. These examples reflect ways narrowed terms of what counts as science and learning are wrestling with students' perceptions of his activities (e.g., Sengupta-Irving & Vossoughi, 2019).

During the interview with Rami, I asked Rami if he talked with his family about the artifact he created in the program. Rami said “no”, then I asked him “did you feel like sharing about the activities' ', he said “no… because they are not interested in science.” Rami here holds a complex thought between what he said earlier when he mentioned that he talked about the activities with his mom and his idea that his family are not interested in science. Furthermore, in another example during our conversation, Rami made a connection between the Newton’s Disc toothed wheel and his father’s job place. Here, this lack of connection, is between the perception that the student has about his family as not interested in science, when his dad engages in STEM-related activities. Furthermore, the learner in other parts of the interview mentioned that he likes mathematics at school and enjoys playing videogames, yet these activities seemed as not “enough” as legitimized practices to make him feel like he is “already” engaged in STEM-related activities.

Rami also described in detail the procedures of building the artifacts, including paying attention to aesthetics and design, demonstrating persistence to build his artifact, and describing the movement of toothed wheels like the ones he saw in cars at his dad's work. Finally, Rami felt joy doing the activities, even when there were challenging moments with building the artifacts; such joy comes from thinking about the new things he learned and the beauty he perceived from these activities:

> Interviewer: How did you feel about what happened at the end? Like the final product? (Talking about SAP activity).
> Rami: Nothing
> Interviewer: That you did this thing, how did you feel?
> Rami: It is a beautiful thing, a new thing, the first time I do it.
> Interviewer: This is the first time you do something like that?
> Rami: Aha…

Interviewer: mm what did this make you feel?
Rami: Joy.
Interviewer: How do you mean joy?
Rami: That I did something new, I learned new things, and it is beautiful.

At the beginning of the interview, Rami mentioned that he likes science at school, and when I asked him “what do you like about science?”, he said “the topics, the things we learn, the experiments and things”. Later, there was a struggle for him to see how “he” as “Rami” can be or already do STEM-related activities, until I asked specific questions about the activities he did in the program. When I asked him “have you thought about what you would like to be when you grow up?” he said “still, I did not think about it” and we continued to talk. The following excerpts provide examples of the tension between what he perceives as not knowing and what he is actually doing. Furthermore, it provides insights into how existing perceptions of who is a scientist (i.e., Einstein, Newton) perhaps creates narrow ways in which he sees who can be or is a scientist. For instance, despite all these examples of engagement and thinking about the program and STEM-related activities, at the end of the interview when we talked about the self-efficacy items, he said “I disagree” for the item “I can use science to solve problems in my everyday life”, and when I asked him “why?”, he said “teacher, I do not know what I could do in science for example”, meaning, his perception is that he does not know what is the utility of science and how he himself can take an action to do something with science. This answer is an invitation to wonder with Rami during the interview, about the possibilities his own everyday activities connect with STEAM. These examples from the interview with Rami show that despite the deep ways of thinking about STEAM practices he is engaged with, from considering scientific practices like testing and experimenting to thinking ethically about aesthetics and utility, he is still wrestling with the idea that science is solely a school thing and at the same time his is still thinking about his science related activities.

Transdisciplinarity

Despite examples of tensions, students reflected diverse ways of thinking about science beyond a narrow disciplinary thinking. The ways transdisciplinarity manifests in students' responses is described through the following subcategories examples: (a) perceptions of scientists, artists, engineers, and inventors; (b) talking about their own identities in relation to the activities, roles, and self; and (c) students' articulation of how they come to understand the activities they engage with.

In their work, Mishra et al. (2011) suggest a transdisciplinary knowledge approach where a learner goes beyond disciplinary practices boundaries and "integrates different solutions, viewpoints, or perspectives" (p.24). The authors propose seven cognitive tools transdisciplinary learning affords, based on Bernsteins (1999) as cited in Mishra et al. (2011): "perceiving, patterning, abstracting, embodied thinking, modeling, play, and synthesizing" (p.24). The authors also view that such an approach helps in creating connections across disciplines that foster learners' creativity. In alignment to the importance of transdisciplinary approaches, scholars in Learning Sciences stress that learners thinking in expansive ways about how STEAM opens opportunity for engaging learners with thinking about the social, political, historical, ethical, and ideological dimensions of STEAM (e.g., Phillips et al., 2018; Takeuchi et al., 2020). Such expansive ways are particularly important to attend for, as it allows for examining STEM practices neutrality, creating entry for engaging with science through transdisciplinary activities, and encouraging learners to think ethically about STEM practices and the unintended consequences of it. The benefits of transdisciplinary engagement also manifest in the ways it affords diverse ways of thinking, being, doing to be experienced by students (e.g., Warren et al., 2020). This contributes to ways in which students come to see their science activities as connected to their experiences and cultural ways of knowing (Warren et al., 2020).

a. Perceptions of scientists, artists, engineers, and inventors

During the interviews students described the roles of scientists, artists, engineers, and inventors (SAEI) in various ways as described in Table 1.3 retrieved from Mawasi et al. (2020a).

Table 1.3

Examples of Stances about Roles and Characteristics of SAEI

	Examples of stances about roles and characteristics of SAEI
Scientists	Scientists have patience and persistence, are smart, ethical, and socially responsible, and work alone.
Artists	Artists draw and paint, use imagination to plan and implement drawings, think and plan what they want, care about aesthetics, and have patience and persistence to experiment with things like colors and drawings.
Engineers	Engineers build things like buildings, they think about the pros and cons of things they build, they have to be accurate so they do not cause damage, they work with people, they plan things, do high- quality work, draw things on paper, and use imagination. Engineering is like geometry.
Inventors	Inventors are smart and have patience. They need to be accurate in terms of mastery and focus, they have ideas and imagination, they experiment and try, and they build things and have equipment to do that.

These descriptions were captured as earlier mentioned across multiple questions. In the students' descriptions we could identify that students had transdisciplinary thinking about the roles. Furthermore, in their thinking about these roles, some students were also talking about relevant cultural and personal resources in their lives in relation to these roles (e.g., self as an artist, dad as an engineer, Thomas Edison as an inventor, aunt as a scientist). Finally, despite evidence for students thinking in transdisciplinary ways about these roles, we also found that there are dominant and normative views embedded in this thinking. This is not to reflect contradiction, rather, it is to reflect the complexity of ways learners perceive these roles, this will be discussed in another theme under presumed normativity.

Students were drawing upon transdisciplinary disciplinary practices to describe these roles and characteristics, when they address questions about SAEI, connected these roles and characteristics to themselves, or described the activities. In their transdisciplinary thinking about SAEI, learners expanded the specific practices one does in a field, towards describing activities, dispositions, and ethical practices within these roles. For instance, artists and engineers use imagination in their work, they plan their work, care about aesthetics and people, and draw things. Scientists are not simply people who do experiments, they are also socially responsible people. Artists are like scientists and inventors, they all persist, and they are patient. While these examples show a form of transdisciplinarity, they come in tensions with narrowed ways in which some of these roles are perceived, which I will expand on when I address dominant views and normativity.

To illustrate transdisciplinary thinking about the roles and characteristics of SAEI, I describe the following example:

In his interview, Fadi's answer about the characteristics of a scientist was "he should be like us, like human beings, not like someone from space. However, he should have an exceptional talent in drawing". Then I asked him "the scientist, how do you mean should be a painter?". Fadi answered: "he should have a talent in drawing, if… if he does not have it, he would not draw beautifully. When he draws a human shape, it becomes a nice drawing." This thought about a scientist as someone who knows how to draw and the emphasis on aesthetics, was also consistent with Fadi's description of an inventor, where he also mentioned that an inventor should know how to draw: "like drawing a house..."... "a house that is not normal house"… "like a palace… but not like any palace… a bigger one, more beautiful, and does not exist in the whole world…" Across these descriptions there is an attention to art and architecture, aesthetics and an attempt from Fadi to draw on cultural resources to describe characteristics of scientists and inventors. Fadi also describes the inventor as someone who incorporates practices from artists and engineers too. Perhaps such descriptions could be connected with activities he did within the space of program, where he built artifacts like the Illuminating Board and he engaged in drawing on it.

b. Students talking about themselves

When students described themselves through what they did with the activities, self in relation to roles, and other self-dispositions, there were multiple stances that reflected their transdisciplinarity. In one example, Yousef describes his imagination process, after he talked about imagination as one of the characteristics of inventors. Here he referred to himself too as someone who imagines, like an inventor. He described an example of how he imagines, and makes meaning of it through imagining a solution to help a cat find a safe shelter during rainy day, and then a process itself of how he imagines.

In another example Noura described herself as an artist when she described the characteristics of an artist. She gave an example that illustrates how patient and resilient she is when drawing. The excerpt also reflects thinking about values as artists should be patient in dealing with frustration.

> Interviewer: mmm… okay so an artist? You.. you told me you like art. What.. what characteristics would make someone become an artist?
> Noura: mmm… they should have a patient spirit in doing the thing, when he wants to experiment it for example. And if for example something was damaged with him they would do it again and test it all over again.
> Interviewer: How do you mean this is like this in art?
> Noura: mmm… for example when I want to draw, there are little things things and I want.. I should have a patient spirit for example when I start coloring, so I do not damage the drawing, however, if it was damaged with me, that I should have the effort to be able to fix it, and not just give up and damage all the drawing with this little thing.

As the excerpt reflect, Noura's descriptions of herself as an artist incorporated ethics and values that she thinks through as she engages in doing artistic activities. Additionally, she described an artist as someone who experiment and tests with things and is patient when experiencing challenge. In incorporating such values, Noura described how an artist practices have overlaps with science practices too (e.g., testing, experimenting, fixing) at the same time, such practices also include ethical behavior towards self and others.

c. Students' description of how they come to understand the activities they engage with

When asked about the activities they did in the program, students had varied ways of describing the activities. Students did not necessarily see all these activities as purely science activities, rather there are multiple examples where they described these activities as art as well, or did not see it as science activity at all. For many, the science part of the activities was mainly the instruction phase that was led by the instructor. Most of the students saw that the Oil and Water activity as a science activity because it involved reaction of substances that they could observe immediately. In other examples, artifacts used in activities were not necessarily perceived as science. Not seeing an activity as science or feeling like a scientist is not a problem from my perspectives, as the varied ways students come to see these activities and roles, describes transdisciplinarity in their thinking about it, beyond one discipline.

For example, Noura mentioned that the Illuminating Board activity made her feel like an artist, at the same time she reflected an understanding and knowledge of its function and the science concept they learned at class with the instructor:

> Interviewer: Third day's activity, why did it make you feel like an artist?
> Noura: Because umm… because I feel like it had some kind of art and… and it's nice how when you draw with ultraviolet rays on this, they light up in the darkness.
> Interviewer: How do you mean, art?
> Noura: It is at the same time art and umm… because you draw on it, and the beads that are on it they also looked nice. And… because it's an invention… because it's… I mean we discovered this thing, that there are things that could light up in the night if you drew on them using some light or something.

Presumed normativity of STEAM

While there is evidence that students were thinking about these roles in transdisciplinary ways, there is also a tension between the expansive ways of their thinking and normative views reflected through their conceptualizations. This theme centers around normative practices embedded in the students' perceptions about scientists, artists, engineers, and inventors (SAEI). Such presumed normativity reflects dominant views about the presence of SAEI and STEAM in learners' lives as defined in narrowed terms by social and political structure in which their learning activities are situated. Such views of perceptions towards what counts as knowledge, legitimate practices, and competence to become a scientist, artist, engineer, or inventor and the possibility of becoming one shape the ways in which students describe themselves and their perceptions of their STEAM engagement.

This category emerged from thinking with three directions, (1) ways norms and competence are defined by legitimate participation within communities of practice (Lave & Wenger, 1991; Wenger, 2009); (2) Scott (2016) synthesize of *Normative Scientific Practices* as defined by historical and cultural meanings of what counts as norms in scientific discourses; and (3) "narrowed definitions of science" (Sengupta-Irving & Vossoughi, 2019, p.492) and other practices reflected through students stances (e.g., using pipette at lab, dissection in a lab, man as a scientist). I view normativity with respect to perceptions as the ways existing social, historical, and cultural structures are defining norms for these students in their learning experiences (e.g., imposed standards, curriculum at school, shaping possible learning trajectories, dominant practices in scientific research). Such normativity is embedded in students' ways of thinking about

STEAM, affecting how they perceive their own practices as valid or not in relation to STEAM activities.

For example, a dominant view that was common across students is that an "engineer" is someone who is engaged in "building", mainly referring to construction engineering, a major form of engineering the students have access to in their surroundings or as someone who does geometry (because the word "engineer" in Arabic -*mohandis/a*- has the same root of geometry -*Handasi-)*. Another example is the perception that an artist is someone who "draws" or "paints." None of the students described other forms of art and I did not ask or provide them other examples of art. While these examples reflect a narrow way of thinking about the two roles, they could be explained by the fact that the two forms of practices are commonly tangible around the students everyday lives, in school and out of school. Other examples reflected through the perceptions of what it takes to be and become scientist, artist, engineer or inventor include: being smart, working hard for many hours, doing good to people, and Thomas Edison as a repeated exemplar of scientist or inventor, and conception of science as related to activities like testing, doing experiments, and working with specific types of materials

To illustrate an example in which normativity is embedded in ways students perceive STEAM, I present the case of Beesan:

Beesan described that the Oil and Water activity made her feel like a scientist. When describing it, she reflected about what a scientist does. She acknowledged that when scientists invent things, they build on other people's prior work. She used Thomas Edison, as an exemplar, within the ways she describes how a scientist practices.

Additionally, in this interview, I asked some questions to her using female pronouns ("she") for artist/ scientist/ inventor/ engineer; however, when she described a scientist, she used "he" consistently. This also happened in the question on characteristics of scientists, even though I used both male and female pronouns.

> Interviewer: mmm… I would like to ask you something, when you did this activity, what did you feel? Artist? Inventor? Scientist? Engineer?
> Beesan: Scientist.
> Interviewer: Why?
> Beesan: mmm.. Because I feel that the experiments that are in the laboratory are all like this with tubes, they all have liquids, things that react, things that bubbles (**بتنفقع**). I feel I am in a laboratory, inside mm.. Scientists laboratory. They try, the scientist first try to know the root of the importance of this.
> Interviewer: the importance of what?
> Beesan: the product or the invention. And they could, meaning, from a thing to invent… something they did not invent themselves, they invented, they could invent a second thing from it.
> Interviewer: How do you mean?
> Beesan: for example mmm… like this for example, if someone says it is beautiful, and he says I would like to do one for example… develop it, make it bigger, meaning new improvements, to improve it.
> Interviewer: How do you mean to improve it? [1]
> Beesan: Meaning, I put new materials… he knows what to put and what not to put, he experiments for example if.. He does.. For example like.. Thomas Edison, when he tried 90 times, attempted to do the light, and eventually he did, he could do mmm… to do multiple times until he reaches the goal or the success.

In the interview, Beesan also describes the characteristics of scientists. She says: "he should be focused" and "he should be smart". Characteristics associated with schooling as I interpret them. Then Beesan continued and began to describe expansive ways in which a scientist can contribute to the world.

> Beesan: he should know what he wants to do
> Interviewer: mmm

[1] *translation note, we both used the word* يحدث *Yuhadeth for improvements, which literally means to update or make something new, but for the whole context, I used improve - the context is connected to "to innovate new things", another word of improve is "*يحسن*" Yuhasen which was used in another context in interviews.*

Beesan: I mean for example, he gives.. Meaning he does mm… he has a benefit to the world…
Interviewer: how do you mean, benefit to the world?
Beesan: Meaning he improves (بحسن, Behassin) the world in[2].. I do not know how to say the word mmm…
Interviewer: Do not worry, just continue…
Beesan: mmm
Interviewer: How do you mean improves the world? What does he do?
Beesan: He develops it, finds solutions, saves the world from things… discovers what will happen.. Mmm.. what will happen… if there is something that will happen also… the hypothesis, he has a hypothesis…
Interviewer: what does he do with a hypothesis?
Beesan: he hypothesizes what will happen, and should know if… what will happen, and has to do something so his hypothesis becomes correct or…
Interviewer: What if this does not happen, what if he did it, and his hypothesis was incorrect?
Beesan: nothing… he tries again to do things… strives mmm… he will get tired in his life I mean.
Interviewer: Diligent you mean?

Within the STEM education context, such normativity privileges a set of practices, modes of participation, and narrow possible futures for learners towards education that privileges economic goals rather than transformative ones (e.g., Gutiérrez, 2007). Students' perceptions of roles, themselves, and possibilities open for them is rooted in presumed normativity that is shaped by both social and political dynamics that privilege certain scientific practices (Harding, 2006). These perceptions reflect that the normative ways in which students experience curriculum is manifested in their meaning making (Erickson et al., 2008).

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[2] *Beesan used the word* بحسن *Behassin, which carries multiple meanings including, making the world beautiful.*

Axiological ways of thinking, doing, and being

In their description across diverse categories, students paid attention to values. I identify these values as they were described through students' stances about activities in the program, daily life, roles of scientists, artists, engineers and inventors, and talk about responsibility and self. These values were in some cases contextualized in relation to STEAM (e.g., describing ethics in STEAM, describing the activity artifact design) and in some cases described generally (e.g., describing self as someone who cares about oppressed people, thinking about helping an animal).

During the interviews, the way for providing an entry to talk about values was through was through an ethics question on responsibilities and, in some situations, questions on the utility of the science or activities the students did. However, during the data analysis of the overall interviews, I identified examples of ways of thinking about values, including thinking about more than human beings in ways students make meaning of activities they do and their self-descriptions. In other words, the expansive ways in which the students' stances reflected values, led me to learn that students' perceptions encompassed values, aesthetics, and ethics. This led me to explore values as reflected in "axiological positioning" through learners' stances (Bang et al., 2016). In this way, I build on Bang et al. (2016) definition of axiologies to conceptualize this theme as ***axiological ways of thinking, doing, and being***, as "values, ethics, and aesthetics - that is, what is good, right, true, and beautiful -- that shape current and possible meaning, meaning-making, positioning, and relations in cultural ecologies." (Bang et al., 2016, p.1-2)

I describe axiological ways of thinking, being, and being through five categories identified in the process, connected to values: (a) ethics, (b) responses to question of responsibility, (c) the perceived utility of the activities, (d) attention to aesthetics and beauty (design, arts, and materials), and (e) describing relations with humans and more than human beings. I view that these categories manifest through learners' knowledge, ways they describe doing things, descriptions of roles, and ways they describe themselves.

a. Ethics

As reflected through the stances of students, they conceptualized ethics in multiple ways explicitly by attending to ethics as a characteristic of being a scientist, consequentiality of an action, causing no harm or damage, and doing good or bad actions. In the following examples, I illustrate how these ways of thinking about ethics are present by presenting two examples that highlight these ways: Faris' response to the question on characteristics of scientists and Noura's response on characteristics of artists. The first example illustrates thinking about ethics in relations to others and the second illustrates thinking about personal ethics in relation to self and others.

When Faris described the characteristics of scientists, he was responding to my question "what characteristics should you have to become a scientist?", Faris responded "Smartness, Ethics, and Patience". I focused the conversation with Faris within this context of understanding what he means, which led him to talk about a scientist as someone who invents and "think(s) about their consequences and harm". In his response to the meaning of "consequences and harm", he said: "Everything has positives and negativities. So, there should for example… I should try to minimize harm. Meaning that does not cause harm to people and little kids." This thought, as I interpret it, reflects a binary thinking about the "good" and "bad" in doing an action. Within this thought, the question on "for whom it causes harm" is centered around "people and little kids". Later, the conversation reveals, in my interpretation, that Faris is largely drawing on Thomas Edison as as his resource for understanding a scientist's job, particularly Edison's persistence in testing until he succeeded (I assume this is an example of a scientist discussed in his school science classes). Faris' conceptualization of ethics reflects thinking about the meaning of ethics, being ethical, and doing ethical actions, however, these three are contextualized within the specific question I asked. In his description of the characteristics, Faris used the word *"أخلاق" Akhlak* which means both morals and ethics in Arabic, later when I continued with asking him more questions, he used a consequentialist description of ethics, and then closed by describing pragmatic thinking of a conduct when describing being patient "I should be patient so I could achieve things" and then "I mean for example not to flip and break things and…", reflecting that the ultimate goal is "minimizing harm" towards achieving an outcome that is beneficial to people and kids. This is particularly interesting as it brings multiple view of values embedded in Faris thinking of ethics (i.e., deontological, consequentialist, and pragmatic, Wringe, 2006, Mawasi et al., 2019). At the same time, these views also show that Faris is wrestling with definitions of ethics that are human and adult centered and moving beyond these definitions to consider values like being patient when work with materials (in this excerpt) and values that are connected to relationality with others through intergenerational learning with others.

Interviewer: What characteristics you should have to become a scientist?
Faris: Smartness, Ethics[3] and Patience.
Interviewer: How do you mean smartness?
Faris: meaning mmm… That I know how to put things and their quantity and take things not recklessly.
Interviewer: How do you mean?
Faris: That I think about inventions consequences and their harm.
Interviewer: how do you mean consequences and their harm?
Faris: mmm… Everything has positives and negativities. So there should for example… I should try to minimize harm. Meaning that does not cause harm to people and little kids.
Interviewer: How do you mean, not cause harm to people?
Faris: For example, umm... hmm… an electrical charger, I mean, a little kid could come with wet hands, touch it, get electrocuted and have something bad happen to him. Now for example … I could put… for example something plastic there to protect the little kids.
Interviewer: Umm… you spoke of ethics earlier, what did you mean by that?
Faris: I mean for example if… well, it's actually related to patience too, I mean if something didn't umm… something failed and such… I should be patient, that is, not break the thing or something. I should be patient so I could achieve things. For example, Thomas Edison and the light bulb, he managed to make it on the 99th try. I mean he kept being patient.
Interviewer: But how is this related to ethics?
Faris: I mean for example not to flip and break things and…
Interviewer: That is, to be patient? And not cause umm… umm… as you said a little earlier, not to cause what, you said?
Faris: Harm
Interviewer: Harm. Umm… alright, and so that it is...

In her description of what an artist does, Noura describes what she would be doing as an artist, in her thinking about the artist, she describes patience as a value that helps an artist to deal with challenges when things are damaged or require testing. She uses her own drawing practice to describe the value of being patient. The excerpt reflects thinking about values as artists should be patient in dealing with frustration and being patient to not cause damage. The effort she describes to work patiently, entails also thinking about an aesthetical aspect of why putting an effort in drawing. Noura describes

[3] *Translation note: Ethics and Morals have same word in Arabic, أخلاق Akhlak, which what Faris used. I used ethics because of the context of the response.*

how an artist should behave in face of a challenge like damaging his work, and trying again to fix it through testing. Importantly, she uses also the phrase " عنده طولة روح في الشغلة", which literally means "having a long spirit when doing something", and in my interpretation, it is a metaphor that for being patient when doing a task, a meaning that entails in it understanding of patience as a value that not only for self, but also affecting others. Such rhythm of patience may conflict with scientific practices that advance rapid and fast change in the name of progress and innovation.

> Interviewer: mmm… okay so an artist? You.. you told me you like art. What.. what characteristics would make someone become an artist?
> Noura: mmm… he should have a patient spirit in doing the thing (عنده طولة روح في الشغلة), when he wants to experiment it for example. And if for example something did not work (خرب) with him, he would do it again and test it all over again from the beginning.
> Interviewer: How do you mean this is like this in art?
> Noura: mmm… for example when I want to draw, there are little things things and I want. Meaning, I should have a patient spirit for example when I start coloring, so I do not damage (اخربهاش) the drawing, and if it was damaged by me, that I should have the effort and ability to fix it, and not just give up and damage all the drawing with it (referring to little things).

b. Responsibility

The following examples illustrate responses to questions on "whose responsibility" if something goes wrong with the artifact they design or their invention. As a reminder, I asked this question because I was interested in exploring students' ethical thinking about their engagement with science. While the questions provided a narrowed entry to discuss ethics through the lens of "responsibility" and "consequential harm", there are examples of learners reflected thinking relationally as well.

A notion of taking responsibility because of following instructions and in relation to "schooling" was shared by multiple students (e.g., a responsible student, is someone who listens to the teacher and disciplined). For example, Beesan mentioned “it is my responsibility” because “I should know”. And Rana said “If a scientist would do something like a scientific experiment and it includes explosions in front of someone, he should study it by himself alone first several times, then rehearse it with someone else. If it does not work, or it fails in the person, and this says about him...meaning something not good”. Additionally, when I asked Beesan about her invention, she, similarly to Faris, justified this through a human-centered lens, namely, causing no harm to people. In the two interviews however, I framed the question within “home” or “house”, and that possibility mediated the “human centrism” of the learners' responses. However, reading this in a subjectivist way is important across students, since in other cases, like when I asked Lara the same question, she also thought of cats and other beings when she articulated to whom her experiment may cause harm if it has a problem, she said, “it might affect someone else, like animals.”

Here I will continue with examples of excerpts from the interview with Faris and Noura to illustrate the ways in which responsibility is reflected in their thinking and meaning making.

I asked the question of “whose responsibility” to seven students of the ten. Example of such a question included, “who would be responsible if your invention has a problem?”. Faris was the only student who answered, “it depends”, all the other students responded either “it is my responsibility” or “it is the scientist / inventor responsibility”. When I asked Faris this question, he said “it depends” on how it happened, namely, causes. Then, when asked this question again in relation to himself, he again said “it depends”, and referred to it as responsibility of a person if they do not follow instructions, and it is responsibility of the inventor if the person used it correctly. While these stances are mediated by the structure of the interview question, they are aligned with Faris thinking about ethics and responsibility in a utilitarian matter, namely, what is good is defined by its consequences and outcomes.

> Interviewer: Umm… I wanted to ask you something, all right? If you, for example, had one of the inventions or activities you'd made or done cause some problems for you at home. Imagine for example… for instance umm... all right, whose responsibility would it be? Who should bear responsibility? If you were an inventor, an engineer, or a scientist?
> Faris: It depends... the engineer, if he umm… I mean, how bad the thing actually is and… the reason it happened.
> Interviewer: You for example, invented or planned something, which caused some problem later. Whose responsibility/fault would it be?
> Faris: It depends on… if the person who used it did it the wrong way, it's his fault. If he used it the right way and it didn't work, then it's the inventor's responsibility.

In the following excerpt Noura takes full responsibility for the consequences of her invention's outcomes. She justifies this by blaming herself for not "being focused" and not thinking about the consequences of her action as she did not plan it well. She draws on her experiences as a student, to explain what happens if she does not "listen well to the teacher" instructions.

> Interviewer: Let's assume that one of those tools, umm… oil, for instance, let's assume there was something wrong with your invention. A problem that caused some spillover and all that… let's say it spilled all over the house. Whose fault would it be? Whose responsibility?
> Noura: Mine.
> Interviewer: Why?
> Noura: Because either I wasn't focused and… and I didn't plan ahead for something exploding in a big way, I didn't think of that option. And I didn't listen well when the teacher said that for example you should put in a small piece and not a big piece and… I don't know, if I wanted to go and fix it, I don't know what one could do in that case

c. Perceived utility of the activities

Through learners' stances about the perceived utility of activities, I found that there were multiple ways learners articulated how they would use the activity artifacts, this includes: displaying it, using it for personal play or with other family members, drawing on it, engaging family members with conversation about it, and observing changes in it. These examples reflect different aspects of values that the students appreciated and were able to identify as affordances beyond perceiving these artifacts necessarily as a scientific artifact. Furthermore, such examples, reflect the interconnectedness between different values that are important to learners, such as, aesthetics and relationality with others and using artifacts beneficially, or merely having it just for display as some students mentioned.

In multiple examples, Beesan described using the activities with her siblings to show them and explain what they did in the program. She described that she also shared the knowledge she learned at the program with her siblings: "I showed them what we did, they were surprised…" ... "they said it is beautiful…" ... "I explained to them everything the teacher explained to us... and I told them… that it is... in science everything can happen, and it is beautiful." Then, when I asked her what she would tell her friends or relatives about an activity they did, referring to the Oil and Water activity, she paid attention to both the artifact aesthetics and the reaction that happens as a result of adding a disc in the tube. Both the excitement and joy in her willingness to engage her siblings and friends with these activities and what she comes to value aesthetically and relationally reflects that the utility of the artifact was not merely perceived by its functional features or science related ones, rather, by also its relational affordances and joy with others.

> Interviewer: Umm… Ok, I wanted to ask you one more thing, umm… for example, take this activity – let's say you want to tell one of your friends or relatives about it, what would you say?
> Beesan: That it reacts, this umm… it's nice this…
> Interviewer: How do you mean, nice?
> Beesan: That is to say that when they come down they look pretty, it lights up in the night, it looks… umm… it's appealing to the umm… that they would like it and such.
> Interviewer: What else would you tell them?
> Beesan: I would tell them that if we added the disc to the… to the oil and water, it reacts and becomes like umm… kind of like spots.

These two elements of affordances are also articulated by other students in some stances. For instance, Faris mentioned that he showed one artifact to his family: "yes, to all my family and *Dar Sidi*", meaning, not only he engaged his brother and parents, but also, this engagement happened within family gatherings at his grandpa's house (Dar Sidi), a place and space for intergenerational engagement and interactions, where play, joy, and family arguments happen with grandparents, cousins, siblings, aunts, and uncles. Then, Faris describes what they did with the artifact with his family, specifically drawing on the Illuminating Board as an example. While Faris describes his active role in sharing with them about the artifact, he described aesthetic details in its design and how it functions and apparently tested these functions with them:

> Faris: At the beginning they thought, they didn't know how to draw on it, and when I showed them how, they also thought that it couldn't be erased, and with the beads, they thought that they were only decorative. I mean this, and in the end, I showed how if I put it in the dark and pointed some light at it, it would turn green, and if I put it in a lit space, it would turn into colors, and if I didn't expose it to any light, it would turn white.

d. Aesthetics and beauty

As mentioned in the previous examples, when students talked about values, an emergent aspect of what they centered across multiple examples are aesthetics, beauty, and descriptions of materials they engaged with. Here I focus on describing examples where students reflected an engagement with such values as reflected in design aspects, artistic materials, and describing the beauty of activities they described or perceptions they had about roles. Such examples include, describing the design process where they build the artifact or draw or imagine, artistic aspects of a design or drawing, materials when engaged in doing an activity at the program or within their hobbies, or doing things more beautifully. Thinking about aesthetics is also something that I noticed through the students' usage of words like “beautiful” or words in the source of “يحسن” / “Yuhassin” which literally means “to improve” or “to enhance”, however, the word in Arabic connects to aesthetics too and respect to others (Fasheh, 2012, Fasheh, 2014). For instance, Fasheh describes the verb Yuhsin as, "what the person does well, useful, beautiful, giving, and respectful" (Fasheh, 2012, p., 14). This articulation of “aesthetics” is aligned with my interpretations of learners' descriptions of words like beautiful, nice, pretty as meaning (Mawasi et al., 2020a). Such stances made me pay attention to ways students are valuing aesthetics and engaged in thinking about activities aesthetically and doing these activities in this spirit of *care about details, preciseness, and beauty,* and to examples where they described themselves as doing such acts. Such attention to aesthetics also demonstrates examples of how transdisciplinarity perceptions are reflected in students thinking of values.

The materials from which the artifacts are made shape possible ways of learning, and they also embed within them ideologies and values (Barthes 2012, 1956; Tzou et al., 2019). In his classic essay on toys, Barthes describes French toys as made of plastic, representing ideologies that are disruptive to childhood and represents adult-centric worlds (Mawasi & Gee, 2021). In their work, Tzou et al. (2019), draws on Ingold (2012) work, “to understand potentialities of materials to exist in relation to our experiences, histories, and futures with them” (p., 311, Tzou et al. 2019), and they construct educational possibilities. In this work, I come to understand the role of materiality through the attention of learners to that they used “science related equipment” like pipettes, tubes, and substances, the process in which they built artifacts using materials like wood and glue, and the details they paid attention to in the artifact design.

To illustrate these points on aesthetics, I will draw on excerpts from two interviews, one with Rami and the second with Karam.

When Rami imagines himself as an inventor, he says that “you need precision” (**دقة**), which entails both paying attention to details and doing things precisely and accurately. In my interpretation, this notion of precision comes from his attention to “enhancement” or “improvement” (**تحسين**) which is rooted in the meaning of *Yuhassin*, as described earlier. This meaning brings with it an attention to aesthetics benefits to oneself and also to others. Then, when Rami describes the characteristics of an artist, he mentions that an artist should have a “good taste”, to make things beautiful and pretty, a process that requires thinking according to Rami. This attention to preciseness and beauty, also described by Rami, when I asked him what you would tell your teacher at school about what you did at Al-Rowad, his response was centered on how the colors changed in the

Newton's disc because of speed and then he described that this artifact is difficult and requires precision, however, it is pretty.

When I asked Karam what you would do to improve the Newton’s disc activity, like the design, materials, or explanations when participating with other students, he mentioned “I’d glue these two pieces together strongly, more strongly, and add a motor.” I asked him, “what do you mean motor?”, he said “Motor… the handle I can...I put it from the hole and remove this piece (pointing at picture) and I put the motor behind… and a thing to make it stable with this (referring to a piece).” Karam not only paid attention to the materials used and pieces of wood he used to build the artifact, but also, he creatively was thinking about adding a motor to automate the rotation of the wheels. In my interpretation, he was drawing on his interest in robotics and playing with Lego to describe such an addition to the tooth wheels. Here, the usage of materials that students can play with (wood mainly), created for him a possibility to imagine adding a new feature. In other examples, thinking about materiality was described through roles, where Karam described: a scientist as someone who makes things and sells them and sits alone for hours to solve problems in a room, an inventor as someone who has “materials” as a condition for him to invent, and an engineer as someone who “sits to imagine how a house would look like, then puts wood in its place, and where to put the blocks.”

Towards this end, I view that considering the aesthetic ways in which learners value their science-related activities expands science learning possibilities as it opens to understand “what is sensible or possible to see, do, feel, and sense” (Tolbert & Bazzul, 2020, p. 2) when learners are engaged in such experiences. Furthermore, this attention to aesthetics and beauty provides insights of the importance of the two in doing science and engaging children in doing science, a practice that comes in tension with what Western ideologies of scientific inquiry values (Kimmerer, 2013). Importantly, it provides evidence that when learners engage in STEAM activities, they also build on their axiological ways of thinking to engage in scientific practices (Bang et al., 2015; Krist & Suárez, 2018).

e. Relationality

This theme refers to stances in which learners mentioned relationality with humans and more than human beings as they talked about the activities, roles, or themselves. The following examples illustrate ways relationality is present in the ways learners are describing their worlds, either with humans or more than human beings. Such stances reflect ways in which relationality shapes possibilities of knowing, doing, and being for learners (e.g., Bang et al., 2016).

Doing science practices from this perspective also becomes relational and entails care to others (e.g., Krist & Suárez, 2018). For instance, Krist & Suárez (2018) assert that doing science while caring for others can be expansive to ways students learn science. In some stances, students thinking of relationality came in various forms. Relationality here is not always reflected in a positive relationality, for example, one learner may describe how they expect an engineer to treat his employee and this description entails a view of power. Additionally, there were multiple examples in which students reflected the importance of attending for relationality. For example, Lara mentioned care for "oppressed people" as why she wants to be a lawyer and she also appreciated the joyful environment with other students in the program and teacher, Lina and Noura mentioned behaviors of engineers with others as they reflected on characteristics of engineers, and

Yousef described his relationship with animals in complex ways. In the following excerpts I will focus on describing one example that reflects relationality and its complexity by revisiting an example from the interview with Yousef.

The excerpt began with a description of the Oil and Water activity where Yousef described that taking the final artifact to his home, he felt like he is bringing a volcano home without causing harm to anyone. Since this artifact included a discussion about volcanism as a phenomenon and modeling it through a chemical reaction in tubes the students made. This led the two of us to talk about Yousef understanding of ethics and later we both talked about the qualities of scientists and inventors.

In the following example Yousef describes the tension between his empathy for animals "I felt with animals" and his justification of testing on animals as "for the sake of science" (**في سبيل العلم**). The notion of "for the sake of science" comes from his usage of a phrase that literally means "for the path of knowledge", however, both knowledge and science have a similar root source in Arabic, within this context, Yousef talks about knowledge as science, reflecting one way of knowing (science as a way of knowing). The phrase, in my interpretation, stems from a religious rhetoric that carries in it someone who chooses the knowledge pathway, should expect to do sacrifices or be "adventurous" as Yousef described himself bringing like a volcano home.

Yousef's empathy with animals comes also in his imagination as an inventor to reuse clay to build a house for a cat and to save her from rain. However, once he enters a lab, he is wrestling between science as beneficial to "people" versus science as beneficial to the "world". Yousef is wrestling between his subject-to-subject relationality with animals to science in the lab subject to object relationality. This notion of wrestling between the two, is also illustrated by Kimmerer (2013) when she describes how in indigenous knowledge perspective, plants are not objects for study like it is in science labs.

Furthermore, in Arabic, in some dialects both the world and people are used interchangeably as **عالم** (Aalam). In this specific Palestinian dialect and within the context of this excerpt the meaning of **عالم** was world, as later he used "**ناس**" to refer to people. This distinction is particularly important as Yousef shifted from thinking about the world to thinking about science as human-centric (shifting from world to people). Knowledge here becomes a science practice that is done by pursuing a career in science to do scientific experiments, learning dominant languages (Hebrew and English) to be successful in communicating with others (despite Arabic being commonly spoken globally, it is marginal in scientific discourses and systematically erased from public spaces in Israel), and to do science for the sake of helping people mainly (than the world, a world that includes more-than-human-beings).

> Interviewer: mmm… and the activity.. This last activity… the Oil and Water.
> Yousef: I felt myself, like risky and adventurous, because it feels that…
> Interviewer: you felt what?!
> Yousef: Risky and adventurous
> Interviewer: Adventurous? And if I ask you among these four: scientist, artist, engineer, and inventor.
> Yousef: Inventor, because mmm, it is like I brought a volcano home (Dar دار), but without causing harm to anyone.
> Interviewer: how do you mean it is important that no one is harmed when we invent things?
> Yousef: Because if you wanted to invent something that would reach the **world**, and **world** shouldn't get hurt. You should… it shouldn't kill the **worl… people.**
> Interviewer: How so?
> Yousef: I mean for example, umm… the scientis… the umm… the scientific experiments that they now try on animals. For example, if there was a new cream or something, they try it on an animal, for example, a monkey or a mouse or for instance…

Interviewer: What do you think of that?
Yousef: **<u>It's for the sake of science so I don't know what I think of it</u>**<u>… </u>it's true that it causes animals to die sometimes, but because… I mean, because it's for the sake of science, I feel like it's fine. Also, my aunt works in biology, and I went to see her twice, I mean, I spent one or two whole days with her, umm… she works… she does experiments on mice. I felt for… I felt for the mice – how they were killing them and… she was working on making the womb grow outside the body, outside the mother's womb… for those who have problems with that thing. Now, they were doing this with mice… now, I felt like they were killing the… they were opening the mother mouse's belly, and sometimes the mouse would die and such. I felt their pain. But she didn't show me the things when they opened the belly and such.
Interviewer: Umm… all right, I'd like to ask you something, in your opinion, what are the qualities in a person who is umm… who is a scientist, what qualities should he have?
Yousef: Smart.
Interviewer: Yeah…
Yousef: Umm… to be able to handle the sights he would see.
Interviewer: How so?
Yousef: Because for example those who work in those uh… on animals for example, they would see blood, they would see animals that would have many things happen to them…
Interviewer: Handle what?
Yousef: They should be able to handle sights that they would see. They should understand many languages.
Interviewer: What do you mean, understand many languages?
Yousef: Because he should… he should have many people from all over the world come up to him. Umm… people who speak Arabic, English, people who speak… I mean, he should first understand English because…
Interviewer: How many languages do you know? Or see in your daily life?
Yousef: Arabic and Heb… Umm… and Hebrew and English sometimes.
Interviewer: You know the three of them?
Yousef: Yeah…
Interviewer: Umm… all right, what qualities does an inventor have in your opinion?
Yousef: Umm… he should have ideas and imagination, which he could turn into a reality.
Interviewer: How so?
Yousef: I mean for example I… I feel like I want to become an inventor because I imagine things and I try to bring things that look like them and I start… I... inve… I work on them.
Interviewer: How do you mean?
Yousef: For example, once.. I was… there was a cat… from the street, it was raining. It is a little cat.. Mmm… I said Haram, poor cat I said I want to do a

> home for her. I brought broken clay and to do it for her. I made a home for her.. And she got used to us, and she kept coming until she died.
> Interviewer: How did this make you feel like you have imagination? How do you mean it made you feel you have imagination?
> Yousef: For example mmm, I do a movie in my head.. And meaning.. Someone there talks to me, he tells me a story, mmm.. If I do not know the patterns I imagine some patterns, and I imagine all this.. For example, let's hypothetically that I imagine Ahmed running running running, then he jumps, meaning this becomes like a movie in my head.

This trajectory reflects ways in which children can make sense of the world through cultural resources around them and giving up their childhood and assets (e.g., empathy, imagination, and trilingualism) towards an adult career, positioning science for humans as a higher order of ethics to justify scientific practices and missing the richness of meaning own native language can reflect (i.e., knowledge path as being beyond science only). Importantly, they become engaged in scientific dominant discourses that systematically erase their cultural ways of knowing and wisdom derive from their heritage (Kimmerer, 2013). These ways reflect thinking of relationality with humans and more than human beings, yet, at the same time show complexities between childhood-adulthood, nature-human, and cultural values-dominant values of what counts as science and knowledge (e.g., Kimmerer, 2013).

Discussion and Implications

This article presents findings on STEAM perceptions from a community-based research project that brought Palestinian students to participate in transdisciplinary STEAM activities in informal setting designed by community-based educators in Israel. This study shows diverse and complex ways in which learners perceive their STEAM related activities, in thinking, being, and doing. Such diversity and complexity are reflected through four themes I presented in the findings section, tensions between schooling and learning, transdisciplinarity, presumed normativity, and axiologies.

With respect to tensions, students often used formal school practices as a way to frame their conceptualizations of learning and what counts as knowledge. Namely, students' perceptions of what they come to understand as knowledge and learning is defined through their school experiences in different examples I illustrated earlier (Erickson et al., 2008). In this way, science learning (or learning in general) becomes associated with school curriculum and experiences. Defining learning through schooling, creates narrowed definitions for ways students perceive their learning engagement, therefore such schooling views of learning, may create a challenge for students to recognize their everyday assets and cultural resources in relation to science or other disciplines. In this way, it narrows the ways students conceptualize their learning experiences and identify the learning possibilities surrounding them in out-of-school contexts. As I have shown, in some examples, such perceptions created a challenge for students to see ways in which science activities exist in their lives beyond school. In other examples, it created a challenge for students to see that learning can be joyful and fun, as it was in this learning environment at Al-Rowad center. Since schools within this context are considered as a major educational resource for students, in the absence of informal learning spaces for STEAM practices, paying attention to the possibilities for integrating informal learning activities within school activities, can be one step towards shifting what counts as learning for students. Schools as described by students, are spaces where they also socialize with their classmates and teachers, a process that can be beneficial to their science learning as a relational process with others.

Despite these tensions in conceptualizing what counts as learning and knowledge I identified that students think in transdisciplinary ways about their learning engagement that do not necessarily privilege science or one discipline over the other. In what I identified as transdisciplinarity in thinking, this study shows the potential of science activities designed with transdisciplinarity and engaging learners with thinking about diverse possible selves to expand students' thinking, being, and doing in heterogeneous ways beyond narrowed definitions of a discipline (e.g., Waren et al., 2020). Scholars have argued that transdisciplinarity supports learners' diverse ways of knowing and allows for heterogeneity in learning (Nasir et al., 2006; Roseberry et al., 2010; Takeuchi et al., 2020). For instance, scholars argued that heterogeneity provides an opportunity for learners to draw on their assets and cultural resources to participate in learning activities (Nasir et al., 2006; Roseberry et al., 2010). As I have shown, through the analysis of learners' perceptions of roles, students talk about themselves in relation to the roles, descriptions of activities (e.g., what they understand from it, is it art or science, how they used it). The study reveals that students had transdisciplinary ways in perceiving these STEAM activities, this included thinking across disciplines, talking about values, describing aesthetic elements of their artifacts, attending for relationality to others in the space and at home, and describing an activity across two disciplines or more. By considering students' transdisciplinary ways of thinking, I also identified that it is present in their descriptions of themselves and the actions they describe in doing the activities, in other words, it represented fluid identities. In this way, transdisciplinarity becomes not a cognitive activity, but also an embodied one that combines thinking, action, and an opportunity to explore varied identities.

While in multiple examples I showed that students' perceptions reflect transdisciplinarity, I also found that there are normative views about the scientists, artists, engineers and inventors' roles and STEAM practices that students reflect. Such roles are either structured through schooling normative expectations or roles that are framed to students in their everyday life. As I have shown, examples of normativity are associated with schooling perceptions of science, normative practices of these roles, and who come to be scientists. While in some cases such conceptions open the opportunity for expansive possibilities, they also reflect broader hegemonic discourses, for example who can be practicing STEM, how these practices should look like, and what tools should be used to do it. In my view, such questions also have social, economic, and political dimensions and could be addressed through examining different structures of power (e.g., class, gender, socioeconomic status, colonizer and colonized relationship).

For instance, in scientific practices context, Harding (2006) pointed that there are normative conceptions towards scientific practices that are shaped by Western science practices. Such conceptions neglect the diversity of the history of science, for example modern science as starting in Europe. Harding also problematizes the neutrality of scientific practices and asserts that these practices have social, political, and historical roots associated with the hegemony of Global North. Harding illustrates these points through outlining the features of Western science as Eurocentric, despite that it draws on other cultures' knowledge that includes Asian cultures and Muslim scientists. Second, modern science shifts of the conception of nature through Western views in a way that alienate other cultures. Third the disproportional distribution of science benefits to peoples of European descents, and fourth the assumed neutrality of modern science.

Therefore, she calls for expanding the understanding of other cultures' scientific practices and legacies to science. A similar notion of problematizing such hegemony is also illustrated by Medin & Bang (2014). Where the authors describe the unique ways of knowing of Indigenous learners and also assert that there is a need for epistemological dialogue between diverse ways of knowing as a way to overcome normativity in science and claims of neutrality of scientific practices. By understanding presumed normativity reflected through the children's stances, researchers can understand ways to design activities that disrupt such normative views and create opportunities for learners to acknowledge the richness of their heritage, culture, and local knowledge, across space and time. Paying attention to forms of colonialism reflected through children's stances and the way it impacts learning is essential to disrupt what Warren et al. (2020) refers to as zero-point epistemology -- a form of colonial violence that denies other narratives towards what counts as knowing, being, and doing science. Such colonial violence is also embedded in the ways "schooling" creates a need to unlearn perceptions about what counts as learning for students.

This study shows the ways axiologies are fundamental to how learners perceive their activities. Students make meaning of axiologies as they describe their everyday experiences, engagement with program activities, and their perceptions. While student examples present varieties in reflecting axiological thinking, they present complex and expansive ways in which children think about values which I described as, axiological thinking, doing, and being. Specifically, I described these diverse ways of axiological thinking through five findings, ethics, responsibility, utility, aesthetics and beauty, and relationality with humans and more than human beings. These findings show that the values system of learners expands beyond binary ways of thinking about actions as good or bad, it also expands thinking only in consequentialism and utilitarian terms, or social good. Their thinking about values in different examples showed the importance of attending for relationality with humans and more than human beings and aesthetics and beauty. Krist & Suárez (2018) argued that understanding students learning of science through axiological lenses, rather than conceptual or epistemological only, provides insights of learners' epistemic engagement in science learning. That is, for some learners' values are essential in how they engage in scientific practice and conceptualize its value (Krist & Suárez, 2018).

In summary, this article presents findings on STEAM perceptions from a community-based research project that brought Palestinian students to participate in transdisciplinary STEAM activities in informal setting designed by community-based educators in Israel. This study highlights how transdisciplinarity and axiologies are fundamental to ways learners perceive their activities. For instance, there were varied examples where students' perceptions of roles, identities, and activities drew upon multiple disciplines with consideration of values. Bridging between axiologies and sociocultural learning theory for STEAM learning can provide new insights for the importance of transdisciplinarity including axiological thinking in STEAM learning processes. Therefore, I consider the educational possibilities for decolonial approaches in STEAM education as a way to account for diverse ways of meaning making beyond Eurocentric epistemologies of the nature of science and scientific practices. While these students' stories present varieties in reflecting thinking, they present complex and expansive transdisciplinary ways in which children think about their engagement with

STEAM, this include values, which I identify as, axiological thinking, doing, and being. Such findings present diverse ways of knowing in which students perceive their engagement in STEAM activities and how they come to understand their learning experiences.

The cultural critic Edward Said wrote: “Every empire, however, tells itself and the world that it is unlike all other empires, that its mission is not to plunder and control but to educate and liberate” (Los Angeles Times, July 20, 2003). Such words invite us to examine education work in its political and historical context and ask towards what ends educational interventions are designed and what discourses they are serving. Such a view is particularly important within this settler-colonial context for two reasons, first it challenges the question on where the history of science begins and second it can provide a point for learners to examine their history and culture beyond a specific framing of time that began by the settler. While the context of this work is within a specific classroom setting, it is hard to ignore that this specific context in which these activities are taking place is rooted in settler-colonial history in and out of school that not only constrains the learners learning resources in school, but also constrains learners’ activity out-of-school. If educators want students to imagine an alternative future for themselves and their society, these futures should be beyond settler-colonial imaginaries of normativity and hegemonic STEAM practices. Describing ways of knowing as reflected in the themes discussed in the paper can be an invitation to understand the need to explore further the broader settler-colonial and history that shapes learners' engagement in science learning in this context. To do such work, one may build on emerging work that is creating the case for settler-colonial discourses to study the Palestinian context wisdom and ways of knowing. For example, Fasheh (1990) describes that, through community education, educators can “reclaim people's lives, their sense of self-worth, and their ways of thinking from the hegemonic structures, and facilitates their ability to articulate what they do and think about in order to provide a foundation for autonomous action.” (p.26)

At a methodological level, I view these findings as one way to examine learners' activities and engagement considering axiological ways of thinking. That is, acknowledging the complexity of learning as reflected in students’ perceptions and ways broader values structures shape such processes. Therefore, I also think that these themes may provide an analytical framework for researchers interested in understanding STEAM learning activities and pedagogy. For instance, through questions like, what knowledge and learning is being privileged in a learning environment? How are normative perspectives on STEM practices being reflected in an activity or instruction? What relations and dynamics exist in a learning environment between learners, learners and tools, learners and more than human beings? What are the values systems that are being supported in the learning environment? Such questions are illustrative and could be addressed through the discussed theme and in support of relevant existing literature in education that stresses the importance of addressing equity issues at different system levels, in pedagogy and instruction, design of learning environments, objects and tools, and relations created within learning spaces.

At an instructional and pedagogical levels, I view that these perceptions require an attention to the ways learners perceive learning associated with school, therefore, designing environments with careful attention to pedagogy and teaching within informal spaces is important in seeking equity-oriented agenda in such spaces (e.g., Stewart &

Jordan, 2017). An instructor within such spaces is not just a facilitator or mentor, they are perceived as “teachers” too, not necessarily because these learners do not have ability to work autonomously, rather, it is their appreciation for the care the teacher gives, help and support they receive from the teacher, affective engagement they create, and generous knowledge sharing they exchange (e.g., Vossoughi et al., 2020). Such perceptions of the teacher role can create expansive ways for learners to be nurtured in their learning process towards shifting their perceptions and recognizing their assets as they engage with their learning activities. One implication of this, could be, taking pedagogical steps towards supporting meaning making shifts of students towards what counts as learning, STEAM practices in and out of classroom. A second implication of pedagogical practices would be nurturing learners to connect between their classroom activities and everyday life practices.

Finally, in their article on decolonizing place in early childhood studies, Nxumalo & Cedillo (2017) argue that “re-storying places through orientations that disrupt settler colonial imaginaries suggests a move toward looking beyond innocent perspectives of children’s place experiences and instead orienting toward explicitly polarized enactments of and dialogues with place.” (p.103). I take this argument to stress the importance of attending to ways broader social and political structure possibly mediate ways learners perceive themselves and may shape such normativity. Therefore, I see it is important to support learners to draw on their cultural knowledge and everyday life assets to engage in learning activities. This could be done through designing learning environments and instruction that expand what counts as learning beyond school, support their transdisciplinary ways of thinking, disrupt normative views in transformative ways through epistemic engagement with learning activities, and most importantly pay attention to the values system and ideologies that learners are thinking through and shaping their perceptions.

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CHAPTER 3

EXPLORING LEARNERS SELF-EFFICACY SHIFTS WITHIN A COMMUNITY-BASED STEAM PROGRAM

Abstract

Prior work has found that engaging in informal learning activities can support non-dominant learners' identity development, agency, and interest in STEAM. Such work often analyzes learners' engagement in out-of-school and community-based settings to examine the way it shapes STEAM learning. In this paper, I build on the potential of community-based settings in engaging non-dominant learners (n=10) to explore learners' science self-efficacy within the context of a four-day science winter program within a community-based organization. Using a mixed-methods approach, I find that while self-efficacy appears to increase on the survey measure, this finding was not replicated in the same way during the interviews. In an inductive qualitative analysis, I find that not all students followed a similar learning trajectory. In this chapter, I explore these differences using examples from interviews with the learners and close by discussing methodological suggestions to address such emerging differences.

Introduction and Relevant Literature

Expanding opportunities for learners to engage in science, technology, engineering, art, and mathematics (STEAM) activities is a subject of active discussion within the learning sciences field and informal learning in science education. Prior work addresses engagement in such activities within out-of-school settings in diverse ways. For example, designing learning environments that aim to support learners' agency (e.g., Barton & Tan, 2010); supporting learners' interest and STEM identities through informal, narrative-based learning activities (e.g., Pinkard et al., 2017); designing equity-oriented informal learning environments for making activities (Vossoughi et al., 2016); and engaging learners in online media like games and transmedia experiences (e.g., Mawasi et al., 2021).

Previous work demonstrates the potential for informal learning activities to create equity-oriented learning spaces and pedagogy that support non-dominants learners in STEM fields (e.g., Barton & Tan, 2010; Pinkard et al., 2017; Parekh & Gee, 2019). Examples of non-dominant learners include girls and women, youth from historically marginalized and oppressed populations, and immigrants. Prior work also examined learning within informal settings and identified varied ways in which social injustice and power issues are reproduced within informal settings as such spaces may be designed through normative discourses of what counts as valid STEAM practices (Vossoughi et al., 2016). Prior work described that simply providing access to STEAM activities isn't sufficient, but the learning environment needs to be designed in a way that supports learners' heterogeneity (Vossoughi et al., 2016; Tzou et al., 2019). Methodologically, such work also invites researchers to pay attention to sociocultural and political learning processes and conditions that mediate and are reproduced within informal learning spaces in the analysis process (e.g., Vossoughi et al., 2016). For example, how students make meaning in reaction to activities they are engaged in (e.g., Davis & Schaeffer, 2019), what their actions' reactions reflect about their thought (Saldaña, 2015b), and how the context of an activity can reflect certain power dynamics that exist within a moment of interaction (e.g., Vossoughi et al., 2020). In this way, studying learners’ shifts in behavior or thought takes into consideration learners' perceptions of their activities, the context of the activity, and the dynamics that may shape such behavior or thought.

Prior work has identified that informal learning activities potentially expand learners’ possibilities to engage in science activities in ways that they are not used to in traditional school science classrooms (Mawasi et al., 2021). Such engagement offers a possibility for learners to enact heterogeneous ways of knowing, being, and doing when they do science activities if designed with such a purpose (Rosebery et al., 2010), support learners’ identity development (e.g., Pinkard et al., 2017), and offer a possibility for teaching about the sociocultural and ethical dimensions of doing science (e.g., Mawasi et al., 2021; Vakil, 2014). Much of the work around non-dominant learners’ engagement in informal learning spaces, designing with and for nondominant learners, and the sociocultural and political dimensions of learners’ engagement in informal settings has been conducted in the United States and Global North. Furthermore, there is little research regarding how informal learning environments affect learners’ science self-efficacy.

This chapter builds on prior work to examine Palestinian learners’ self-efficacy shifts before and after they participated in an out-of-school science community-based program that includes transdisciplinary science activities (STEAM). This study attempts to identify methods for understanding such shifts within the context of Palestinian learners’ engagement in an out-of-school community-based program in Israel. In this study, in addition to understanding learners’ cognitive shifts through science self-efficacy as a construct, I consider the broader contexts in which the activities take place to understand if and how contexts mediate learners’ self-efficacy shifts. This consideration of the context offers an opportunity to examine the relationship between the social world and the individual (Walker, 2010).

Understanding learners' science self-efficacy within the context of Palestinians in Israel is important for both practical and theoretical reasons. On a practical pedagogical level, cultivating self-efficacy is a major motivation of the collaborators of this study, namely, the community-based organization of Al-Rowad for Science and Technology as they work with learners from the "Arab society in Israel". Understanding the role of context enables researchers, as well as the collaborators, to expand the methodological tools towards applied research with local communities. This could be a generative way of engaging local communities in research questions and inquiry (e.g., Medin & Bang, 2014).

Historically, Palestinians in Israel marginalization is rooted in settler-colonial citizenship dynamics (Rouhana & Sabbagh-Khoury, 2015). This settler-colonial reality creates a reproduction of injustice within education systems and mediates learning in curricula and other aspects of education (Rouhana & Sabbagh-Khoury, 2015). Within this context, Palestinian learners are often described through deficit discourses within education research and practice (e.g., gap achievement discourses in comparison to Hebrew speakers). Such discourses could be shifted through an understanding of learners' perceptions and the ways existing sociopolitical structure manifest in their perceptions of their learning. Such a shift can help researchers and educators in changing the assumptions about Palestinian learners and identify ways to see them through an asset lens that attempts to understand the origins of their perceptions about learning.

Theoretically, self-efficacy is defined as the belief that one is capable of taking part in an action or an activity at a designated level (Bandura, 1997). Self-efficacy is shaped by physical, social, and self-evaluative reflections on one's behavior (Driscoll, 2005); these reflections affect how learners perceive their ability to successfully complete a task (Bandura, 1997). Often, self-efficacy is examined through individualistic terms, that is, it focuses on increasing the learner's self-efficacy as an individual with less attention to the individual's social and political worlds that shape their perceptions. These terms also ignore the social conditions that mediate learner activity and thinking (Saldaña, 2015b). That is, simply measuring or designing for individual self-efficacy change can ignore the context where learning happens (e.g., Ben-Eliyahu et al., 2018), the learners' engagement with others as they navigate their learning trajectories (i.e., relationality), and that individual learning goals have also collective ends as they collaborate with others (Järvelä et al., 2010).

In their citation of Bandura's work (1986), Usher & Pajares (2008) cite, "self-efficacy beliefs help determine the choices people make, the effort they put forth, the persistence and perseverance they display in the face of difficulties, and the degree of anxiety or serenity they experience as they engage the myriad tasks that comprise their life. (p.751)" However, attending to individual choices, effort, persistence, and perseverance without examining the preconditions that exist for students to be able to enact their self-efficacy can be insufficient. Usher and Pajares (2006), describe four sources of self-efficacy: mastery experience, vicarious experiences, social persuasions, physiological, and emotional states. Such sources are connected to learners' social world and they are not only shaped by the individual choices or decisions solely.

Within the context of this study, self-efficacy as a construct is used to measure learners' self-efficacy towards science. In the study I pay attention to the context in which the activities are situated to understand the affordances and limitations of such effects. The current research is guided by two overarching questions. First, I explore whether the students' self-efficacy in science shifts after engaging in an out-of-school, community-based program and how such shifts manifest. Second, I consider the ways in which changes in learners' science self-efficacy relates to students' perceptions of schooling and learning.

Methodology

This study draws on a mixed method design, using multiple data resources and analytical tools (Tashakkori & Creswell, 2007; Greene, 2007). I aimed to study the shifts in self-efficacy that happen as learners engage and participate in this program. Using a mixed-methods design enables researchers to draw upon multiple sources of data and analysis procedures to interpret the processes that are happening within the context (Greene, 2007). A variety of data sources and analysis contributes to enhancing findings validity and credibility (Greene, 2007; Erickson, 2012). Such sources allow researchers to develop insights drawing on evidence from multiple perspectives (Erickson, 2012). Additionally, a mixed-methods design allows addressing specific local logistical considerations. For example, two varieties of Arabic are used in the context, depending on the situation (i.e., diglossia), academic Arabic for the pre-post questionnaire and spoken Palestinian Arabic during the interview. The two data sources provide insights on the ways that each assessment mediated learners' responses. The purpose of using a mixed methods design in this work is convergence (Creswell & Clark, 2017), that is, yielding a complementary understanding of quantitative descriptive data, followed by an inductive qualitative analysis (Erickson, 2012; Thomas, 2006).

Measures and materials

I used a pre-post questionnaire that included questions about learners' science interests, technology engagement in general, and science self-efficacy. For the purpose of this paper, I am focusing on the five science self-efficacy questions based on Bandura's work (Nagy, et al., Under Review) (Appendix B). The pre-post questionnaires were translated to Academic Arabic, and the translation was reviewed by two people fluent in English, Academic Arabic, and Spoken Palestinian Arabic. The purpose of this questionnaire was to understand learners' affective changes. All students (n=10) completed the pre-questionnaire before they began the program activities, and all but one student completed the post-questionnaire on the final day of the program (Table 2.1). The student who left early on the final day completed the questionnaire just prior to the interview (one day after the program ended).

After the program activities were completed, I conducted semi-structured interviews with all students, where I asked them to elaborate on selected items from the questionnaires. The interviews were conducted in a mixture of Spoken Palestinian Arabic and Academic Arabic. For example, for the self-efficacy questions, I would read the item in its original form from the written questionnaire (Academic Arabic) and the learner would answer in Spoken Palestinian Arabic. In some cases, when a learner asked for clarification, I would clarify, or encourage the learner to answer the way they understood the item. The interviews were recorded and then transcribed by professional services. I reviewed all transcripts for accuracy.

The semi-structured interview covered multiple topics related to learners' engagement with transdisciplinary science activities in the program, at home, and at school. This paper focuses on the section of the interview where learners were asked to revisit the self-efficacy items from the questionnaire and explain their thinking. Interviews within education research can be a pedagogical tool that may mediate learners' responses (Vossoughi & Zavala, 2020). Therefore, students' answers or justifications for how they completed the questionnaire may have been mediated by the interview process itself. Importantly, learners were not asked to explain why they chose the answer on the posttest. Instead, they were asked the question anew, encouraging them to answer based on how they were thinking at that moment, with the interviewer emphasizing that there was no right or wrong answer. The flow of interviews varied for students; therefore, some students did not give a justification for every item. The answers during the interviews were slightly different than the answers on the written questionnaires. I discuss these results below.

Hands-on activities

The program consisted of four major transdisciplinary hands-on activities designed by the organization (see Figure 2.1). These activities are, (1) Super Absorbent Polymer (SAP), where learners were introduced to concepts and phenomena like colors and diffusion; (2) Newton's Disc, which focused on light, color, and mechanical motion; (3) Illuminating Board, where learners explore characteristics of light, dark, and illuminating materials in objects and animals; and (4) Oil & Water, where students were exposed to volcanism, density, and reactions between substances. While the program was promoted to students as a science program, these activities were interdisciplinary by design. For example, each activity involved an artistic element, reflected through colors, aesthetics, and processes like drawing that learners would engage in as part of the activity. Learners were able to identify these artistic elements, and they provided opportunities for transdisciplinary learning.

Figure 2.1: *A Group of Learners Engaged in SAP Activity which Integrates Learning about Colors and Diffusion*

The goals of Al-Rowad for Science and Technology organization are to engage Arab learners in STEM with high quality hands-on activities, to support learners' entry to science, and a societal infrastructure for Arab engagement in STEM and pipeline of Arab learners into science careers. Two educators from the organization led the instruction, facilitating activities and supporting learners to successfully complete the final artifact to take home at the end of each session. The two educators have been part of Al-Rowad since 2013. The lead teacher has an academic degree in engineering. The sessions included discussion with the students, direct instruction, and time allocated for hands-on work (see Figure 2.2). Within each activity, the lead instructor also presented examples of science in everyday life, such as the colors of a rainbow, cooking, wheels, and cameras.

Figure 2.2: *A Learner Testing the Characteristics of the Illuminating Board during a Group Activity*

Quantitative findings

Overall, despite the small sample size, findings show a trend towards learners' science self-efficacy improving from pretest (M=3.2, SD=.36) to posttest (M=3.5, SD=.38), ($t(9)=-2.15$, $p=.06$). I view these findings as descriptive, rather than use them for inferential statistics. To follow-up, I explored each item separately (Table 2.1) to better understand student perceptions. Interestingly, when looked at individually, the results show that only one item "I can use science to solve problems in everyday life" (Pretest M=2.6 (SD=.97), Posttest M=3.6(SD=.52), ($t(9)=-3.0$, $p=.015$)) shows any meaningful pre- to posttest difference.

Table 2.1

Pre- and post-questionnaire science self-efficacy items. Students answered using a Likert scale: 1=Strongly Disagree; 4=Strongly Agree

	Pretest Average (Standard Deviation)	Posttest Average (Standard Deviation	Interview Average (SD)
I can learn science easily.	3.6 (0.52)	3.5 (0.53)	3.3 (0.64)
I can solve problems by doing a science experiment.	3.2 (0.79)	3.4 (0.97)	3.1 (0.63)
I can use science to solve problems in everyday life.	2.6 (0.97)	3.6 (0.52)	2.7 (0.62)
If I have questions about science, I can easily find the answers.	3.2 (0.63)	3.4 (0.70)	3.6 (0.60)
I can do science activities well.	3.3 (0.67)	3.7 (0.48)	3.5 (0.54)
Overall	**3.2 (0.36)**	**3.5 (0.38)**	**3.2 (0.61)**

I next used the qualitative data to examine how students were operationalizing these concepts in order to better explain the findings from the pre- and post-questionnaires.

Despite the fact that the interviews were conducted within 1-3 days of the posttest, student responses aligned much closer to the answers given on the pretest. In fact, mean responses dropped for all items except for the statement “If I have questions about science I can easily find the answers.” This can be explained for multiple reasons: different contexts, different instrument modality, and timing (the interviews were conducted one to three days after the completion of the program). For instance, students’ engagement in the informal learning environment was short compared to the school science experience they are used to (e.g., Ben-Eliyahu et al., 2018). One explanation could be that during the posttest, students answered the questions in the context of the informal learning environment, but during the interview, they answered the questions drawing upon a larger set of school experiences. A second point in relation to context, my role in the interview was different from the interactions they had with educators in the program.

Even though many students referred to me “a teacher”, they knew I was interviewing them for research purposes. For instance, my role during the four-day winter program was an outsider compared to the two educators from Al-Rowad who engaged directly with the students. During the winter program, I gave the students instructions for the post activity questionnaires and the pre- and posttest, I took pictures and videos of their activities, and sometimes expressed excitement about the hands-on activities they did. I did not have as much direct interaction with them as the two educators from Al-Rowad did. However, during the interviews, my interaction with the students was direct, I introduced them to the purpose of the interview, described to them that there is no right or wrong answer, and engaged in conversation with them about their experiences with STEAM activities.

These dynamics may explain some of the students’ behaviors during the interviews as it was a different context than the program setting (Russ et al., 2012). The students’ interaction with me was varied in terms of speech patterns (Russ et al., 2012), that is, some students were louder than others, some more quiet than others. I observed that the interview provided some students a space to talk more than they did during the program activities, and for some students they were quieter. I indeed was in a power position as a researcher during the interviews (e.g., Vossoughi & Zavala, 2020), at the same time, I attempted, through the interview questions, to encourage students to reflect on their learning experiences and perceived roles (see Appendix A for a sample of semi-structured interview questions). Lastly, as mentioned earlier, the questions on the science self-efficacy items, came at the final stage of the interview process, perhaps, the interview itself pedagogically mediated these varied responses (e.g., Vossoughi & Zavala, 2020).

Qualitative data analysis and coding procedures

I used inductive analysis to identify why students chose Strongly Disagree, Disagree, Agree, or Strongly Agree on the self-efficacy items. Specifically, I conducted an inductive data analysis (Thomas, 2006; Erickson, 2012) to better understand ways of thinking that mediate learners' responses. I interpreted and analyzed these stances in their original language in Palestinian Arabic. Because language is situated and represents contextualized meanings that, in many cases, can be understood only by locals, I conducted the analysis in the original language, then I translated the selected coded stances within transcriptions. Then I created codes in English, and the stances that reflected codes were translated to English. I then worked with a senior researcher (from the United States) to discuss the codes.

The coding process in this inductive analysis was conducted across two iterative cycles, (Saldaña, 2015a) in English, to allow discussions between the two researchers. That is, for each item, I highlighted major stances within a student answer, then in the second cycle for each answer, I organized the stances while also naming the codes. In some codes I initially used the words of the students (e.g., "it is easy", I wrote as "science is easy”). In other examples I interpreted the student stance (e.g., “someone walks through the vocabulary with me”, where I coded it as “seeking help / information from resources). These procedures were reviewed and discussed between the two researchers.

For multiple stances, a single statement was coded with more than one code. That is, a student may express multiple ideas in their stances, such stances would be coded differently to represent each particular stance the student said. The following example illustrates how three codes derived from a conversation, when a learner addressed the question around the item “I can learn science easily”:

> Participant: Mm… like I said someone walks through the vocabulary with me and reviews with me …I cannot learn easy... easy things. I want to inquire.
> Interviewer: How do you mean that you inquire?
> Participant: To make sure of things... like for example… in books... for example there are things different than things… for example some say when you sneeze and your eyes are open, your eyes will fly. But some books say no… because there is something that holds the eye and does not allow it to move from its place.

In this exchange, three statements reflect three different codes: (1) help seeking, “someone walks through the vocabulary with me”; (2) process required to engage with science, “I want to inquire”; and (3) ability to understand or comprehend science, “to make sure of things… like for example… in books”. Each sub-category is connected under the broader item “I can learn science easily”, the learner seeks help from resources like books, while at the same time perceives his ability to understand such resources and the need to conduct more inquiry as important to science learning. Within the end of the second cycle for each item, I grouped major codes into sub-categories across students' answers for each item (Table 2.2).

Qualitative data findings

While the activities were intentionally designed to be different than the students' normal classroom practices (i.e., hands-on learning rather than direct instruction), they were also created to align with curricula goals in some cases (e.g., teaching about a similar phenomenon the students may learn at school). Table 3 shows the results of the analysis where we considered the context for what counts as science as interpreted by the learners. The goal of this analysis was to identify representative emergent codes that capture the range of the students' beliefs. Table 2.2 shows the results of the qualitative analysis of the different ways that students responded to the five science self-efficacy items, with codes to establish patterns in the response.

Table 2.2

Qualitative Coding of Items from Interviews

Item	**Sub-Categories**	**Description of sub-categories**	**Example of Learner Stances**
I can learn science easily.	Easy vs. difficult school topic	Perceived ease or difficulty of topics covered in school	"Because it is the easiest topic, yes it has challenging vocabulary, but it is among the easiest topics (at school)."
	Ability to understand / comprehend science	Description of one ability to understand or comprehend science	"For example, a new topic we learn, I understand it easily."
	Knowing science	Assessing knowing science	"it is not that easy to learn science… As I said, there are topics I know about, there are topics I do not."

	Help seeking from resources (e.g., adults, internet, books)	Student describes help seeking behavior	"I immediately can answer questions… even if my classmates did not know them… I know how to do it … and look for things for example… I look for it on the internet."
	Process required to engage in science (e.g., being smart, inquiring, answering questions)	Student describes perceived process required to engage in science (e.g., being smart, inquiring, answering questions)	"Because there are things that I do not understand, this requires me to ask and inquire more to know more about it."
I can solve problems by doing a science experiment.	Ethical thinking (e.g., finding what is right or wrong, consequences, utility, care for environment)	Student reflects an ethical thinking about their problem solving (e.g., finding what is right or wrong, consequences, utility, care for environment)	"for example, the light board... I put it as a light during the night. It helps me save electricity."
	Curiosity (e.g., curious to know outcomes, testing / experimenting to find answers)	Student curios about testing and experimenting find answers and look for outcomes	"doing experiment and tests that make cream (for skin) helps in not shaving"
	Other (e.g., general, I do not know, school)	Other general statements (e.g., I do not know, experiment as something at school)	"For me not all scientific problems I have to do an experiment to know how to solve it… I can find a possible solution…"
I can use science to solve problems in everyday life.	Science is not useful	Student describes if science is useful	"I do not use it for problems in my life"
	Science is beneficial in general	Student describes if science is beneficial	"I benefit from something, I can think at the moment I have a problem… and see if I can figure out solution"
	Distance from science (e.g., science in lab, at school)	Student describes a distance from science (e.g., science in lab, at school, homework)	"I feel science has nothing to do with my everyday life… scientific experiments, labs, research… I go to school, come home, do homework, use the computer, do sport and all these things, play with the cat, I do not feel it has anything to do with science…"

	Strategies (e.g., testing, asking questions, learning how things work)	Student describes strategies to deal with problems	"For example you are on your computer, and suddenly it turns off, I bring cables and put cables here and see places where I can put cables"
If I have questions about science I can easily find the answers.	Help seeking from resources (e.g., parents, book, internet, teachers)	Seeking help from resources	"On the computer or I ask someone… my dad and mom… I ask teacher"
	Independent strategies (e.g., thinking, self-explanation, searching in internet or books)	Student describes independent self-strategies to find answers	"I try my best to think and keep looking on the internet as much as I can"
	Other	General answer	"you can find answers everywhere"
I can do science activities well.	Being knowledgeable - procedural and declarative (e.g., avoid mistakes, be responsible, and answer right)	Student describes being knowledgeable (procedural, declarative) as a condition to do science	"I know how to solve them… I know how to build them again"
	Understanding / comprehending the activity's requirements	Student describes understanding and comprehending science as a requirement to engage in science	"Then when the teacher explained how, I understood."
	Following scaffolds and teacher modeling	Student describes following teacher scaffolds as an indication of their ability to do well in science	"For example, the light, like I did … the teacher does it in front of us, and I do it easily as well."
	Persistence and addressing challenge	Student describes persistence as a condition to do well in science	"like if I do an activity in science I put all my efforts and everything on it."
	Creativity as strategy to address challenge	Student reflects creativity in addressing a challenge when doing science	"it was… it was a bit challenging… also I was not… I did not know what I should do, I mean. I was trying to think… I was trying to think as much as can to know… so I know how to build it."

Summary of findings

Following these results, we were interested in understanding why student answers varied across contexts. One explanation that we identified is that there is neither internal nor external consistency in the way that students operationalize the term science in the item. For example, for some items students' perception of science is narrowed through the conceptions they have at school, while in others the context of science was general or related to activities they did during the program. Namely, by external consistency within an item, some students used the term to mean the school subject, whereas others took a more holistic approach. By a lack of internal consistency, we mean that individual students changed the way they defined the term between questions (e.g., for the item "I can learn science easily," a student might have described doing well in science class, but for the item, "I can use science to solve problems in everyday life," a student might describe a scientific phenomenon that occurs at home).

This absence of a shared definition of science among students is likely one reason why there were varied ways in conceptualizing science context. The examples from the interviews in Table 2.3 reflect that learners demonstrated diverse ways of contextualizing science. For each item, the learners referred to either school, the program, everyday life, or general science, or a combination of these. The only item where a majority of students referred to the program activities was with respect to doing science activities well, for this item, seven students referred to the program and three referred to science in general. I speculate that the addition of the word "activities" mediated this response, because "doing hands-on activities" was a major component of their learning experience within the program.

Only the item "I can use science to solve problems in everyday life" showed a more pronounced change between pre- to posttest in our quantitative analysis. However, during the interview, conducted one to three days after the workshop ended, the students reverted back to roughly their pretest scores. This suggests that participating in the program activities have potential in that they temporarily changed learners' views of science, as evidenced by the posttest scores, but this shift was fleeting. There may have been a novelty effect that dissipated after the workshop (e.g., Tsay et al., 2020). Additionally, the context of the interview itself provided students the opportunity to talk about their experiences and feelings, a context that is different than the survey itself. That is, the students may perceived the goal of the two instruments differently. In response, the curriculum should be refined to nurture students wondering about ways science is present in their everyday lives, practices with which they are already engaged, and their learning experiences in and out of school. In this way, expanding learners' views of what counts as science and learning beyond presumed narrowed definitions of school-related terms.

Discussion and Implications

The goal of this study was to explore self-efficacy shifts of ten students as they participated in an out-of-school transdisciplinary science program. Specifically, the major focus of the study was if and how self-efficacy shifts occurred. In a mixed-methods design, I used five items to identify descriptive statistics of learners' self-efficacy shifts, then I conducted an inductive qualitative analysis for interview data where students answered these questions anew. In this work I used the quantitative method qualitatively to describe the data of items in the pretest and posttest. Given the small sample, this data does not establish a statistical significance, therefore it is treated as descriptive. Following the quantitative methods, I conducted a qualitative analysis to further explore and understand the learners' perceptions of science and of the activities in which they participated.

The first question addressed in this study is, if and how students' self-efficacy in science shift after engaging in the program. Descriptively, the findings reflect shifts in students' self-efficacy; however, these shifts were driven by a single item. As the overall shifts in self-efficacy per findings were driven by a single item and since this item was not stable during interviews, I do not claim shifts in self-efficacy. However, these findings suggest that there may be changes in self-efficacy that are worth exploring and the varieties in the ways students respond to items poses interesting questions about learners' perceptions about self-efficacy.

Such perceptions collectively across students' responses reflect a need to explore with students' contexts of their conception of science activity further. The interview data analysis showed various ways of conceptualizing science across items. An explanation of these varieties in learning trajectories is through diverse ways students reflected on their description of engagement with science and science activities. For example, ways students describe what counts as knowing to do or solve a problem, "like these ones (activities), if they come again, I know how to do them." A second example, varieties in perceptions of what is required to engage with science (e.g., inquiring, smartness, answering questions "even if my classmates did not know them"). Finally, perceived self-efficacy in relation to tools, artifacts, and resources available to students, in the program (e.g., hands-on activities), school (e.g., teacher), and everyday life (e.g., books, internet, intergenerational interaction).

Addressing the second question of this paper, on if and how learners' science self-efficacy relates to learners' perceptions of schooling and learning. These results reflect that some learners' perceptions of what counts as science connects to their conception of doing well in school science in different ways, understanding and comprehending the teacher as an indication of doing well in science. This connection was characterized in various ways by respondents, knowing and being able to do and follow procedures and instructions; seeing science as a lab activity at school done by the teacher; and help-seeking from an adult when dealing with challenges (see Table 2.3). These varied ways described by students for the context of science in relation to school, carry a tension. In one hand, in some examples they present normative views about what counts as learning and knowing (e.g., being smart, answering questions correctly, finding answers easily). On the other hand, school and teachers the way students describe, are major resources for them to seek help and learn about science. Furthermore, in multiple examples, even when the activity was in relation to school, a student described actions they would do to address challenges (e.g., "try to solve it and understand by myself") and to seek help from resources (e.g., searching the internet for answers). Therefore, designing a culturally sensitive learning experiences for students that nurture them to connect between school science, everyday science, sources where they learn about science (like internet, joint activities in intergenerational interaction with adults and siblings or peers), and practices they already do (e.g., art, dance, music), can be beneficial in helping them build connections and see themselves as capable of doing science.

Table 2.3

Examples of Ways Students' Conception of Science is Related to School Science from Interviews

Description for science as related to school	**Example of stance**
Knowing, comprehending, and being able to do and follow procedures and instructions as an indication of science ability	"I mean, I like it.. I come to understand the teacher, and solve. If I do not understand, I do an experiment that we learned today, and try to solve it and understand by myself"
Seeing science as a lab activity at school done by the teacher or explained by the teacher	Science is easy because "When the teacher explains to us...eh.. she explains it to us... I understand it immediately, and I answer immediately." Science explicitly a school activity, "How is it possible that science helps you in your everyday life? **mmm just at school"**
Help-seeking from an adult, internet, books when dealing with challenges for some students	"If for example the answer was in front of me, I see it. But if it requires me to conclude and so, I need help from teacher"

Importantly, such engagement of students does not come in isolation of their interaction with family members or educators. As I interpret in students' stances, intergenerational interaction with adults, peers, and siblings is an essential source for their engagement in learning related activities (Vossoughi et al., 2021). For instance, the student mentioning their teachers, reflect a component of relationality, rather than dependency on teachers. These interactions should not be viewed as a lack of student autonomy or independence, rather, a perspective that the students' relations with others are fundamental for nurturing their learning process through joint activity (Vossoughi et al., 2021).

This study was beneficial in identifying two important aspects of students' perceptions, first the varieties they had internally and externally across items reflect the unique ways students navigate and experience their own learning trajectories. Second, the study demonstrated examples of ways students' self-perceptions are likely connected to their schooling experiences (Erickson et al., 2008; Sengupta-Irving & Vossoughi, 2019). Such experiences can create narrowed ways in which students perceive their learning activities. For instance, despite describing rich ways of their engagement with STEAM practices and interest in science in school and at home, one student said, “I do not know, teacher, what I can do with science.” That is, some students were still thinking about if such activities are related to science practices, as described in the previous chapter. Prior work on science identity has noted school science structure creates challenges for students to view science beyond schooling terms (Mawasi et al., Under Review). Despite the small sample size in this study, there are heterogeneous ways that students are engaged with science (Rosebery et al., 2010). However, these ways should be nurtured to help learners identify the varied ways science is present in their lives. For future studies, I stress the importance of not only exploring the knowledge or learner gains of students in these spaces, but also, exploring identity shifts and how these connect to the broader sociopolitical structure that affects learning in and out of school (e.g., if and how students have access to informal learning spaces for science).

Another implication of the analysis conducted with respect to the variety of ways students conceptualized the context of science is the methods and assessment tools used. That is, the pre-posttest items were adopted from research conducted in another culture. Even with the careful translation to Arabic, it did not fully capture the complex ways in which students perceive items. In their descriptions of the context of science, I identified rich responses that go beyond a simplified version of an item. Considering the context in which students refer to science when they respond to items can give different responses from students (e.g., Ben-Eliyahu et al., 2018). For example, as mentioned earlier, adding the word “activities” in the Arabic version, made eight students of the ten, articulate their answer in relation to the program activities. While this word was added for a better translation, the contextual responses of students indicate the importance of paying attention to the lingual aspects of instrument development to explore their meaning making as they engage with such measures.

Finally, I acknowledge the limitations of the study instruments within this context, the need to validate the instrument, and the need for a larger sample. Yet, given the constraints of research within real-world contexts, rather than a controlled lab study, I view these results and findings as one way to explore the dynamic changes that occurred. I see this as an opportunity to view the complexity that context brings to the development, refinement, and interaction of instruments within the research process (e.g., Ben-Eliyahu et al., 2018; Russ et al., 2012). For instance, I see that it is important to revisit the methodological tools applied within this local context or nondominant research field work contexts, in four ways: first, linguistically being open to expand ways students are expressing their thinking and learning process (e.g., being open to use both academic and spoken native Arabic). Second, understanding learners' perceptions of learning and teachers' role, ways learners perceive artifacts, and the context mediating learning activities, within the process of creating and iterating measurement instruments. Third, to examine ways students conceptualize the context of learning activity when asking about broader terms of self-efficacy than science only. Lastly, being explicitly open as researchers for the pedagogical implications of educational research instruments when interacting with students (Vossough & Zavala, 2020).

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CHAPTER 4

ENACTING ACTS OF SELF-DETERMINATION AS A FORM OF PARTICIPATION IN STEAM ACTIVITIES IN AN OUT OF SCHOOL SETTING

Abstract

This study examines the ways in which self-determination was enacted within an out of school transdisciplinary science program by focusing on the case of Rami, a fifth-grade Palestinian student. I build on work that argues for the attention to the sociopolitical nature of learning as a way to understand participation in transdisciplinary science activities. Specifically, I draw on Davis et al. (2020) conceptualization of self-determination to focus on the learning trajectories of Rami. I explore what happens when a learner's self-determination is enacted in the context of participating in out-of-school transdisciplinary science activities, which I will refer to as STEAM activities. The findings demonstrated varied ways of how a student enacted his self-determination within this learning setting. This enactment of self-determination created learning possibilities for him and others to participate in STEAM practices. These possibilities show that acts of self-determination allowed the student to navigate his learning trajectory in multiple ways in order to participate, to enact acts of resistance, to express himself during activities, and create possible futures. Some of these acts of self-determination could have been perceived as "disruptive", "off-topic", or/and "disengagement" if viewed through a deficit lens. However, the findings suggest, in alignment with Davis et al. (2020), these moments enabled Rami to navigate his learning trajectories, help others, play with others, and participate in STEAM practices. I close the article with discussing the implications for researchers and educators.

Introduction

In the past decade, a growing body of literature in the learning sciences, science education, and cognition has been examining learning and instruction through a sociocultural, political, and ethical lenses (e.g., Calabrese Barton & Tan, 2019; Philip & Sengupta, 2020; Tzou et al., 2019; Vossoughi et al., 2020). Prior work in the field suggests that understanding learning should be grounded in ethical questions that examine the ways in which issues of power, ideology, and injustice manifest in learning environments (Esmonde & Booker, 2017; Philip et al., 2018a, 2018b). Such work offers a lens to explicitly attend for transdisciplinary STEAM learning as sociocultural, political, and ethical (Takeuchi et al., 2020). Prior work also offers possibilities to understand learners' heterogeneous ways of knowing and doing in learning environments (Rosebery et al., 2010). Equity-oriented work within the field challenges deficit and normative notions of nondominant, minoritized, and historically oppressed learners in learning and doing STEAM activities by taking learners assets into account and complex ways of being of learners (e.g., Nasir & Cobb, 2006; Tzou et al., 2019; Pinkard et al., 2017). Finally, previous work expanded methodologies to better understand learners' actions, meaning making, and interaction dynamics during learning processes and moment-to-moment interactions (e.g., Esmonde & Langer-Osuna, 2013; Vossoughi et al., 2020). Therefore, through an attention to learning as sociocultural and political, prior work in the field has been contributing to the design and study of pedagogical approaches that created transformative educational possibilities in learning settings for nondominant learners and communities (Bang & Vossoughi, 2016).

Situated within literature that aims at understanding the sociocultural and political nature of learning in educational settings, this study builds on Davis et al. (2020) conceptualization of self-determination as sociopolitical and intellectual action in learning within an out-of-school setting. In this study, within a community-based organization aimed at engaging Arab students in Israel with science activities, several activities involved students working with hands-on artifacts that were designed and developed by the organization's educators. Ten students participated in a winter break program for four days where they engaged in a series of hands-on activities combined with facilitation from the organization. In this study, I investigate one case of how one learner enacted forms of self-determination during his participation in the program activities as he interacted with other peers, materials, and educators. I build on the genetic methodological approach used by Davis et al. (2020) to analyze the moment-to-moment interactions and learning trajectories of one student as he participated in varied activities across the third day of the program (Davis et al., 2020; Vossoughi et al., 2020; Vygotsky, 1978). Specifically, I explore, (1) if, when, and how does the student express forms of self-determination when participating in STEAM learning activities? (2) in what ways do acts of self-determination contribute to the student's and his peers' participation in STEAM activities?

Relevant Literature

I use the broad term *STEAM* to refer to transdisciplinary learning experiences that integrate diverse practices across disciplines to engage learners with science learning (e.g., Calabrese Barton & Tan, 2019; Takeuchi et al., 2020). Prior work in the learning sciences, science education, and cognition paid attention to the importance of designing informal learning environments for STEAM learning in and out of school to engage learners with science learning and practices (e.g., Pinkard et al., 2017; Hennessy Elliott, 2020). Research within informal and out-of-school learning settings put an effort on understanding students' identities development (e.g., Barton & Tan, 2010; Van Horne & Bell, 2017), learners' work with materials (e.g., Parekh & Gee, 2019), and learning opportunities afforded by such spaces to nondominant learners to support their varied identities development, interest in STEAM, and agency towards STEAM (e.g., Barton & Tan, 2010; Pinkard et al., 2017). Such work highlighted the educational possibilities that informal learning environments can create for nondominant learners in STEAM, as opposed to schooling norms, existing normative views of nondominant learners, and oppression reproduced in curricula and school environments (e.g., Nasir, 2011). However, such spaces, if not designed and studied through a justice-oriented lens, may be a space for reproduction of power and injustice (Hennessy Elliott, 2020; Mawasi et al., 2020b; Vossoughi et al., 2016). At the same time, work in the field has been examining the ways in which informal learning environments are also spaces where existing macro political power and injustice issues are reproduced (Vossoughi et al., 2016). For instance, Vossoughi et al. (2016) describe a framework for analyzing such spaces that attend to analyzing injustice dynamics within educational systems and learning environments, examining learning as historical and political in the learning setting, exploring ways in which artifacts (like values, tools, culture in the setting, instruction) are reflected in pedagogy and practice, and understanding the sociopolitical values of learning activities. In doing so, studying and designing learning environments take into consideration ethical dimensions that examine the question "towards what ends." (Philip et al., 2018b). Furthermore, such work suggests that simply introducing nondominant learners to STEAM activities without an attention to learning setting dynamics and pedagogy is insufficient to ensure equity and justice within such spaces (Vossoughi et al., 2016; Mawasi et al., 2020b). For instance, nondominant learners have to navigate existing power and injustice hierarchies in their interactions in learning environments and while they engage with curricula and pedagogy (e.g., Vossoughi et al., 2020; Hennessy Elliott, 2020).

Within the Learning Sciences research, there are calls to attend to diverse ways of thinking, doing, and being within learning environment settings (e.g., Nasir et al., 2006; Roseberry et. al., 2010). Such work asserts that learning is a complex phenomenon that should be addressed across multiple activity systems (Engeström, 2000; Gutiérrez & Vossoughi, 2010). This complexity requires an understanding of learners' engagement beyond binary definitions such as, engaged/disengaged or on-task/off-task behavior or participation/non-participation as a measure of whether learning processes are occurring (Vossoughi et al., 2021). That is, forms of engagement that could be referred to as "disengaged" or "off-topic" or "off-task" could be generative for students learning (e.g., Langer-Osuna, 2015). That is, such work suggests acknowledging the diverse repertoires, assets, and forms of participation students bring to the learning setting and ways they can be generative for learning (Nasir et al., 2006; Rosebery et al., 2010; Sengupta-Irving & Vossoughi, 2019). Connected to this work, prior work also argues that children's practices and ways of thinking in learning environments are interconnected with their everyday social and political life experiences (Erickson et al., 2008; Nasir et al. 2006; Sengupta-Irving & Vossoughi, 2019; Shalhoub-Kevorkian, 2019).

In this study, I build on prior work that examines learning as sociocultural, political, and ethical. I draw on work about science learning in STEAM informal environments (e.g., Barton & Tan, 2010; Pinkard et al., 2019; Parekh & Gee, 2019) while also examining political and ethical aspects in the students' learning experience in the setting (e.g., Vossoughi et al., 2020; Hennessy Elliott, 2020). I build on this work to explore examples within an out of school learning setting whether students express acts of self-determination.

In focusing on the sociocultural and political micro interactions in the learning setting, I explore ways students' acts in the learning setting can challenge what Shalhoub-Kevorkian (2019) refers to as "unchilding" discourses that see children as political capital. In this work, the author argues that despite the "settler-colonial invasion of childhood" (p.1) including in education within the state of Israel, "Palestinian children continue to negotiate creative ways to understand their situation and imagine other futures. Their bodies are indeed sites of colonial violence, but their lives also signify hope and resilience." (p.19) Such examples of negotiation exist in learners' sociocultural and political micro-interactions with others and the artifacts in their learning environments (Vossoughi et al., 2016; Vossoughi, et al., 2020). For instance, nondominant learners in science learning environments have to resist existing normative and dominant practices that have been designed through hegemonic ways of knowing (Harding, 2006; Kimmerer, 2013; Medin & Bang, 2014). That is, learners' engagement in STEAM practices are grounded in ethical and relational forms of participation, histories, and ideologies that shape such practices and learners' interactions with each other and materials (Barajas-

López & Bang, 2018; Bang & Vossoughi, 2016; Krist & Suárez, 2018; Medin & Bang, 2014; Philip et al., 2018a; Van Horne & Bell, 2017).

Viewing learner engagement within learning environments through individualistic terms, may provide an insufficient understanding of the nature of learning as relational and collective (Davis et al., 2020; Jackson, 2021; Vossoughi et al., 2020). Focusing on learner engagement through individual centered constructs like agency, free choice, and ownership, without a broader examination of the collective ends of learning can narrow the perspectives for examining how the learning activity manifests itself. For instance, in my observations of the case presented in this study, I noticed ways in which the learner's actions are targeted towards the collective with other students and teachers. For example, Rami experimented with light on his own clothes and invited Fadi and Yousef to look and to test it with him too. Rami also invited the teacher to look as he was pointing the light on his clothes. Such actions are embedded in relations to others and materials.

Focusing on the studied phenomena through individualistic terms that center the learning activities on individualistic learning outcomes may narrow the understanding of learning achievements as also a collective process. Therefore, I borrow from Davis et al. (2020) the term of self-determination to describe the interweaving dynamics between the individual and collective in the process of interacting with peers, teachers, and materials in the setting. I also build on Davis et al. (2020) work within an informal learning setting, because I view it represents a framework that it can have a broader collective sociopolitical implication for the experience of Palestinian children in similar learning environments.

Specifically, in this study I examine ways in which self-determination as a form of engagement was enacted when Palestinian students participated in an out-of-school community-based transdisciplinary science program in Israel. Borrowing from Davis et al. (2020), self-determination is defined as, "contestations and moves to elsewhere that shift activity and direct future socio-political and intellectual status." (Davis et al, 2020, p.2). These acts of self-determination involve, "resistance to or refusal of ideas or positioning within the space… negation, asserting identities, and reinterpreted boundaries." (Davis et al, 2020, p.2) In their work, the authors provide examples of acts of contestation instances that reflect resistance and refusal such as "opting out of a question and/or prompt", "refusing help or refuting need for help", "corrections or disagreements in discourse" (Davis et al, 2020, p,6). Examples of "*moving to elsewhere" include,* "claiming ownership", "inserting playfulness", "pursuing personal interests", "going off-script", and "maintaining & caring for artifacts over time" (Davis et al., 2020, p.6). By applying this framework in another context that is organized differently than the context in Davis et al. (2020), I examine if and how the acts of self-determination manifest in this different context and with different types of activities. In addition, I offer methodological insights on ways to look at such moments using the framework, and I explore ways such forms of self-determination offered learning opportunities for students in the setting.

Methodology

This article is part of a larger project that aimed to understand learners' perceptions and engagement with STEM activities. I conducted this study in collaboration with a community-based organization called Al-Rowad for Science and Technology. The community work engages Arab students in transdisciplinary science activities as a way of addressing “gaps” within science education which these students experience (e.g., achievement in exams, quality of education at school, marginalization, classroom size). The collaborative research project was conducted within a four-day program during Winter break in December 2019. Ten learners participated in the program and engaged in one hands-on activity (building an artifact) each day for four days. Each artifact was based on a scientific phenomenon and included a facilitated discussion with educators from Al-Rowad. In this study, I conducted moment-to-moment interaction analysis of a learning trajectory for one student in the program as he participated in activities during the third day of the program (Chinn & Sherin, 2014). Focusing on self-determination moments, I explore if and how the student’s interaction with peers, materials and the teacher reflects examples where acts of self-determination were enacted and experienced and the ways these moments enable expansive learning possibilities for this learner and others. In other words, I examine the students' development of learning as it evolves through his social interactions and with materials employing a microgenetic method to explore the student learning trajectory (Chinn & Sherin, 2014).

In this section on methodological approaches, I elaborate on the study context, program activities, data collection, and data analysis approach.

Study broader context

A group of ten students participated in an out-of-school community-based organization program for transdisciplinary science activities (STEAM activities) over the course of four days (the same 10 participants every day). The program was led and designed by Al-Rowad for Science and Technology. I collaborated with Al-Rowad to study students' perceptions and engagement as they participated in these activities. Program participants included 5 girls and 5 boys Palestinians from two Arab towns in the Haifa district of Israel. The students were in 5th grade (n = 5) and 6th grade (n = 5). Two educators from Al-Rowad led the four-day program during Winter Break in December 2019. One educator was the main teacher who led the activities and facilitated scientific discussion with learners. The second educator was the teaching assistant and supported the teacher and students as they built artifacts. The two educators are women.

The activities used throughout the week included engagement with engineering, technology, math, and artistic practices. Therefore, I refer to these activities as STEAM activities. Overall, each day covered a major scientific phenomenon where learners engaged in discussion about it, learned about related concepts of the phenomena during discussions, pedagogical moves, and instruction facilitated by the leading teacher (whole class discussion), did hands-on activities to build an artifact model related to the phenomena (individually), and tested with extra materials available when relevant (e.g., testing with paper filters). The sequence of activities each day was varied, however, they all included these common tasks. The major activities were as follows (see Table 3.1), on the first day, students learned about Super Absorbent Polymer (SAP) and built an artifact which allowed them to observe colors change over time due to distribution of colors. On the second day, students built an artifact of Newton's disc where they learned about light colors and mechanical motion. On the third day, students built an illuminating board connected to an ultraviolet (UV) "pen" which they could use to draw in the dark. On the fourth and final day, students experimented with solutions to understand the characteristics of water and oil. All artifacts were designed and made at Al-Rowad for Science and Technology through a process that considers science pedagogy and sociocultural learning.

Table 3.1

Major hands-on activities for each day during the program

First day activity: Super Absorbent Polymer 	Second day activity: Newton's disc 	Third day activity: Illuminating board 	Fourth day activity: Oil and water 

Data collection

As part of the larger project, I collected data from multiple sources including video, photographs, interview data, and measures of self-efficacy. I collected approximately 8 hours of video recordings that covered all of the program activities in addition to photographs that captured major activities (approximately 75 photos per day). I also conducted post-program interviews with students to explore their perceptions of engagement in transdisciplinary STEAM activities and collected pre-post efficacy measures to explore self-efficacy shifts (see previous chapter on self-efficacy). Students also completed daily post-activity questionnaires after completing their artifact each day

(Mawasi et al., 2020a). During the data collection, I wrote field notes about the setting that included notes about major activities of the day and logistics. While multiple data sources supported the understanding of ways students experienced the space and perceived STEAM activities in general, in this study I only focus on the videorecording data to address the research questions.

The initial goal of this study started with a broader question about forms of participation in STEAM learning activities in this setting. Then, as I engaged in data analysis, I narrowed the research focus to exploring moments in which forms of self-determination were enacted across the activities one particular day. I selected the third day because the activities in it involved a variety of tasks and because students were already used to the classroom norms. I elaborate more on the selection criteria in the next section.

Day 3 activities: Learning about materials that light in dark and building an illuminating board

In this paper, I focus on analysis of data from the third day of the program. I decided to do an in-depth analysis of this day because it afforded a range of activities where students could participate in different ways: discussion, hands-on activities, going to the big board, and testing with different types of materials. While on other days some of these activities existed too, on the third day, the activities and tasks' structure were logistically clearer to me as a researcher in the field as I became familiar with the context. I also noticed that students became more used to the norms of the setting when engaged in activities and tasks (i.e., discussion, hands-on activities, familiarity with materials) despite each day having different topics and different types of materials. In addition, by the third day, students were becoming more used to each other and the educators, which allowed space for informal conversations to happen. Finally, within this day, the educators could also ask students for their observations of artifacts they already did and to share about activities they did at home with such activities.

Based on the observation field notes and video-observation notes, I describe in detail the third day's major activities in order to set up a context for the analysis. As mentioned earlier, in this activity, students built an illuminating board. The details of these activities are as follows: the teacher began by welcoming the students, asking them general questions about activities they did with previous artifacts at home, and introducing the activities for the day. Multiple students participated in this discussion. The teacher also reviewed some concepts and materials that the students had been exposed to on previous days, such as SAP, diffusion, and Newton's disc. Next, the teacher introduced the topic of the day on light, "materials that glow in dark," the fluorescence phenomenon, and principles of vision, referring to phosphorescent materials.

During the presentation, the main teacher introduced topics using slides, and distributed different hands-on materials and equipment for the students to test and experiment with, for example green and red paper filters to explore what they could see (and not) when they look through them. The teacher then distributed materials to the students before explaining how to build the artifact as a way to give students time to explore and prototype with materials. Step by step, the teacher introduced new materials for use in building the artifact (e.g., wood, screws, glue). For each material she also invited one or two learners to help her distribute materials.

During each step, the students worked alone while the teacher repeatedly encouraged the students to ask questions, ask for help, or talk with each other. Before introducing and putting the illuminating board piece where the students would be expected to draw, the students engaged in a collaborative drawing activity on a big board where they tested drawing with UV light. The students then returned to their desks where they were introduced to new materials (e.g., holder for board, sticker, and small size board). The students then added more features on the board, specifically, the teacher showed them where to tie a string that would be used to tie a light to the board. Once students completed this part, the teacher talked with them in small groups about substances sensitive to UV and reminded them of concepts they discussed earlier in the day. The students then tested, in small groups with UV light, what they would see if the room light were turned off and they used UV light. After that, the students returned to their seats and tied a small UV light to the string they had before. They also decorated the string with beads that had fluorescent materials (i.e., absorbing light). As the students finished, they began to test the small light on their board with the room lights on and off. Finally, each student drew or wrote on his own board at the end of the day.

Rationale for selecting Rami as a case

The rationale for selecting Rami case are the following reasons, first, my observation in videos of his behavior in the learning environment as engaged in building artifacts, interacting with peers and offering them help, participating in discussion, using scientific vocabulary and concepts and at the same time using informal language and humorous talk, and taking action to stand up for himself and others. While, during the interview, Rami spoke in a very low volume and formal tune, compared to the varieties of volumes and humorous language he used in the classroom. Second, when I watched the videos closely, I noticed moments where I could observe him enacting acts of resistance to participate in the discussion and activities. These acts were unique in affording varied ways of participation in the setting activities for him and others. Third, I also noticed Rami helping Fadi and the rapport between them while watching the videos. Such moments were fundamental from my observation to Fadi's success in building the artifact and participating in activities. Such relationship highlights what Davis et al. (2020) referred to as generative ways for both of them as individuals and peers to engage in activities beyond binary classifications of individual versus collective learning definitions (Davis et al., 2020, Vossoughi et al., 2021). Finally, the videos selected for Fadi and Rami as I will describe later demonstrated a clear consequence of the activities happening in the space, which allowed closer attention to moment-to-moment interaction with peers, materials, and educators (particularly the leading teacher).

Data Analysis

The analysis of video data was informed by interaction analysis approaches while taking into consideration the moment-to-moment interactions within a local context of activities (Erickson 1986; Erickson, 2006; Chinn & Sherin,2014; Jordan & Henderson, 1995). I used a microgenetic method to conduct microanalysis of the moment-to-moment interactions of one learner over the third day activities as a focal unit of analysis. I built on what Erickson (2006) refers to as neo-Vygotskian interaction analysis to observe the learner behavior over time as interacted with others and materials. This way, I paid attention to the learning activities events as they evolved historically in the setting towards the possible futures they create (Vossoughi et al., 2020; Vygotsky, 1978). In the analysis of the video data, I also noticed learners embodied actions across different moments (Goodwin, 2000) and the use of language within the activities' context (Gee, 2014). While I did not conduct embodiment analysis nor discourse analysis, noticing these moments informed my understanding of learner interactions with others and materials. Finally, the analysis of the data for this study is also grounded in my thinking through literature in sociocultural and political theories of learning as described earlier. Specifically, I used Davis et al. (2020) framework to illustrate ways forms of self-determination were enacted across time and activities.

Procedures

Organizing and watching video data

In order to understand the data better, I watched all videos that covered the eight hours of program activities. First, I organized each camera video in a separate folder and watched the videos from cameras that provided the most accurate chronological sequence of activities in alignment with her observations in the setting and field notes. For each day there was a primary camera and another one or two (depending on logistics on that day) as supplementary recorders. Watching all videos allowed me to observe the flow and structure of activities, describe the various types of student and educator activities in the space as well as students' participation in the STEAM learning activities. While reviewing the video data for the first time, I did not take notes to allow time for an uninterrupted, overall observation and understanding of what the video content.

As I was engaged in data analysis of the students' interviews and post-activity questionnaires (Mawasi et al., 2020a), I noticed different instances where the students praised the learning environment and teachers, as such "fun", "there is joy", "receiving help". I also noticed different ways in which learners described their identities that reflected transdisciplinary ways of participating in scientific practices through arts or engineering or design (see the first chapter on perceptions). These findings were supported by my presence in the field observations and notes communicated in memos I analyzed the interviews

My engagement with this data made me revisit the videos in waves of analysis with a broad research question focusing on how learners were participating in STEAM learning activities in this learning environment. As I described earlier and as reflected in the description of the third day, the students had an opportunity to engage in diverse activities and tasks in the setting. This led me to another question of whether or not the context and type of an activity mediates the learners' interactions with each other, educators, and materials. These thematic starting points led me to discuss observations within these videos where I could see different arrangements and organizations of activities (e.g., times where learners discuss in one whole group together vs. time to work alone), varied materials which learners used across the four days (e.g., laser cut wood, SAP, different designs of artifacts, paper filters, acid substance), an increased interaction between students compared to the first day, and varied moments that aligned and contrasted with students' perceptions.

Initial observations from videos

The methodological approach presented earlier, led me to further narrow the focus of the inquiry. Building on prior work that centers the importance of social interaction within STEAM informal spaces and based on the initial thematic understanding of the video data, I decided to focus on how learners interact with each other, materials, and educators. Then, in order to explore these interactions, I chose to focus on the third day activities as it offered the most comprehensive view of a varied range of activities within the four days program. Specifically, I was interested in exploring these interactions as they evolved on the third day across varied types of activities (Chinn & Sherin, 2014; Vossoughi et al., 2020; Vygotsky, 1978).

I analyzed the videos from the third day with an attention to the interaction of two students on whom the camera was focusing: Rami, a 5th grade boy and Fadi, a 6th grade boy. While analyzing the footage, I noticed Rami participating in the discussion often without permission (like raising his hand), and both students had different moments where they did activities together. Specifically, there was a moment in which Rami took Fadi's artifact to help him and showed him how to build it. Thinking through literature that attend for history and future of learning within micro-interactions (Chinn & Sherin, 2014; Vossoughi et al., 2020; Vygotsky, 1978), these observations led me to wonder about the historicity of this moment for Rami and wonder about its affordances for Rami's interactions with Fadi and others, educators, and materials in the learning environment (Vossoughi et al., 2020; Vygotsky, 1978). I initially began with the episode which brought my attention to the relation between Fadi and Rami, a moment where Rami helped Fadi. I conducted a moment-to-moment analysis of two minutes of this interaction and shared my observation of the analysis with senior researchers. Then, guided by the question on the history and future of this moment, I watched all the videos and wrote memos for the descriptions.

Memos writing as part of the analysis

Building on interaction analysis approaches (Chinn & Sherin, 2014; Jordan & Henderson, 1995), combined with video-ethnographic observations (Erickson 1986; Erickson, 2006), and attention to talk and embodied gestures (Goodwin, 2000; Gee, 2014), I watched the third day videos in depth in segments (14 videos, 7.75 minutes on average). For each segment I wrote analytical descriptive memos that describe the major activities in the learning environment with focus on Rami and Fadi. The memos focused on micro-analysis of the behaviors in the environment as students engaged in activities during the day.

The memos and observation notes of these activities centered on the context of activities and instruction for the whole group (e.g., describing activity type, major contribution of students, ways of participation of students), students' interaction with each other (e.g., observed side talk moments, helping, working together with materials), and students' interaction with materials (e.g., what a student did with materials, what they did together). The writing of these observations was guided by thinking analytically through questions building on literature (Saldaña, 2015). Thinking through such questions made it possible for the observations memos to be an integral part of the analysis process and thinking about the data. This includes, thinking about the context of activity type affordances for learners; what is considered as intellectual in students contribution and by whom (Vossoughi et al., 2020); in what ways students are engaging with each other's, materials, and educators (Parekh & Gee, 2019); how does the teacher responds to these contributions; what are the implications of individual learner contribution on the whole group; who is being dominant in the space and when as a way to think about power dynamics (Esmonde & Langer-Osuna, 2013); how does teacher position learners across activities (Anderson, 2009; Anderson et al., 2017); if and how the context of an activity type enables or constrains students thinking and participation (Vossoughi, personal communication); and ways participation structure in the environment by design or as emergent by students choices creates possibilities for learning (Vossoughi, personal communication).

These descriptive memos included descriptions of observed behaviors of students in the learning environment focusing on Fadi and Rami as they are the two primary students in the camera frame and thus draw the camera's focus. In some cases, during writing memos, I referred to supplementary videos from different angles to understand the broader context of an activity (e.g., if the teacher pointed with her hands towards a student or made eye contact with a student). The memos also included description and quotes of major talk that happened in the space. In addition, the description of embodied engagement reflected in students' interactions with each other, materials, and educators when possible, such as ways students helped (or not) each other or asked for help (Vossoughi et al., 2020). These memos and talk provided an understanding of the context and discourse for each activity type within the day. For example, the use of scientific vocabulary, ideas, and thoughts shared by the teacher and students in an activity, when and how a student was praised by the teacher, dynamics between students, affordances of activities for participating in STEAM practices like testing, experimenting, imagining, planning, and designing.

In summary, these memos consist of analytical writing and included screenshots for activities and descriptions. These screenshots also capture different gestures that illustrate embodied interactions as well when students interacted with each other, with artifacts and materials, and with educators. The writing of the memos was in English as it is my major academic communication language and as a way to involve senior researchers in discussing this data. I used Arabic phrases when needed during the writing of the memos.

Engagement in memos writing

The engagement in writing analytical memos illustrated that Rami and Fadi had different learning trajectories reflected in ways they participated in the activities' settings. For example, I noticed that Rami, in contrast to many students in the group, often did not raise his hand to answer questions even though he was actively talking and using scientific concepts. Rami often just joined the conversation from the side. While Fadi participated less in discussions and worked like other students to build his own artifact in the time allocated for that. In some moments there was a struggle for Fadi to build his artifact, he asked for help or he observed how his peers are working to learn from them.

Overall, I found that students had opportunities to participate in diverse scientific and artistic practices in the setting afforded by these variations. Such as, talking about science, testing with materials, experimenting, wondering, and planning. These variations in the participation may also be because “non-participation” in discussion was also respected by the teacher, as she recognized students listening and witnessing as a kind of participation and engagement. And such variations also might be due to the nature of the activities. For instance, some activities afforded testing materials in peers, moments for playfulness, sharing with the whole group and other activities had students working individually to build their artifacts.

Second, the relations and dynamics between students with each other in the space contributed to their experience in narrowed and expansive ways. For example, the observed close relation between Rami and Fadi reflected their observed moments of play, joy talk, and care, made it possible for Rami to enact his positionality as helper and for Fadi to ask for help and receive help that was fundamental for Fadi success in building the artifact and working independently later. An example of narrowed relationality is when I observed one student in the space from the back, Faris, interrupting other students and not making it possible for them to talk. But even this moment was expansive to others – two students including Rami stood up for themselves and joined the discussion despite Faris interruption.

Third, there were varied moments when students asked for educators’ affirmation in the space, sometimes during discussion and sharing examples from their home, sometimes during doing activities, and sometimes when they were testing materials and wanted them to see what they were doing. Finally, different types of activities enabled fluid positions in the space. In some activities, if we look at the teacher reaction to Rami behavior, we will think he is “disrupting” per the teacher comments (e.g., insisting to work on board when it is not his turn, taking materials without permissions). At the same time, in other activities, he was positioned as knowledgeable (e.g., engaging in discussion), as helper (e.g., when he helped Fadi and helped teacher distributing materials), and creative (e.g., drawing on board).

Across these examples of findings focused on Rami and Fadi, I particularly noticed that Rami enacted several moments of playfulness, resistance, and agency. The playfulness reflected in the way he was interacting with Fadi. Examples of playfulness reflected in, joking, humorous talk, making voices when testing with materials, teasing Fadi, and at the end of the activity wrote a word expressing his frustration from a moment where the teacher asked him to go back to his seat. Rami's acts of resistance reflected in his way of navigating this space to participate in activities. Specifically, he often did not raise his hands to answer, while this made the teacher in many moments not praise him, he continued to do this as a way to engage in this space. He also did this from my interpretation because there was another student participating often and the teacher praised him often. Rami resistance was not an individualist, he used his resistance multiple times to participate and contribute to setting. For example, playing with materials before the teacher gave instructions as a way to plan his step, asking the teacher to distribute materials like others. Another example, in humor and exaggeration he told the teacher to choose him to help her distribute materials because she always chooses girls only. Another example, a moment when Faris interrupted Beesan, Rami pointed at Faris and asked him to let other people talk. A third example, when Faris noticed the teacher giving Faris more time to experiment with the big illuminating board he wanted to extend his own time too, but the teacher asked him to go back to his seat, he insisted and took the light and joined the group. Finally, Rami demonstrated agency when he took action for himself and others when the teacher was not responding or he asked the teacher to turn off the light so they could play and experiment more.

These three encounters with peers, the teacher, and the classroom materials made me realize that the ways Rami was interacting enabled moments for learning possibilities to others. In my observation, these moments of playfulness, resistance, and agency were possible due the design of the learning environment and pedagogy enacted in the space by educators who by design attempted to support learners in varied ways (e.g., allowing different forms of participation, welcoming playfulness and humor, making students feel safe to test and sharing wrong answers).

From memos to self-determination

These observations and findings led me to think about existing literature that explains what I observed through the analytical memo writing and discussion in the focus of observing Fadi and Rami interactions. This led me to two articles that helped me clarify and understand better such experiences through the lens of acts of self-determination as operationalized by Davis et al. (2020) and Vossoughi et al. (2021).

This work made me realize that the students' experience in the space reflected what Davis et al. (2020) and Vossoughi et al. (2021) described as acts of self-determination to navigate their learning trajectory and negotiate their identities in the space. This understanding led me to more narrowed research questions that specifically focused on Rami’s experience and asking about the moments in which Rami enacted forms of self-determination as he participated in STEAM learning activities. Also, I wondered whether these acts were generative in contributing to his and other peers' participation in STEAM activities. Guided by the theoretical framing of Davis et al. (2020) and Vossoughi et al. (2021), I present the findings on Rami's experience across different moments of time and activity type.

The observations I had of Rami are in alignment of the self-determination framework of Davis et al., (2020) in varied ways, I noticed several moments of "acts of contestation" and "moves to elsewhere" as he interacted with peers, materials, and educators. Examples of "acts of contestation" reflected in Rami's resistance to teacher disciplining comments, refusing to accept her request to go back to his seat, and he often participated without raising hand. As well as I clearly noticed moments where Rami "moves to elsewhere", such as, engaging in playfulness behavior with materials, teacher and his peers, caring for details in his artifact design, caring for his peers when he helped Fadi and when he asked the teacher to be fair, and expressing himself using his artifact at the end of activity as both a form of "claiming ownership" and "resistance" (two categories within Davis et al., 2020 framework).

Findings: Acts of Self- Determination

Focusing on the research questions of self-determination, I present the findings through examples that illustrate when and how Rami enacted different types of self-determination in the learning space. I present these examples to illuminate how these moments created expansive possibilities for Rami and others to participate in the STEAM learning activities.

Rami is a Palestinian boy who was in fifth grade when he joined the winter program at Al-Rowad center. Across the activities within the selected day of analysis, he demonstrated varied ways of self- determination acts. Examples are first reflected in moments of **“resistance and refusal”** to teacher instruction, norms in the class, taking action for himself and others when he experiences unfairness, taking further steps to experiment with activities before or without permission from the teacher, and experiencing the STEAM activities in unique ways to the others. Second, by **“moving to elsewhere”** through playfulness with materials, peers, and the teacher, wondering about the benefits of the artifact, inserting joy and humorous language when doing activities and interacting with others, doing what Davis et al. (2020) refers to as “going off-script” through the acts he did. Such off-script acts might be considered as “disruptive”, like taking materials from the bag on the teacher desk without her permission. Other examples include refusing to follow the teacher’s instructions and instating to join other students on board when it is not his turn, caring for design of artifact and asking for affirmation about it, and caring for others when doing activities.

Here I provide four examples across diverse activities and tasks from data that illustrate micro-moments of enacting forms of self-determination. I constructed these examples by tracing instances of particular kinds of acts, such as bids for participation, across different tasks, interactions, and moments. Since different kinds of acts were distributed across these tasks and interactions, the examples weave together moments from the same activities but with an eye towards illustrating different ways that self-determination was evident. I did not systematically code the video or transcript, and the examples are not necessarily representative of all instances of self-determination. Rather, I used the Davis et al. (2020) framework as a lens that allowed me to see and interpret Rami's engagement in a new light.

Example 1: Participation in discussion, "I did not take pictures", but I can join in other ways

Participation in discussion

During the broader discussion students would be sitting together and looking at the teacher as she facilitated the conversation. As the teacher welcomed students at the beginning of the day, she asked Rami "how are you today?". She asked them "are you happy today coming in the morning?". Rami answered and smiled, "no" in a humorous way (because they had to wake up early and come).

Rami initially looked around as the teacher was welcoming other students. Then the teacher asked if they remember previous activities, he said with others "the SAP", looking at the teacher. The teacher asked, "what did we call this experiment?" to encourage students to mention the Arabic concepts they used in previous days. While Beesan mentioned the word "absorption", simultaneously Rami smiled and tried to remember a concept they used, Rami attempted and said, "Hygroscopy", "ترطب" (here he was actually referring to an absorbing substance in that experiment that absorbs liquids (i.e., SAP), but apparently used a word that linguistically from similar source in Arabic). Then, he immediately whispered, "I do not know". Then Rami, moved his hands from under the desk to the top of the desk, moved his gaze from the teacher to his hands, and smiled. He looked to the right side, shook his head to the left, tapped fingers on the desk, and looked back again towards the teacher.

The teacher continued to prompt the students, saying “experiment of…?”, “the experiment we used SAP in… experiment of…?” … then she said, “the experiment of -Hulam-هلام” (in Arabic), which means “Jelly”. Rami looked around and whispered words (unclear). Then the teacher also asked students if they took pictures to document changes in the artifact they were creating on the first day (i.e., diffusion of substance and change in its colors). Rami said, “I did not take pictures.” The teacher, in a friendly surprised tone responded, “You did not take a picture?” At this point, another student chimed in and said, “I did”.

Rejoining the discussion

As the students continued to talk, Rami was not fully taking part in this conversation since he said he did not take pictures. While the others were talking, he had an aside with Fadi, who was sitting next to him. These whispered side conversations between the two were repeated across the day during the activities and sometimes involved quiet laughs. When other students shared, the teacher asked them more elaborative questions compared to Rami, like “what did your brother see?”, “did you explain to him?”. For example, she later also welcomed Fadi when he shared with everyone about a conversation, he had with his father about Newton’s Disc motion as connected to animation. This example opened up a conversation about how cartoon animation works with students. The teacher asked students different questions including a question that opened up an opportunity for Rami to join the conversation again. As she talked, she asked “nice, why do I see them in motion?” referring to animation. Rami interrupted and said, “because of the speed of lights”. It was not the answer the teacher expected so she said, “because of the speed of…?”. Multiple students whispered and answered. Rami said again “the light”. During this exchange, Rami answers had a different tone and volume. Some moments he spoke loudly and clearly or interrupted or in some cases he whispered.

Varied moments and ways for participation in the discussions across the day

During the day there were multiple opportunities where students could answer the teacher’s questions. Some of these questions were social (e.g., how are you today?) and others were about activities (e.g., why do we see animation in motion?). Often these discussions were happening with the whole group while students looked at the teacher as she facilitated the discussion. Rami’s participation varied from moment to moment. He often answered questions without raising his hand. Sometimes he used humor as he talked with the teacher or peers. He attempted to answer, even when he was not sure about the answer. These moments of contribution to the discussions were accompanied also with different tones of voice. Sometimes Rami would say things loudly to express his perspective and sometimes he just whispered or simply turned to Fadi for a side conversation.

Summary

I view these variations in participation as a form of self-determination because these are moments where Rami chose his own way to join a conversation and participate in the discussions. By doing so, he was refusing to be positioned as a non-contributor and instead participating through different variations of talk that included humor and scientific vocabulary too. Rami also was resisting traditional schooling norms where he would be expected to raise hand to talk. The teacher responded in varied ways to such moments, for instance, in some cases she would expect following classroom like norms (e.g., raising hands, respecting other students turns) and in others she welcomed informal talk and participation (e.g., building on a student wondering comment to ask a question or encourage a student).

Rami used scientific concepts to engage in the discourse of discussion, talked with peers, and interrupted in discussion without raising hand to assert this positionality as a contributor and legitimate participant (Lave & Wenger, 1991). At the same time, Rami contributed in his own way, using humor sometimes, side talks with Fadi, answering without raising hand occasionally, whispering, or even talking loudly. Finally, across the day's moments of the discussion, Rami's contributions were helpful to others, there were different moments where Rami's contributions created opportunities for other students to also talk, join discussion and wonder with him, and even gave initial "prompt" to others. For example, when Rami answered "light", Fadi followed him and answered similarly. A wrong answer from Rami that was generative for the discussion, as the teacher followed it with a question to engage them in the discussion. In another example, Rami thought about solar panels as an example of an object that absorbs light, which led the teacher to explain the solar panels function to the students. The two examples illustrate that Rami's participation expanded to benefit other students too in the setting and that his ideas and forms of participation were taken up by the teachers.

Example 2: Inserting playfulness and humor in tension with norms

The observations also demonstrated there was a rapport between Fadi and Rami. The side talks between them clearly involved laughs, whispering, and humor as mentioned earlier. However, in one case the teacher misunderstood this relationship. Across the activities Rami did not stop to engage in playfulness, there were moments where inserting such behavior included an invitation for others to explore and wonder with him. This invitation for others to be part of his experience comes in tension with the teacher's initial perception of his humor.

Rami's humor with Fadi in tension with teacher perception of Rami's playfulness

When the students and the teacher talked about principles of vision, Fadi thought "a camera" would be one of these principles. The teacher had a dialogue with Fadi. She asked him "now I am seeing you…? Right? And you are seeing me? Do we have a camera?". Fadi in confusion said "yes, it is there". The teacher continued in dialogue with Fadi and asked, "if this camera was not here, and I turned off (the light), can I still see you and you see me?". While Fadi was thinking, Rami laughed at his answer. Then Fadi said, "yeah, ah". The teacher continued with Fadi "so this camera is important for vision?... no, my precious (plural to everyone)". Then the teacher immediately turned to Rami and commented on his behavior saying to everyone, "we should not laugh at wrong answers. We want to listen to all answers even if it is wrong. Even if it is wrong do not be afraid to raise your hand. Because we learn from wrong answers. Imagine the first time I did the SAP activity with you and I immediately asked Karam to answer (apparently Karam already knew this activity from another context) how would it be beneficial to ask everyone if Karam already told us about the substance? But when we started to listen to all the wrong answers and we began to correct it, we were learning. So, we should not be shy to talk. I always tell the boys; I want to listen to wrong answers. I do not want to listen to only correct answers. We can correct mistakes, learn, and comprehend the phenomenon that is happening." As the teacher continued to mention the principles of vision, Rami joined also and said "a mind, a mind…"

Commenting on Rami's humor as an opportunity to emphasize the learning space is for everyone

The teacher's encouragement of students to join discussions with "wrong answers" was something that created a space for many students to join the discussions, including Rami himself. The teacher also used, "we" to create a sense of community for the students within this space. However, clearly here when he laughed at Fadi, Rami was picked up on as this behavior is not consistent with his friendly relation with Fadi from my observation. Another moment where Rami enacts his humor and could be understood as disruptive and therefore the teacher intervened, is a moment where Faris asks a question not related to the program activities about how mirrors work, the teacher again welcomed Faris' question, she said "nice", but did not answer the question. The teacher mentioned to everyone, "it is a nice question, this a huge topic, however we are talking about light", still she said "your question is very nice and there a long answer for it, there are rules to answer it and calculations, at some point you will learn it in physics", then Rami interrupted saying while almost whispering playfully "*Khalas* (no worries) we do not need to know" (since it has long answer, rules, and calculations). The teacher immediately responded to Rami and said to everyone, “I really like he (Faris) is thinking ahead, so you all start thinking about all what we are talking about and making connections”. Despite that Rami was using humor, the teacher emphasized that Rami should be respectful to others.

The teacher comments to Rami, comes at tension with the privileges she gave to Faris compared to others as reflected in times he had opportunities to participate and more time to use materials on the big boards, two moments that Rami himself later resisted and pointed to the teacher on when it happened. In my view, Rami's comment here could be a critique of the abstract illustration of physics as a topic that they will learn in the future using rules and calculations. In other words, his voice as a child and through humor pointed at ways adults illustrate to him science practices, even though he himself is already engaged in such practices.

Rami’s “off-script” playfulness and humor as an act of self-determination

Rami’s playfulness was not just in humorous talk, it was also within moments of offering help and going “off-script” to experiment with materials. For example, Rami asked the teacher to help her with distributing materials multiple times. The teacher asked students “who would like to help me today?”, while the teacher tried to be fair with all students, she chose Noura. Rami complained in a humorous way “why always girls?”, and then the teacher asked them both to pass the filters paper, where Rami volunteered to help the teacher pass it. I view such moments of offering help as moments where Rami was looking for an explicit affirmation from the teacher to participate in activities. An attempt in my view to seek the teacher affirmation and approval for legitimate participation in these activities (Lave & Wenger, 1991). These moments where Rami asked for affirmation, come in contrast to moments where he just would jump from his chair and do things without permission.

A moment where Rami went "off-script" in a way that was generative for exploring new ideas by himself and with Fadi was when they were testing the red and green paper filters to read texts (see Figure 3.1). As students were experimenting with both colors, Rami experimented what would happen if he put the paper in front of the projector light on the desk in front of him, Fadi joined him and did the same. Despite the teacher looking at Rami in excitement, she asked him and Fadi to remove the paper filter immediately from the projector as it will burn the paper from the heat of the projector. On one hand, Rami was testing the "what if" he puts the papers in front of the light with Fadi, the teacher was excited the students were exploring with these papers, but also, she asked them to be careful with materials.

Summary

As the previous moments present, there were multiple moments where Rami took action to participate in activities within the space. Rami actively enacted this participation through available materials, offering help to the teachers and others, and playing or being humorous with others. Sometimes this playfulness and humor came in tension with teacher values and classroom norms, however, it did not stop Rami from attempting to participate in varied ways in the activities. To position himself differently, across the activities Rami sought to have affirmation from the teacher when he asked permission to participate, helped in distributing materials, and even later during the day when he was working on his artifact and asked her to look if he is doing it the right way. These examples illustrate Rami attempts to seek affirmation as a way to be positioned as a contributor, knowledgeable, helper, showing care to others, and doing things the right way. It also illustrates that Rami's engagement within the space is relational with others too.

Figure 3.1: *Students Experimenting with Paper Filters in Two Colors*

Example 3: It is our (my) right, not his right only to participate

As I described in previous examples, Rami enacted varied ways of participation in the space when he contributed to the discussions and learning activities. These included moments where Rami also sought to build social and intellectual connections with the teacher related to his work (e.g., showing her what he did with artifacts; calling her to see how he engaged with materials such as during UV light activity). In other moments it was raising his hand to answer despite that he often did not raise it often, instead he would just answer informally or whisper answers. That is, there were moments where Rami asked for permission to participate by raising his hand. There were moments where he simply just answered informally while the teacher was talking.

Across these moments, I view that Rami wanted to assert his positionality as a contributor, yet at the same time, in some cases was hesitant to, and in others he simply wanted to assert his own right to participate. He enacted these acts through varied forms of participation in the activities and discussion (e.g., interrupting, raising hand, offering help). I describe examples of such moments and then illustrate if and how they describe forms of self-determination.

We are raising our hands and want to participate too: "you tried one hundred thousand times"

In a discussion about the spectrum of light, many students raised their hands to answer teacher questions, as a common norm of this setting. More students became involved in this discussion compared to earlier discussions. Rami did raise his hand this time too. While the students were raising their hands, a student from the back interrupted while raising his hand and said "me, I want to say something." The teacher said, "Can we try to listen to Noura, let's have turns, I will listen to you, I will listen." Faris insisted and continued begging the teacher "teacher no, let me." Rami turned to the back and pointed at Faris, he said, "you tried one hundred thousand times." While Rami was exaggerating, he was referring to that Faris had the opportunity to answer and talk in discussions many times, while others did not, and now Faris should give other people the opportunity to answer teacher questions. Faris put his face down. Noura began to talk, Rami moved his face to his left to listen and looked towards Noura. Faris looked towards Noura too, at the same time he was still moving his body up for teacher attention. Here, clearly Rami's act of self-determination was to suggest to Faris to be respectful to others, which allowed a space for Noura to talk. The teacher did not intervene or build on Rami's comment to Faris (as she did comment in other moments on Rami's "disruptive" behavior), the discussion just continued. That is, as Rami's comment was aligned with the value system of the activity, the teacher did not reprimand his intervention as she did in other moments. Faris raised his hand again, the teacher welcomed him to talk after Noura had finished. Faris said, "Ultraviolet and Infrared are just from the sun… they emit from the sun." Rami whispered interrupting, "Liar,…there is a pen.. [inaudible]." In my interpretation Rami meant "false", but he used the word liar informally out of frustration, as a fact check for Faris. However, because of Rami's way of participation, what he said was unnoticed by the teacher. The teacher interrupted Faris and said to him, "do you know there are sensors working on Infrared?" The question made Rami wonder and he asked, "what does it mean sensors?" (this time without raising hands). Then the teacher explained to the students in Arabic the source of the word, so they conceptualize its meaning. For instance, the teacher used multiple words to describe sensors (i.e., حساس / مجس/ مستشعر, which literally means "it is sensitive, or it feels"). The usage of multiple words to refer to sensors here provided a linguistic range that helps in understanding the function of the sensor. After explaining the words, the teacher shared examples of automatic doors working on Infrared when entering a big store. The teacher said, "how did it (the door) see me?", Rami first said, "camera" (apparently because of the teacher's usage of the word "see"), then immediately corrected himself and said "sensors". The teacher said after Rami to confirm, "sensors".

Across this flow of discussion, Rami's acts of self-determination as reflected in asking for fairness from Faris to wondering out loud, enabled expansive ways for others to join the discussion, learn about new concepts, and wonder with him. I also view his informal way of participation without an invitation, a moment that I consider "moving elsewhere" as he is wondering with others. For instance, such a wondering moment reflected in his question to the teacher about sensors opened a discussion about its function and related vocabulary.

#SuperAmazing, We Scribbled Your Work: Moments of Expression

In another activity later, where students were experimenting with a big illuminating board on the wall and drawing on it, the teacher asked students to go in turns. Yousef wondered, "if I write (with the light) from far away the font would be wide and thick?" the teacher said, "try it, it depends on how strong it is, this one (light) is not that strong." Fadi and Rami went in the first-round group, they drew and wrote words. The students on board have their tools. The teacher said "*yalla*, all try it, draw nice drawings, choose anything", Lara said, "I do not know" then the teacher shared ideas with students, she said, "write a nice adjective about yourself, yeah, adjective you like about yourself, something nice, a hobby, a drawing, everyone their own choice, you may use shapes." Then the teacher looked at Rami and Fadi, and said "Creative, fantastic…" ... then she asked them what they wrote, because one-word Fadi wrote is unclear. He said it is "bombastic" (he wrote it in Arabic alphabets with missing letters). Rami wrote "#رائع جدا" which means "#super amazing" or "#very cool". Rami and Fadi drew lines on the board with the light too to test how strong the light could be and observe how drawings disappear slowly over time (Figure 3.2). They tested different ways of drawing and writing using the light on the board.


Figure 3.2: *Rami and Fadi Drawing and Writing Together on the Illuminating Board*

The first-round students including Rami went back to their seats. More students go to the board to draw and write using the UV light. As Rami went to his chair, he said while looking around and gesturing scribbling with his hand, “I scribbled it” Referring to what he did on the board. Fadi joined and they said together while talking with peers, “to the one who wrote [inaudible] we scribbled it for you” they were joking as Rami did a gesture with his hand to show how he scribbled a drawing with the UV light.

As a new group on the board, the teacher gave them materials, she said “you may print your hands, be creative, each one an idea…” While giving students on board materials, Rami from his seat noticed a sheep shape and he laughed saying, “there is a sheep” … the teacher said, “yeah, there is sheep, elephant, and many shapes”. She asked them what they thought of the board, one student said “it is nice” ... the teacher said “it is unique? Unique…” Students continued to draw, they drew multiple things, including objects, words, using shapes from teachers, and also printing their hands. These materials, like the sheep, were not among the tools Rami used earlier when it was his turn.

When Rami was on the board with other peers in the first round, he tested Yousef's question on the strength of light, he built on the encouraging comment from the teacher "try it." Which is also illustrated in his following comment later, "I scribbled it." He had a space to test and play with the light scribbling and writing words. At the same time, these forms of *moving to elsewhere* were encouraged by the teacher as legitimate STEAM practices, creating a space for diverse ways of expressions to be enacted (Gee & Parekh, 2019). These forms of expressions with materials and peers created a space for "*moving to elsewhere"* to engage in artistic expression, testing, writing, and scribbling *as* acts of self-determination. In my interpretation, Rami's acts were with others and materials and allowed a space for him to see these practices as a "valid" way to engage in the science activity (Davis et al., 2020, p.8). A moment that Rami also celebrated with others when he and Fadi shared how they scribbled on the board humorously.

From #SuperAmazing to #Tuz: Moments of Frustration and Resistance

In another moment, the lights are turned on in preparations for the last group to join. Rami stood up and went to the board again, he said to the teacher, "teacher, I'd like to draw a sheep", then as Faris did not leave the board, Rami complained "teacher, he is still standing, still standing". The teacher pointed at Rami and said "Rami, Rami, Rami… please give others space." Rami resisted and attempted to draw, and she said, "no no, dear, we want to give opportunities for others, because it is their right to participate too." The teacher took from Rami the light, and he went back to his chair. As he was back to his chair, Rami frustrated and looked at Fadi, he pointed at the artifact in progress he is building and did X gesture with his hand and said to Fadi, "Tuz" which means "to hell with it" or "damn it" or "what the hecka" in my free translation. When Rami said this word, both he and Fadi laughed. Rami again, in frustrated voice, pointed at Faris and loudly said "teacher, he was with the previous ones, was with the previous ones" Faris this time said, "none of your business", Rami while resisting said, "I want to draw!!!", he stood up, took light from the bag without the teacher permission this time. And attempted again to join others and draw with them, even though it is not his turn.

Even though there were varied moments after this incident with Faris where the teacher involved Rami in activities and where Rami himself continued to participate in activities, at the end of the day, as students had time to work individually to test their own artifact once it was completed, Rami wrote on his own board, #Tuz #طز. Apparently, this word was as an expression of the moment he was frustrated from the teacher not allowing him to draw on the big board a second time to draw the sheep, not staying on board for same amount of time as Faris, and when teacher took from him the materials when he himself tried to resist teacher request and took the light from the bag. This shift from #VeryAmazing/#VeryCool to #Tuz, is a "moving to elsewhere" moment where Rami was expressing his frustration using informal and humorous language in a creative way (see Figures 3.3.1 and 3.3.2).

Figure 3.3.1: *A Student Drawing on the Big Illuminating Board and #Superamazing which Rami Wrote Appears on the Left Corner*

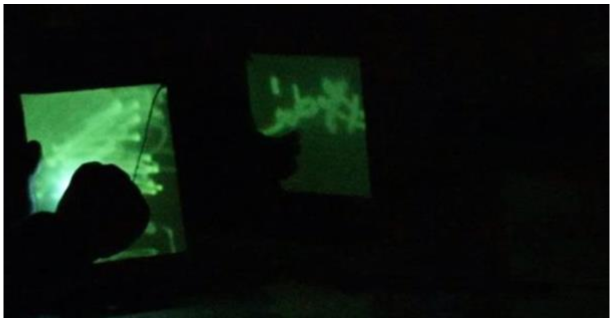

Figure 3.3.2: *Fadi Scribbling on his Final Artifact on the Left, Rami Writing #Tuz on his Board on the Right*

What Rami did initially on the big board with Fadi allowed them to test how the UV pen works and later use it their own way on their own artifacts. In the first moment context, the teacher was present when Rami wrote #SuperAmazing, she also encouraged both of them. Later, when Rami did this work on his own small board after his resistance moment, Rami wrote #Tuz, in the absence of the teacher. The frustration expression of Rami came despite several examples of teachers nurturing his participation and his peers' engagement across activities during the day. Therefore, Rami's acts of playfulness, humorous talk, and resistance would not be enacted if he was not aware of the teachers welcoming for students' varied ways of participation and non-participation as well. For instance, while Rami ended the activity writing on his board an expressive word, Fadi chose a different trajectory as he scribbled on his board to test the light. What the two did on their own personal boards at the end of the day, connects with what they both tested together on the big board, yet, at the end each one used the board differently.

Rami attention to "fairness"

During his participation in the activities, Rami's attention to fairness was enacted multiple times in generative ways to him and others. In such moments, Rami's attention to “fairness” were reflected as he enacted his resistance and refusal to a student behavior (Faris) and to the teacher (during the board activity). In example 2 from the previous section, Rami did this humorously (where he asked the teacher to choose him to help her, like the girls). In the first description within example 3, Rami raised a concern about fairness while resisting a peer behavior when Faris interrupted others. Rami enacted resistance while refusing the teacher request when she asked him to leave the board in a collaborative activity and go back to his seat as his turn was over. Finally, Rami ended up expressing his frustration using his own artifact.

While these moments may be perceived as “disruptive” or “disengagement” with classroom norms, they opened new possibilities to engage in the activities for him and for others. First, when he pointed to Faris to give space to others to talk, Noura did talk and Rami himself did not have his own time (like Noura, Faris, and later Karam) to talk. Rami within this segment of time just inserted his answers through “whispering” or saying a few words informally, what he used to do before to be heard (and sometimes unheard because his voice was not loud). Rami used his voice to ask to remind Faris (and perhaps the teacher), that Faris participated many times and should give others the opportunity to participate too. Second, when Rami persisted in contributing through whispering or wondering about the sensors, without permission, it opened an opportunity for others to learn about a real-world example of where they would see infrared. Third, Rami humor made it possible for him and Fadi to play with light on the board beyond what the teacher asked them to draw and write. Fourth, Rami acts of self-determination and persistence were important moments for creating a pathway for him to predict and decide what to draw on the final stage of the artifact building. Such moments include, noticing that Faris is still on board and the teacher giving him more time, a moment that allowed him to enact his resistance and advocate for fairness. He refused to listen to the teacher and decided what is best for himself, which was a crucial moment for him to test new materials he did not test before. Then, sharing with Fadi what he is planning to write on what he thought would be the final artifact (a board).

Summary

Across these examples, Rami actively was engaged in varied forms of self-determination that reflected ethical and relational thinking about others. First, he pointed at the structure of participation in the activities to share with Faris and the teacher that there is no equitable distribution of activity roles. Second, when the teacher did not allow him to rejoin, he insisted to be part of the collective board activity and wanted to draw again. Third, Rami expressed his frustration to Fadi when went back to his seat.

In these examples, there was a tension between the educational possibilities that nurtured such forms of self-determination (e.g., teacher encouragement, supporting Rami to use varied forms of modalities, scribbling) and moments where the teacher asked Rami to follow existing activity structure and norms. In the two situations, Rami’s acts of self-determination depended on the type of activity and dynamics he had with peers, teachers, and materials.

Across these moments, Rami enacted self-determination in the form of contestation and moving to an elsewhere. Examples of these moments include Rami's resistance to Faris behavior, then the teacher ignored Rami. As a result, Rami took an action to ask for his right to participate equally like Faris. In doing so, Rami pointed to the teacher, she is contrasting herself by asking him to give others equal opportunity to participate when she is not giving him (and others) the same opportunities as Faris. This resistance also took other forms with Rami's attempts to answer questions or participate in discussions informally. Such moments, indeed, were generative for others, as I mentioned in the previous section examples. Secondly, these acts of self-determination included also moments of "***moving to elsewhere",*** as Rami consistently inserted his humor and playfulness, used informal language, involved Fadi by communicating with him, expressed himself using his own artifact and on the big board, and as he was doing activities, he was predicting what he will be building and drawing and writing next.

Example 4: Care for others, materials, and himself

The previous examples reflected a tension between Rami's attempt to be friendly and humorous and the teacher's expectations of students to respect each other, be careful with how they use materials in some moments and follow settings norms and activities' structure. At the same time, despite such tension, it is evident that the teachers nurtured and supported Rami to enact varied ways of self-determination in the space. Without such support from the teachers and from the environment Rami would not be able to feel his actions are valid. Yet, these tensions in my interpretation made Rami across different moments work towards changing the way he was positioned. This positionality was fluid across activities and engagement with others and materials. Here I describe multiple moments that illustrate Rami's care and responsibility as a form of self-determination.

Care and Responsibility to Others and Materials

In my observations, Rami across the day enacted several moments that challenged this view of him being "careless" of others and materials or reckless as some teacher stances indicated (e.g., the comment of moving filter paper away from the projector, not being fair with others when insisting to join one more time on board). Rami behavior in varied moments challenged these views. In different moments, I found that Rami acts of self-determination took a form of care and responsibility as he interacted with others and materials. Rami's care was not only towards himself, but also towards others and towards materials. Such care and responsibility as ethical behaviors challenge the initial thoughts of him "laughing at Fadi", being disrespectful to Faris, not using materials well, and disrupting norms by doing things without permission.

Among these examples, moments where Rami demonstrated care for Fadi through humor with him, helping Fadi build his artifact, and testing materials with him as a way of exploration. Another example is Rami caring about details in his own artifact design, how it looked, wondered what it is beneficial for, and planned it carefully throughout the day. For instance, Rami was constructing and deconstructing the artifact without glue as prototyping. Rami also carefully balanced the artifact and looked at it from different perspectives to make sure it is balanced.

Rami supporting, playing, and learning with Fadi

When students began working on their artifact, Fadi said to the teacher, "I have a taken piece", meaning one piece is missing. Rami looked to Fadi side, he checked if Fadi's pieces are ready to be used and said, "you have one that is not taken." Then Rami went back to work on his own artifact. Here, it was one initial example, where Rami took initiative to make sure Fadi is ready to go and work on his artifact.

In another moment which happened at a later stage of the activities (after the board conflict incident in the previous section). Rami looked at Fadi and noticed he was struggling. Rami first, put his hand on Fadi's arm as a gesture of encouragement. And immediately began to help him as the teacher asked if anyone could help Fadi. When the teacher asked for help, Rami immediately put one hand on Fadi's hands and one hand on the artifact to stable it. Then, as Fadi was looking at the teacher to correct her for mispronouncing his name, Rami took from Fadi the screw hands, moved the artifact model towards his side, and started to show Fadi how to do it while holding Fadi's artifact (Figure 3.4).

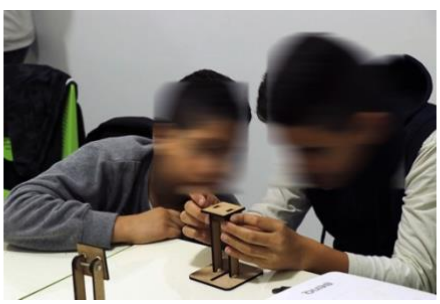

Figure 3.4: *Rami Helping Fadi to Enter the Screw to Combine the Holder and the Stand*

Fadi observed how Rami was turning the screw nut for the holder carefully as his body was close to Rami and his eyes were focused on Rami's hands. When Rami finished turning the screw nut, he tested if the holder was working. Then he moved it back to Fadi. Once Fadi had his artifact back, both Fadi and Rami continued to test the rotation movement of their own artifact models. The teacher thanked Rami for helping Fadi. A moment here, where Rami was positioned as someone who can give help to others, an opportunity that potentially helped both Fadi and Rami learn and play together and test their artifact's function.

In a third moment later, the rapport between the two made it possible for them to play and test a big UV light the teacher gave them. Students around the room had their own light. Fadi and Rami were playing together. During this activity, Rami took the light and was pointing it towards his teeth to test the reflection with Fadi. Then the teacher told Rami, "*Yalla*, give it to Fadi." Rami passed the light to Fadi. During that moment, Rami noticed the reflection of light on the white clothing of Fadi, he pointed his finger towards it. Fadi took the light and pointed it towards his body. As this exchange continued, the two were exploring the reflection on their clothes, teeth, and artifacts. As they were testing and experimenting with the light together, they were excited jumping, dancing, singing, and making voices. They also took an object the teacher had on the desk and wondered what it was. The teacher saw them, and said, "experiment on it", then she encouraged them to observe changes that are happening to colors "look how it became", as this object was made of substances sensitive to UV light (Figure 3.5). This playfulness with light continued throughout the activity, and included Rami calling the teacher several times to look at the reflection of the light on his shoes.

These examples of "*moving to elsewhere"* (e.g., wondering and testing with light, expressing excitement in dancing, imagining new ways to test with materials) also demonstrate how the activities included moments where Rami enacted a collective ownership through inviting others to join him wondering (Davis et al., 2020; Vossoughi et al., 2020, 2021). A finding that aligns with Davis et al. argument, that self-determination within learning environments goes beyond individualistic terms, as it also has broad implications on the collective.

Figure 3.5: *Rami and Fadi Testing Light on a Pink Object that was on the Desk Close to them. The Teacher Encouraged them to Experiment the Effect of Light on the Bottle*

Rami communication with the teachers

Rami communicated with educators through humor, questions, offering help, asking for affirmation, and gaze offers examples of his attempts to be involved, but also to the varieties of ways the space afforded him to engage with peers, materials, and educators. This does not come in contradiction of previous examples, rather, it shows that the dynamics within a learning setting are fluid and complex. For example, Rami was supported in many moments. When he said in frustration to the teacher "teacher, look, they (the wood) keep falling." The teacher asked, "why do they fall? What do we need to add?", some students with the teacher said, "glue." Rami persisted and continued to work on his artifact as the teacher talked, trying to understand the functionality of the piece. Rami shifted his eyes to the piece and tried to fit it. Later he wondered out loud and said, "teacher, what is its benefit?", the teacher did not answer, yet these two moments made him continue working while apparently feeling he can continue to ask questions and seek help as he is building the artifact. When he finished this part, in excitement he said, “I did it, I did it… that…” while other students were still experimenting with the wood pieces and the teacher preparing for the next part of the activities. In another moment, he wondered again while building his artifact and testing where to put pieces in holes, “what if I flipped it?” while looking at the teacher. These “off-script” wondering questions sometimes came while the teacher was busy with other students and not able to pay attention to him, however Rami continued to ask and talk without a formal permission to do that. It is possible in my interpretation that the teachers not giving him immediate assistant allowed a space for Rami to try again and continue wondering while working.

While Rami resisted teacher instructions in some moments, he looked for affirmation from the two teachers as he worked on his artifacts. Such moments of asking for affirmation were important to Rami, to demonstrate he is building the artifact right. As the teacher assistant reminded students “be careful to make sure it is straight and not sloping”. The teacher assistant said this comment, while observed multiple students’ artifacts with poles that are still not straight. Rami moved his body back and looked at his artifact poles to see if they are straight. Rami put back one hand on the right-side pole to balance it and make it straight. Then Rami moved to balance the other side. Finally, once he balanced it, he looked at the teacher, and asked her “is this correct?”. The teacher said “yes”. Throughout this example, he cared about the teacher's view, but also, he carefully examined his own artifact, fixed it, and balanced it, then asked for teacher affirmation.

Rami's care for materials: deconstruct to reconstruct

Rami's care for details of materials, how to use them, and how to build with them allowed him to plan, test, create, engage in wondering about what he is doing, model the teacher, and support Fadi later. He attempted to orchestrate his engagement with these practices while also actively answering teachers' questions in discussions or when she asked random questions as the students were working. For example, when Rami had his artifact almost done. Rami had to tie a string to the artifact while also answering and engaging with the teacher questions prompts. After doing that, he moved the artifact away from him to see how it looked like, he tested its movement, and looked at it. He rotated the board. Attempted to take off the board and deconstructed it to improve it. He fixed the sticker with his hands. Then, he put the board back as he was trying to make it in the center. Eventually, he resumed to be focused with the teacher while she asked questions to students.

Summary

Throughout these examples I found varied ways in which Rami's enactment of self-determination took a form of care and responsibility to teachers, Fadi, and materials. Rami cared about having communication with the two teachers and building connections with them. Rami did this by offering the teacher to join him when he was experimenting and testing the light, he did this by offering to help distribute materials, and asking for affirmation if he does his artifact well. Rami's communication with the two teachers in relation to materials included wondering about the materials and asking them questions as he was working (e.g., what is it beneficial for? What if I flipped it?). Rami also carefully was paying attention to teacher gestures when she was modeling to students how to build and was showing it to Fadi too in multiple examples. Rami involved his peer Fadi in exploring materials and made it possible for both of them to play together and exchange humor. This care and responsibility extended to materials and as he worked on building his artifact and engaged in varied activities using it. These activities reflect also another form of ethical behavior of Rami, that is, involving others in his wonder and exploration process and thinking aesthetically about artifacts.

Discussion and Implications

I began this work with a broader question regarding the ways learners engage and participate within an out-of-school STEAM program. Focusing on Rami's case, I narrowed this question to if and how the student enacts forms of self-determination within the space and where such acts are expansive to the learning trajectories of others. To address the research questions, I used a microgenetic analysis approach that examined the ways self-determination acts manifested across different types of activities and tasks within the setting over time (e.g., from student initial participation, to participating in building the artifacts, to engaging with varied materials, to resisting norms in the space, to ending the activity with self-expression). I looked at the evolvement of events over time as a whole, then selected moments that illustrate the discussed examples. Through this analysis, I focused on these acts as they evolved in the moment-to-moment interaction with peers, educators, and materials within the learning trajectory of Rami.

Throughout the analysis of acts of self-determination as part of the learning process, I aimed to demonstrate the moments in which such acts happen, ways they evolve, and ways they can be generative to the learning of the individual and others. Building on my understanding of self-determination as a collective process, I also illustrate that the learning process goes beyond individualistic terms, rather, the acts of self-determination contributed to the learning of Rami and to others - students and educators - in the setting. Focusing on four examples on participation, playfulness, rights, and care, I described in the findings instances when Rami demonstrated acts of self-determination. The forms of self-determination Rami enacted constituted what Davis et al. (2020) referred to as “contestations and moves to elsewhere,” reflected through Rami’s interaction with peers, teachers, and the materials in the setting. Examples of these acts included resisting norms in the classroom to ask for his right and students' rights to participate equally, wondering about materials, inviting others to test and wonder with him, and enacting care and responsibility to others and materials. In this way, Rami’s acts of self-determination were generative and created learning possibilities for others as he played with them, shared his knowledge, and experimented with materials with them. That is, the acts of self-determination enactment outcomes were not individualistic ones. They are relational with others and artifacts in the learning environment, and the acts cross boundaries between the individual and collective (Davis et al., 2020; Vossoughi et al., 2021). For instance, Rami enacted self-determination while working on his own artifact. When he wanted to participate in other activities, he invited others to wonder with him, and he helped others. These self-determination actions enabled Rami and others to participate in activities that involved wondering, playing, testing, hypothesizing, and engaging in STEAM practices.

While the learning setting encouraged Rami to practice self-determination, these acts were occasionally in tension with the teacher's expectations of norms. In some moments, the teacher supported Rami’s acts; in others she did not. These tensions can possibly be explained by the challenge in distinguishing between norms at school (e.g., raising hands to answer, using formal language) and his experience in this community-based setting (e.g., having fun, joking, playing with others, learning new things every-day, support from teachers). That is, the norms of this setting varied, and at times, the teacher's expectations aligned with his schooling experience and at times the norms of this community-based program were quite different. Apparently, when Rami’s acts were in alignment with the value system or logic at play in the setting, the teacher did not reprimand him.

While this tension reflects a need for the student to liberate himself from his schooling experiences, I view the teacher’s comments on his behavior as generative. Some of the teacher’s comments enabled a trajectory for Rami to enact his self-determination at different times during the day to assert his positionality as a knowledgeable, responsible contributor, and a helper. The analysis showed that Rami explored and negotiated diverse positionalities in his participation through acts of self-determination thus creating opportunities for Rami to engage in STEAM practices in the setting and supporting him to explore multiple identities in relation to others and materials (Van Horne & Bell, 2017).

The acts of self-determination connected to the histories Rami had with the teacher and others (and possibly school) and seeded desired futures he wanted to have in his interactions with others and materials as he built his own artifact and engaged in activities. In this way, teacher-student conflict is not necessarily disruptive, it can also be generative to the learning process and help students in navigating their possible futures. At the same time, Rami's acts of self-determination across different positionalities demonstrate that such a process is fluid even within a small segment of time. This fluidity has both constraints and affordances: in some moments it meant a load he had to carry with him, in others it was expansive to his learning and others. For instance, in asserting his playfulness and humor, Rami was resisting his own "unchilding" (Shalhoub-Kevorkian, 2019). This act of resistance to what counts as good students' norms was a challenge he had to negotiate in his everyday life as a student.

In enacting his self-determination and moving within his fluid positionalities, Rami's case represented ways "resistance and moving to elsewhere" can shift possible futures within a learning trajectory at this small scale of analysis. The enactment of self-determination across time and type of activities demonstrated how such acts can be fluid and distributed yet historically connected. This fluidity allowed Rami to enact diverse forms of self-determination, but also, in ways that can shift perceptions of him, enable him to work with others, and also practice STEAM activities in his own way. The learning space where Rami was able to enact his own forms of self-determination made it possible for him to shift his positionality and engage in STEAM practices while interacting with peers, talking with the teacher, and building his artifact. Such engagement in shifting positionalities while engaged in acts like playfulness, as Sullivan and Wilson (2015) suggested, support learners in achieving their learning goals and affecting learners' identities within a group. For a student like Rami, this could mean attending explicitly for his contributions within the group and nurturing him to perceive his practices as valid practices in learning about and doing STEAM (Davis et al., 2020).

Across these episodes, I demonstrated that Rami's learning trajectory was mediated by his interaction with peers, teachers, and materials. Rami's engagement with peers, teachers, and materials are examples of the complexity of studying and understanding human behavior in learning environments. As I mentioned earlier, each interaction afforded certain types of behavior for Rami and sometimes others within the scope of the study. For instance, these ways of engagement enabled Rami to test, plan, hypothesize, work with others, and wonder. Namely, it made it possible for Rami and others to engage in various STEAM practices. Such interactions also afforded different moments where Rami could enact acts of self-determination relationally. This relationality to others and materials provided insights into ways learning processes include relational and ethical aspects when students navigate their learning trajectory (Krist & Suárez, 2018; Parekh & Gee, 2019; Vossoughi et al., 2020). In attending to the relational and ethical ways in which learners interact with others and materials in a learning environment, researchers can pay attention to the values that shape learners' activities and impact their learning process and achievement (e.g., Philip et al., 2018b). Such attention offers an invitation to acknowledge heterogeneity in ways of knowing when designing STEAM learning experiences (Roseberry et al., 2010; Warren et al., 2020).

At a methodological level, this moment-to-moment engagement with data illustrates the importance of how microanalysis can reveal new perspectives of students' learning experiences and how their trajectories evolve in the setting. Such a methodological approach offers a perspective to examine students' learning across space and time (Vossoughi et al., 2020). This approach enabled me to look at Rami's story from a different perspective where I was able to acknowledge his brilliance in navigating the setting as he interacted with others and materials. In this work, through the analytical approach, I was able to examine the sociopolitical dynamics of the learner's interactions within the learning setting. In this study, an understanding of the student's micro-interactional moments highlighted the generative ways the learner enacted his self-determination within the space, positioning him as actively engaged in determining his own futures, rather than simply viewing such actions through a deficit lens. That is, building on de Certeau's (1984) notion of the practice of everyday life, the student actively navigated power structures in the space to enact self-determination across different activity contexts. Such enactment of self-determination constitutes a possibility for the learner to disrupt power dynamics, explicitly and implicitly, towards transforming his own learning trajectory through expansive ways that can support others in the setting too.

In closing, these micro-moments where Rami enacted acts of self-determination cannot be isolated from the macro context in which these activities are broadly situated. That is, Rami had an opportunity to be in an environment that nurtured his self-determination in varied forms, however, this is not the reality of all learning environments - both formal and informal -where students spend their time. Therefore, pedagogically, this work can offer a lens to invite teachers and researchers to think about the classroom dynamics as a space where learners' self-determination could be nurtured through their interactions with teachers and peers. It also invites teachers and researchers to examine the sociopolitical dynamics in students' interactions when engaged in STEAM activities.

Future Directions and Limitations

This study drew on video data as a main source for conducting a deductive analysis that examines self-determination through the lens of Davis et al. (2020), where acts of self-determination are defined through "acts of resistance" and "moving to elsewhere" in the learning environment. The study focused on the case of one student's moment-to-moment interaction during one of the days of instruction. While this chapter does not look at changes in engagement or generalizing these findings for other students, previous findings from this broader program of research point to diverse means of engagement within the space. These varieties are reflected in the ways students perceived their activities and ways they enacted their identities in relation to STEAM practices.

The findings in previous chapters and in this chapter may indicate that students also within the space enacted their self-determination in a way that could be similar or different than the case I examined in this study. That is, students had varied learning trajectories within the space that are worth exploring in depth across the four days. Towards this end, since this qualitative work focused on one case study in a small scale of time, future work in similar contexts may consider expanding the scale of time in which learning activities are examined as a way to better understand the evolution of learner engagement within the space. A second possibility is to expand the analysis to include more learners from this setting as a way to examine when and how certain activities afford or constrain types of participation. Finally, this work was centered on the student's interaction with peers, materials, and the teacher, and less attention was paid to the pedagogy enacted by the teacher across the four days. Future work may consider examining the impact of instruction on learner's engagement in the space more explicitly. Furthermore, as this study demonstrated there was fluidity in the positionalities Rami carried across activities. This could also be an area to explore with respect to educators in the learning setting. Namely, future research could study what type of positionalities educators enact across different types of activities in the learning environment and how an activity context can shape such a positionality.

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CHAPTER 5

CONCLUSION

Towards Expanding Analytical Approaches to Study Learners Perceptions and Engagement

Across this three-articles dissertation I explored ten Palestinian children's perceptions of transdisciplinary STEAM activities and their engagement within an out-of-school community-based organization program using multiple methods across each article. In doing so, this dissertation makes scholarly contributions to the study of children's experiences when they engage in informal science related activities. It also makes methodological contributions for studying children's experiences in educational settings. This work also offers a lens through which researchers can examine learners' perceptions and interactions within learning environments through a sociocultural and political lens that views learning as a complex relational and ethical process. In this summary chapter, I first present an overview of major contributions of each article. Then, I illustrate major implications and significance across all the three chapters. Next, I offer future research directions and questions for research and practice that could be considered for future work. Finally, I close this introduction with a personal reflection on this work.

Summary of Contributions

The first article offers an analysis of learners' perceptions of STEAM activities as reflected in the students' descriptions during interviews with each individual learner. The findings demonstrated students' thinking about their STEAM activities in various and complex ways. Studying students' perceptions of their STEAM activities reflected that students are wrestling between their schooling experiences and their conceptualizations of what counts as learning. It also demonstrated that students perceive their engagement with science in transdisciplinary ways, that is, a student may engage in scientific practice, yet, at the same time may perceive it not necessarily as pure science, despite that the organization presents these activities centering science and technology. I demonstrated in examples where the transdisciplinary perception of such activities is generative as students perceived their actions as a form of art or engineering. In some examples, a student may not identify connections between their actions and thinking in relation to scientific practices. That is, a student may be engaged in a scientific related practice like testing or hypothesizing or imagining when doing arts, yet not view such activities as related to science. This complexity of students' beliefs is reflected across multiple examples of normative views of what counts as STEAM and learning that students are wrestling with. Finally, the students' axiologies, reflected in their descriptions of ethics, values, and aesthetics demonstrated that students' engagement with STEAM activities is not merely conceptual, it also connects to their values in and out of school. Such values could be shaped by their schooling experiences, adulthood expectations, and their everyday life realities as I discuss in the first article. In analyzing students' perceptions with STEAM activities, I contributed to work that stressed the importance of expanding science education to challenge hegemonic discourses that shape scientific practices to support learners' diverse ways of knowing (Takeuchi et al., 2020; Warren et al., 2020). I also offered a lens in which children's perceptions reflect varied ways in which existing normative and deficit ideologies are perpetuated in their self-concepts and their actions (e.g., Erickson et al., 2008; Sengupta-Irving & Vossoughi, 2019). The implications of these findings are that studying learners' perceptions requires attention to learners' realities and everyday lives that shape these perceptions and learners' ways of knowing. Nurturing learners to identify connections between their everyday experiences and identities can support learners to see how these include practices that connect with STEAM practices. Additionally, exposing learners to transdisciplinary ways of thinking may help learners go beyond what counts as learning as shaped by their disciplinary schooling experiences.

In the second article, I explored if and how students' science self-efficacy shifts as they participate in an out-of-school program where they engaged in STEAM activities. There are no claims for science self-efficacy shifts of statistical significance in this chapter. However, the inductive qualitative analysis of students' answers during the interviews revealed that students perhaps understood the science context differently as individuals and also across each item to which they responded. Students understood science contexts in varied ways across the items (e.g., school science, doing activities in the program, science as a big thing). These perceptions provide insights for the design of assessment tools when working with nondominant learners. Namely, despite the limitations of the study in terms of sample size, the findings in this article suggest a need to consider sociocultural and contextual meaning making of students as they engage with assessment instruments. Such a consideration invites researchers to examine the expansive and varied ways learners conceptualize science. Acknowledging the limitations of such instruments and seeking to develop culturally sensitive tools that are respectful to children thinking processes, take into consideration the rich and complex ways in which learners can make meaning of their learning experiences, and value learners diverse linguistic practices can create educational possibilities where learners not only use such instruments as “like a school thing to fill”, rather, it can be a possibility for them to learn also about themselves, shift their perceptions, and reflect on their learning processes.

In the third article, I examined how one learner's interaction with his peers, educators, and materials evolved as he participated in STEAM activities through micro moment-to-moment analysis. I highlighted how these interactions mattered for the opportunities the learner had to enact his own self-determination. Such enactment of self-determination was a generative process for the learner's engagement with others and materials and for others to engage with him. In this chapter, I offered an analysis that demonstrated the importance of activity context and classroom sociocultural and political dynamics in shaping the learner’s positionalities across different activities. Such positionalities were fluid, as reflected in roles and acts the learner asserted and inserted throughout his learning process. In doing so, the learner asserted his childhood, resisted schooling related norms that were present in this informal learning space, and reflected values and ethical behaviors of care and responsibility towards others in the setting. The findings of this study contribute to ongoing research that aims to examine learning as a sociocultural, political, and ethical process that is also shaped by relations created between the learner and their environments (e.g., Uttamchandani, 2020; Vossoughi et al., 2020). Methodologically, this chapter demonstrates the importance of viewing learners’ interactions from a different perspective that can tell a different story of the learner engagement in the space (e.g., Davis et al., 2020; Vossoughi et al., 2020). That is, it highlights the need to understand learning complexity and the ethical responsibility researchers have in studying children and their acts of self-determination as they navigate and negotiate their learning within existing activity structures in educational settings.

Importantly, this work is aligned with the major findings of the framework I built upon in the analysis of self-determination (Davis et al., 2020). Undertaking this work in a different context with a different population contributes to the ways in which the framework could be of value in other contexts. A final implication of such an understanding relates to creating and designing learning environments that nurture students to enact acts of self-determination in ways that are generative for their learning as individuals and as part of a community of learners, while taking into consideration the importance of the role of educators in facilitating such acts through pedagogy and instruction.

Major Implications for Research and Practice

The overall dissertation work has implications for research and practice around the design and study of equity-oriented STEAM learning environments for nondominant learners. The research implications I illustrate here are beneficial to researchers in education whose work includes research on learning and cognition, sociocultural and political aspects of education, childhood, transdisciplinary STEM education, informal learning and community-based research, learner engagement and interaction, and research methodologies. The practice implications of this research offer pedagogical contributions to the work of educators who are engaged in transformative social change in and out of school with nondominant learners.

First, learners have diverse perceptions and ways of engaging in STEAM activities. These varieties demonstrate that students' learning trajectories (Lave & Wenger, 1991) are mediated by cultural resources, experiences, and perceptions with which they are wrestling. Therefore, one implication that I found across the three articles is aligned with the argument that heterogeneity provides expansive learning opportunities that go beyond the boundaries of a discipline, particular way of knowing, and dominant views of what counts as science (Rosebery et al., 2010; Takeuchi et al., 2020; Warren et al., 2020). That is, nurturing learners to negotiate experiences that take into consideration heterogeneity as an integral part of the design of learning environments offer learners the possibility to enact their own meaning making (e.g., Rosebery et al., 2010; Tzou et al., 2019). In relation to STEAM activities, such an implication adds to existing discourses on the importance of expanding the boundaries of science education to be explicitly transdisciplinary. Such transdisciplinarity not only can afford learners space to engage in multiliteracies and draw on skills across disciplines (Gee & Parekh, 2019; Mishra et al., 2011), but also it can challenge dominant and hegemonic ways of doing and engaging in science to include social relations and axiologies as integral in how students perceive and engage with scientific practices (e.g., Tzou et al., 2019).

Second, this work challenges deficit views of nondominant learners and children. Across all three articles of this dissertation, I demonstrate the complex and deep ways in which children articulate their thinking about their experiences in and out of the program. I also observed and analyzed their interactions within the space. Across these chapters, I was able to demonstrate that despite the existing normative ideologies children are wrestling with, they were also actively engaged in negotiating their meaning making of their experiences. Such meaning making was, in many examples, relational to others, both human and more-than-human beings, with a thinking of values and interactions with others. The implications of this understanding are both contextual and broad. First, seeing Palestinian learners through deficit discourses, not only provides a limited view of their assets, but also such discourses are reproduced and internalized by students and educators. For learning environments to be more humanizing to these learners, they should shift away from defining learners through standardized and schooling terms. Learning environments may create educational possibilities for learners to more explicitly enact the rich ways they think about and engage with learning activities and to prepare them to transform the complex realities they live in (Frerie, 2007). Broadly, this dissertation asserts a need to nurture children to actively enact their childhood and positionalities in learning environments. In doing so, researchers and educators acknowledge that children's voices and experiences are valid, engage in dialogue with them, and position them not just as learners but also as partners with whom to learn. Such engagement can create a possibility for intergenerational learning between children and adults (e.g., Vossoughi et al., 2020, 2021). Pedagogically, this offers a space for interactive and critical dialogue between peers and educators. Methodologically, it offers an invitation to develop ways where children's contributions are not only being heard in a design-based research process, but also nurtured through critical pedagogy (e.g., Mawasi & Gee, 2021; Vakil, 2014) and considered as a major learning opportunity for adults too.

Third, methodologically, by drawing on varied methods to study students' perceptions and engagement, this dissertation offers an opportunity to examine learning across different contexts and scales of time. When read together, the chapters highlight how a certain context of an instrument and analytical approach can demonstrate a different understanding of the student perception and engagement with learning activities. For instance, in the first article, I used an interview instrument to conduct interviews with students after they completed the program activities. While my engagement with this methodology allowed me to learn more about students' perceptions, it also made me realize I should be paying more attention to the ways in which the instrument mediates students' responses, the ways the context of the interview compared to their engagement in the program shape their responses, and simply their perceptions of me as a researcher. In the second article, I demonstrated the importance of accounting for the context in which students refer to "science" when they respond to questions about their science related activities. And in the third article, a microgenetic analysis showed how one learner's engagement in the setting was full of rich interactions. The moment-to-moment analysis which built on the first two chapters, allowed me to see his story beyond a deficit lens. These examples demonstrate the possibilities of expanding our methodological tools to study learning experiences of nondominant learners', rather than making assumptions and claims based only on one methodological perspective. Therefore, the understanding that learning manifests across multiple contexts and activities systems should be also reflected in the methodologies used to make claims about learning and student interactions.

This work was conducted in collaboration with a community-based organization of Al-Rowad for Science and Technology through a research-practice partnership (Mawasi et al., 2021). The work of an organization like Al-Rowad, grassroot youth initiatives, and informal learning spaces, are rich spaces of learning, expertise, knowledge, and wisdom that was built for many years of engagement in social change work. Such organizations already engage in iterative educational processes, they already test things, design, and actively evaluate their work. This understanding invites us as researchers to think about the meaning of "intervening" in work of community-based communities rather than engaging in dialogue with them to exchange expertise and knowledge and learn together (e.g., Bang & Vossoughi, 2016).

For each one of these points, there are also practice and pedagogical implications that could be beneficial to the work of organizations like Al-Rowad, informal learning environments for STEAM education, and critical pedagogy in STEM. First, in order to nurture students' diverse ways of thinking and knowing, challenging normative views about STEAM should be central within science education. That includes, examining when and how the ways existing hegemonic practices of science manifest in the ways science activities are presented to children (e.g., Tzou et al., 2019; Vossoughi et al., 2016). Second, education research must pay attention to when and how broader deficit views of children and nondominant learners manifest themselves in the pedagogical practices and assumptions about learners (Vossoughi et al., 2016, 2020, 2021). Third, educators and researchers should focus on learners' engagement in the learning process in a way that helps them negotiate their realities experiences in and out of school (e.g., Nasir, 2011). That is, education spaces should allow students to enact their self-determination and express themselves in varied ways. For example, through activities that interconnect with students' everyday, cultural and political lives, consider values that shape their perceptions, and affirm how their ideas and contributions are valid during the learning process. Fourth, in a reality where scientific and technological practices continue to become "not neutral," (e.g., Harding, 2006) but rather political, engaging children with the ethical implications, history, and possible futures of science through a critical pedagogy is essential in helping them connect between scientific innovation and their own realities as nondominant learners (e.g., Vakil, 2014). Finally, this work demonstrates the importance of educators' roles in shaping students' experiences in the setting, that is, the facilitation and careful attention to artifact design was fundamental in supporting learners and helping them begin to shift their conceptualization of what counts as learning beyond schooling definitions. However, at the same time, since schools are a major educational resource for nondominant learners, the call here is to identify ways in which informal learning activities could be integrated into schools to help learners shift their perceptions of their learning activities.

Future Directions for Research

This research was centered around the learners' experiences across the three articles. Less attention was paid in the analysis to the pedagogical practices and instruction for science and cultural-sensitive pedagogical practices enacted in the setting. Future research may consider and analyze the pedagogical practices that mediated students' perceptions and engagement within this out-of-school setting. Such work can explore ways certain pedagogical practices create educational possibilities for learners to think epistemologically, conceptually, and axiologically about science practices. The work also examined the students' perceptions and engagement with less attention on the quality of interactions between learners and educators. For instance, across the chapters, I illustrated examples that provide evidence for procedural and declarative knowledge, students' engagement in explanation and reasoning, moments of wonder, and engagement in interactions with others (in the classroom and as described by students with their families). However, I did not assess the quality of these types of engagement with science related activities. Indeed, such work is essential to better understand their experiences, and future work should consider such an analysis to support learners not only in doing science but also communicating science with peers and the public. This could be done through interactive engagement approaches (e.g., Chi & Wylie, 2014).

In this dissertation, I attempted to view educational phenomena through a sociocultural and political lens, however, less attention was paid to the settler-colonial broader reality of the study's context. Future research may consider designing and studying critical STEAM environments grounded in decolonial and critical pedagogy approaches (e.g., Tzou et al., 2019; Vakil, 2014) to explore and nurture ways of knowing Palestinian learners and their families when they engage in scientific and technological practices. This includes an attention to land, education about space and place, and history of science and technology in the contexts where they live. Such work not only can support learners to engage in dialogue with varied ways of knowing, but it will also help them transform their realities in ways that attend to their past, present and future.

Thirdly, a major motivation for me to join graduate school was my interest in the study and design of educational technology. I have been particularly interested in exploring the sociocultural and interactive aspects of students' engagement with technology (e.g., Mawasi et al., 2020). Such an understanding, I believed, would contribute to the design of equity oriented educational technology and collaborative learning environments mediated by technologies. I ended up in a very different pathway in this dissertation work. Little did I know that this pathway would also be so well connected to my major interests, especially the ways I realized the importance of ethics and values in science education and the power dynamics in learning environments. In relation to educational technology, this takes me to two places. The first is the importance of engaging students in understanding the ethical aspects of the technologies being intervened in their learning environments and everyday life through critical digital literacies. The second is methodologically reflected in approaches to study learning interactions with technologies. That is, considering the moment to moment interaction of students as they navigate their learning trajectories across distributed activity systems, designing ways to nurture students' individual and collective digital self-determination rather than structuring their interactions or collaborations to privilege certain types of participation or task behavior, and emphasize the role of educators and pedagogy in orchestrating such behaviors when learners interact with educational technology systems (e.g., Aguilera et al., 2020).

I close this work with words I came across during the first week of the first quarantine in March 2020, as I revisited Daring to Dream by Paulo Frerie (2007). While considering that education work has limits, he asserted the importance of nurturing learners and educators to transform their realities, acknowledging, “change is difficult, but possible.” Pedagogy and education can create possibilities for learners to develop tools and language that liberate learners and educators, however, in recognizing the limitations of education, I view an opportunity for more education work with learners and educators to happen. In dialogue between the research and practice implications, I view the importance of creating a space for critique and collaborative knowledge construction in research-practice partnerships. That is, our collaborations can create channels for exchanging feedback, expectations, and challenges to the existing status quo within research work and practice. And finally, our work must recognize the importance of analyzing and studying learning environments in ways that pay attention to the consequentiality of innovative interventions in educational settings (Bang & Vossoughi, 2016; Mawasi et al., 2020). Specifically, shifting from broadening access to STEAM activities for nondominant learners, towards an examination of the ends such work is conducted (Philip et al., 2018; Vossoughi et al., 2016), if and how such access enables learners to transform their realities (Freire, 2007), and attention to pedagogies and instructional approaches that nurture STEAM learning and learners' engagement with activities (e.g., Vakil, 2014; Vossoughi et al., 2020, 2021).

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APPENDIX A

SAMPLES OF QUESTIONS ASKED DURING SEMISTRUCTURED INTERVIEW

- **General questions**

  What is your favorite topic at school? How often do you go to the library? Have you visited a museum before? Did you share these activities with your family, siblings, or friends?

- **Questions about the artifacts**

  What was your goal joining this program? How would you describe what you did in this activity to your friends at school? What was your favorite activity? What was your least favorite activity? What was your favorite part of this activity? What would you improve in the activity design? Did you feel successful doing this activity? How do you see this activity in your everyday life? How would you use it? What do you think you learned doing this activity? What challenges did you have doing this activity? Do you think this activity is art or science?

- **Learners' perceptions of scientists, artists, engineers, and inventors (SAEI)**

  what do you think the characteristics of scientists, artists, engineers, and inventors are? (Learners were asked one role at a time.) Among these four, what did you feel doing this activity? Or When you did this activity did you feel like a scientist, artist, engineer, or inventor? Let's imagine you are an inventor; how would you improve or enhance this activity? Which one of these activities made you feel like scientists, artists, engineers, or inventors?

- **Responsibility** in doing activities to understand their ethical thinking. Example of a question: *Imagine your invention caused an issue in your house. Who would be responsible for that*?

- The final stage of the interview was allocated for walking through items from the pre-post survey that students answered during the four-day program. Students were not asked to recall how they answered previously but were asked the questions anew in order to elicit explanations for their answers and further explore their perceptions of the pre-posttest items (see APPENDIX B for examples of examples of science self-efficacy items).

APPENDIX B

SCIENCE SELF-EFFICACY ITEMS IN ENGLISH AND ARABIC

Self-efficacy items used in pretest, posttest, and asked as anew by the end of the interviews with each student.

Items in English

	Science Self-efficacy	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
1	I can learn science easily				
2	I can solve problems by doing a science experiment				
3	I can use science to solve problems in everyday life				
4	If I have questions about science, I can easily find the answers				
5	I can do science well.				

Items translated to Academic Arabic

غير موافق مطلقا	غير موافق	موافق	موافق جدا	يمكنني تعلم العلوم بسهولة
غير موافق مطلقا	غير موافق	موافق	موافق جدا	يمكنني حل المشاكل عن طريق عمل تجارب علمية
غير موافق مطلقا	غير موافق	موافق	موافق جدا	يمكنني استخدام العلوم لحل مشاكل في حياتي اليومية
غير موافق مطلقا	غير موافق	موافق	موافق جدا	إذا كان لدي سؤال حول العلوم يمكنني بسهولة أن أجد الإجابة
غير موافق مطلقا	غير موافق	موافق	موافق جدا	5. أنا أستطيع أن أفعل فعاليات علمية بشكل جيد

APPENDIX C

UNIVERSITY HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL DOCUMENT

APPROVAL: EXPEDITED REVIEW

Ruth Wylie
Division of Educational Leadership and Innovation - Tempe
480/727-5175
Ruth.Wylie@asu.edu

Dear Ruth Wylie:

On 12/15/2019 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Participation and Engagement in Informal STEM Activities in a Community-based Program
Investigator:	Ruth Wylie
IRB ID:	STUDY00011170
Category of review:	
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Arabic_pre_post, Category: Translations; • Interviews, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • irb-protocol-1210, Category: IRB Protocol; • letter_From_org, Category: Other; • Parents_Consent_V2, Category: Consent Form; • post_activity_survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Pre_post_English, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Recruitment, Category: Recruitment Materials; • Social_Media_Ad, Category: Recruitment Materials; • Verbal_Assent, Category: Consent Form;

The IRB approved the protocol from 12/15/2019 to 12/14/2024 inclusive. Three weeks before 12/14/2024 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 12/14/2024 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the “Documents” tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Arej Mwassi
Rod Roscoe
Arej Mwassi
Elisabeth Gee