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Stakeholders' Conceptions of STEM and Elementary STEM Clubs Within a Community-University Partnership

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ABSTRACT

Informal community-based science, technology, engineering, and mathematics (STEM) clubs provide rich informal learning environments that help elementary-aged students develop STEM knowledge and skills while fostering their initial and continued interests in STEM. This phenomenographical case study sought to interpret stakeholders' (five university personnel, two club facilitators, one teacher, one parent, and three elementary students) conceptions of STEM and STEM clubs involved in a community-university partnership in an afterschool elementary STEM club at a community center. Phenomenographic analyses produced three hierarchical categories in stakeholders' conceptions of STEM: an indifference towards STEM, viewing STEM as a holistic discipline, and STEM as applicable and useful in life. Among stakeholders' conceptions of STEM clubs, four hierarchical categories described clubs as a non-STEM related space, a means to promote STEM, provide STEM learning, and an additional site (apart from school) to produce STEM knowledge, skills, and enjoyment. Findings suggest that community and university stakeholders held varying conceptions of the purpose of STEM, with the strongest disagreement in how informal STEM clubs should be structured. Stakeholders nonetheless agreed that STEM clubs were vital resources to promote STEM and enhance STEM-related life and soft skills.

Keywords: community-university partnerships, elementary education, informal education, phenomenography, STEM clubs

Introduction

The National Science Foundation, among other national level educational organizations, has lauded that club-based science, technology, engineering, and mathematics (STEM) *informal* (per Eshach, 2007) experiences enhance STEM learning and affect for K-12 students. The National Research Council's (NRC, 2015) report on *Identifying and Supporting Productive STEM Programs in Out-of-School Settings* found that K-12 students spend only 20% of their waking hours in school, where the remaining 80% spent outside of school could include participating in cooperative STEM learning activities (p. 8). Further, the NRC stated that STEM clubs can contribute to students' success in STEM by providing hands-on learning activities with peers to develop both cognitive (content knowledge, academic) and non-cognitive (soft skills, affective) skills, supplementing STEM learning and enjoyment unmet due to the constraints (e.g., time, curriculum, space) of the formal K-12 STEM classroom. Related research affirms the NRC evidence that students who participate in STEM clubs have improved achievement in cognitive and non-cognitive domains (Blanchard et al., 2017; Hite et al., 2018;Hite & White, 2019, 2021; Sahin, 2014) and persistence in STEM (Gottfried & Williams, 2013). Given that STEM interests can be cultivated as young as the elementary level (Bybee & Fuchs, 2006), access to STEM clubs among primary students is desired among many communities looking to provide younger students access to STEM outside of the classroom (DeJarnette, 2012), where science and math subjects receive the least amount of instructional time (Blank 2012; Lavy, 2010). Since these activities occur outside of school, community partnerships (with local universities) can help design and implement STEM clubs to improve outcomes for K-12 students, especially those that are under resourced and may not have access to rich, out-of-school science experiences (Duodu et al., 2017).

This paper describes a community-university partnership (CUP) formed between local K-12 educators and a research-oriented university with a mutual aim to improve elementary STEM education through afterschool STEM clubs. We define this CUP as "collaborations between *community* organizations and institutions of higher learning for the purpose of achieving an identified social change goal through *community*-engaged scholarship that ensures mutual benefit for the community organization and participating students" (Curwood et al., 2011, p. 16). The STEM club in this case study was developed internally (by university faculty and staff), in consultation with technical assistance from the research literature, and with input from the community partners (i.e., day of week, age group of interest). This relationship is a step in the right direction, as per the NRC report, "research is needed to better specify and understand the ways in which learning develops across formal and informal settings, [especially in] leveraging community resources and partnerships" (NRC, 2015, p. 29).

In order for the CUP to reach its mutual goals, it is vital that the community stakeholders understand the premise of the CUP and its intended utility (Curwood et al., 2011). Doing so not only provides greater input to the design and implementation process (of STEM Clubs), but also to amplify the importance of STEM for elementary aged learners in the community. As such, a community's understanding in or value of STEM clubs or the premise of STEM itself is necessary. Therefore, the purpose of this study was to explore community stakeholders' conceptions of STEM and STEM clubs. By exploring the understandings and expectations of the CUP STEM community, we may foster more productive relationships between stakeholders and these informal STEM programs. The outcomes of this study will be used to inform current and future STEM club programming so we may better leverage CUP stakeholder input and resources to enhance our local pipeline of STEM savvy elementary students.

Literature Review

Definitions and conceptions of STEM are diverse and vague (Bybee, 2010), influencing researchers to explore a more definitive answer to *What is STEM?* There is a growing body of literature that showcases conceptualizations of STEM from specific groups of the STEM ecosystem. For instance, Breiner et al. (2012) found that university faculty and staff have differing conceptions on STEM, depending on the relevance and impact that STEM has on their personal and professional lives. Further, they described how university personnel, especially non-STEM faculty, were more indifferent towards STEM. Most faculty—STEM faculty included—viewed STEM in its individualized disciplines rather than as a holistic whole. Classroom teachers also hold similar conceptions of STEM but have shown to lean more towards integration when immersed in effective STEM education professional development (Ring et al., 2017), or compelled by integrated standards (NGSS Lead States, 2013). Research has shown that afterschool STEM club facilitators—who may not necessarily be certified classroom teachers—possess strong STEM identities due to the authentic, real-world STEM activities they plan and implement in STEM clubs (Aslam et al., 2018). Much of their conceptions on STEM clubs involve the development of students' technical STEM skills and helping students to ground theoretical knowledge in real life applications. Thus facilitators with passion for and commitment to the STEM club is fundamental to its long term success (Blanchard et al., 2017). Regarding facilitation, Davis et al. (2023) concluded from a systematic literature review of studies on STEM clubs that

> the literature highlights that STEM clubs should be facilitated in a way that is driven by student interest, moves outside of the traditional teacher role, and nurtures in participants the ability to enact peer teaching roles or consider being a possible future facilitator. STEM clubs offer facilitators more flexibility, creativity, and innovation in their teaching than is possible in a more traditional classroom context. (p. 11)

Parents are generally unsure about what STEM means or entails, but nonetheless see the importance and value in learning STEM for their children's future careers (Hernandez et al., 2016). Students' conceptions of STEM, on the other hand, are dependent upon the exposure they receive from parents (Plasman et al., 2021; Tay et al., 2018), formal learning experiences in the K-12 classroom (Mullet et al., 2018), and in the community from informal learning opportunities (Afterschool Alliance, 2015). While a concrete definition has yet to be agreed upon among both researcher and practitioner groups (Radloff & Guzey, 2016), considering how all those involved in the STEM ecosystem (inclusive of parents and students) conceptualize STEM would paint a broader picture of what informal STEM learning is or should be, fostering greater understandings of STEM.

One way to capture community stakeholders' conceptions of STEM are through non-compulsory (compared to formal or school) involvement in STEM, like informal, afterschool community-based STEM clubs. Afterschool STEM clubs have proven to be effective spaces for K-12 students to learn and engage in STEM skills and knowledge not typically learned in the formal classroom setting (Afterschool Alliance, 2015). STEM clubs in the afterschool setting provide access and exposure to STEM students that build critical thinking and problem-solving skills, as well as enhance interest and enjoyment in STEM especially at the elementary level (Ching et al., 2019; Sahin et al., 2014).

Furthermore, research has shown that engaging in STEM clubs involved in a CUP, in particular, have a myriad of benefits for all those involved in the partnership (Hite et al., 2020, 2023; Foster et al., 2010). Multiple studies have showcased community stakeholders—teachers, parents, and students—as well as university personnel having positive outcomes in bilateral learning and understanding of STEM (see Allen et al., 2019; Hite & White, 2022; Playton et al., 2021, 2023; NRC, 2015; Tay et al., 2018; Toma & Greca, 2018). Thus, we find it imperative to study and understand community stakeholders' conceptions of STEM and STEM clubs, doing so through a theoretical framing that permits interpretation on how individuals develop meanings and variation from their understanding (of STEM) and experiences (of/in STEM clubs).

Theoretical Framework

To explore varying understandings and experiences among a group, this study employed the theoretical aspects of phenomenography. Phenomenography initially emerged as an empirical rather than a theoretical or philosophical tradition (Marton, 1981), and was initially viewed solely as a methodological practice (Åkerlind, 2012). However, since phenomenology was first established, Marton (1986) has clarified that phenomenography also undertakes theoretical and ontological perspectives as it provides a model to answer questions about thinking and learning. Since then, phenomenography has been used in various other studies as theoretical or conceptual lenses in addition to a qualitative research design (see Andretta, 2007; Cope, 2004; Ornek, 2008). In phenomenography, learning can be viewed in two different lenses, as first-order and second-order perspectives (Marton, 1986). In a first-order perspective, learning is viewed from the researcher's perspective, specifically how the phenomenon of study is related to their worldview and their understanding of reality. Whereas, learning from a second-order perspective is centrally focused on the ways the participants' experiences (of a phenomenon) mediate their understanding and conceptions (of said phenomenon). For instance, research in best practices on learning STEM is largely viewed from a first-order perspective, whereas studies that examine the ways in which participants experience STEM learning is indicative of the second-order perspective (e.g., Gandhi-Lee et al., 2017; Mullet et al., 2018). This second-order perspective is useful to CUP research to ensure the voices of non-research stakeholders are duly represented.

Perhaps the most significant tenet of phenomenography is its non-dualistic ontology, meaning that a participant's experienced world is neither constructed nor imposed on by the participant, instead it theoretically exists as an internal relationship between the participant's understanding of the phenomena and their experiences with the phenomena (Marton & Booth, 1997). Given the different ways of experiencing a phenomenon, this theory permits modeling of experiences, among very different people, within the same phenomenon. In using phenomenology as a theoretical lens to undergird a study, "the researcher aims to constitute not just a set of different meanings, but a logically inclusive structure relating the different meanings" (Åkerlind, 2012, p. 323). Using phenomenology in this study allowed us to capture the varying definitions and divergent conceptualizations of STEM among different stakeholder groups involved in STEM education. This theoretical perspective compensates for assumptions made in the aforementioned research that all stakeholders involved in STEM clubs share a common understanding of STEM and expectations for out-of-school STEM learning. Thus, a dearth of research remains on how various CUP (community and university) stakeholders conceive of the purpose of STEM and envision students' participation in such clubs.

Without knowledge of how all stakeholders conceptualize STEM and STEM clubs (phenomena of interest), CUP STEM clubs will be unable to reach their full potential in meeting the mutual aims of the university and community in bolstering K-12 STEM learning. In that regard, understanding how CUP stakeholders conceptualize STEM learning via experiences in and conceptions of CUP-based STEM clubs could help inform best practices and improve informal STEM learning spaces for students in the community. Guided by this research approach of phenomenography in the context of this study, this study addresses the following research question: *How do stakeholders involved in a CUP-based elementary STEM club conceptualize STEM and afterschool community STEM clubs?*

Method

Given the duality of phenomenography as a theoretical framework and methodological approach, this study utilized phenomenography as method to "produce an objective, qualitative description to represent the way that individuals perceive reality" (Alsop & Tompsett, 2006, p. 245). Qualitative accounts of stakeholders' conceptions of the phenomenon of STEM and STEM clubs were examined collectively from the sets of participants (stakeholder groups), as opposed to analyzing data from individuals. These accounts, taken from the set of participants, are then organized into what are known as *categories of description*, the primary outcomes of phenomenographic research. While variations exist in the extent to which categories of description are organized (Åkerlind, 2012), the process is both iterative and comparative. Multiple rounds of sorting and grouping are necessary, in addition to comparisons between various participant accounts, as well as between distinct categories of description themselves. Furthermore, a significant premise of these categories is that they are structured in a logical manner, typically hierarchically. This structured and logical set of organized categories form a field that is known as an *outcome space*, wherein "the outcomes represent the full range of possible ways of experiencing the phenomenon in question, at this particular point in time, for the population represented by the sample group collectively" (Åkerlind, 2012, p. 323).

Elementary STEM Club Framework and Context

The conceptual framework for the elementary STEM club in this study was guided by the NRC report's (2015, p. 15) three factors that foster productive STEM club programs: 1) Productive programs engage young people intellectually, socially, and emotionally (e.g. first-hand experiences with phenomena and materials, engaging students STEM practices, and establishing a supportive learning community); 2) Productive programs respond to young people's interests, experiences, and cultural practices (e.g., position STEM as socially meaningful and culturally relevant, support collaboration, leadership, and ownership of STEM learning where staff are co-investigators and learners alongside young people); and 3) Productive programs connect STEM learning in out-of-school, school, home, and other settings (e.g., connect learning experiences across settings, leverage community resources and partnerships, and actively broker additional STEM learning opportunities).

The STEM Club for this present study consisted of university (i.e., faculty, staff) and community (i.e., parents, teachers, students) stakeholders of a local STEM club established through a CUP at a large southwestern research university. The CUP-based STEM club in this research is one among 10-15 active STEM clubs established and led by the university. This STEM club takes place at a local community center, which is unique because most STEM clubs occur at the school location and are not at the elementary level in this community. Participating students mirror the demographics of the community center, as predominantly Hispanic and classified as low socioeconomic status. Approximately twelve elementary students (grades K to 5, four males and eight females) participated in the STEM club, which met once a week for the duration of one typical calendar school year (approximately thirty-six weeks). Activities and content of the STEM club included weather, probability, and algebraic logic. Mobile tablets (iPads) were also used and incorporated into these activities at least once a month.

Participants

Selection of participants in phenomenography research was purposive in that the approach sought to glean participants' conceptions of a phenomenon; in this particular context, defining STEM and conceptualizing STEM clubs. Some phenomenographic researchers suggest a sample size between ten and thirty participants (Mullet et al., 2018; Ornek, 2008). However, other studies have indicated a variation of small and large sample sizes (Gandhi-Lee et al., 2017; Limburg, 2008; Velasco & Hite, 2022).

In total, twelve participants were recruited for this study. As this study sought to analyze the collective conceptions of STEM learning via a community STEM club, it was necessary to sample various participants who encompassed the CUP of this STEM club. The twelve participants in this study consisted of five stakeholders from the community—three students (S1, S2, and S3), one parent (P), and one elementary classroom STEM teacher (T)—and seven stakeholders from the university—staff and faculty personnel (UP1, UP2, UP3, UP4, and UP5) that included the two STEM club facilitators (CF1 and CF2) who were not current classroom teachers. Notably, CF1 had been a mathematics teacher, nationally board certified in early adolescent mathematics and received national recognition for excellence in K-6 mathematics teaching. CF2 held no prior or current teaching credentials. Aside from two university faculty and the elementary STEM teacher, all participants in this study were directly affiliated with the CUP STEM club of study, meaning sampled students were participants in the STEM club, the parent participant was a parent of a STEM club student, community center facilitators assisted with the STEM club, and the three university faculty coordinated and established this specific STEM club as examples. Table 1 describes demographics of participants in this study.

Table 1

Community Stakeholder Participant (n=12) Demographics

Stakeholder	Sex	Ethnicity	Notes
University Personnel (UP)			
UP1*	M	White	Associated with CUP STEM club in this study
UP2**	F	White	Not associated with CUP STEM club in this study
UP3**	F	White	Associated with CUP STEM club in this study
UP4*	F	White	Not associated with CUP STEM club in this study
UP5*	F	White	Associated with CUP STEM club in this study
Club Facilitator (CF)			
CF1	M	Pacific Islander	Facilitator of STEM club and university researcher
CF2	F	Hispanic	Community center overseer of CUP STEM Club
Teacher (T)			
T1	F	Hispanic	Elementary STEM teacher with a focus on science
Parent (P)			
P1	F	Hispanic	Parent of S1, child participant in CUP STEM club
Student (S)			
S1	M	Hispanic	3rd grade student participant in CUP STEM club
S2	F	Hispanic	3rd grade student participant in CUP STEM club
S3	F	Hispanic	4th grade student participant in CUP STEM club

Note. M = male. F = female.
*University faculty
**University staff

Data Sources

The primary source of data for this study were one-time, in-depth, semi-structured interviews with each of the participants. All researchers (i.e., authors of this article) participated in the creation of the interview items, as they related to the tenets of phenomenography in terms of seeking participants' conceptions of STEM learning via informal STEM clubs (see Appendix A for protocols). Literature from the *Informal Learning Report* (National Academy of Engineering & National Research Council, 2014) and Funds of Knowledge framework (Moll et al., 1992) were consulted in protocol development to inform question design that related to STEM understandings and the relevancy of STEM, respectively. Interview items queried experiences along the same themes of a community STEM club and STEM learning in general across all interviews, although interviews were slightly modified based upon the interviewee. Interview questions were simplified to ensure that items were comprehendible for the students, but nonetheless followed the same line of inquiry regarding their conceptions of the STEM club they were participating in and their experience in STEM learning in general. The student participants were interviewed for about fifteen minutes, and the adult participants were interviewed for about thirty minutes. All participants were interviewed about one month after the start of the STEM club, and all interviews were audio-recorded. The online interview transcription application, Otter (2020), was used to transcribe all interviews. Transcriptions were then audio reviewed thoroughly to verify interview segments that were erroneously transcribed from the software.

Analysis

There is not one prescribed technique in analyzing phenomenographic research, as different phenomenographers employ a variation of frameworks from one study to the next (Åkerlind, 2012). Retrospectively, Marton (1986) argued that there are no specific algorithms to discover conceptions of a phenomenon, rather just a proposed set of guidelines to employ when evaluating participants' understandings of a phenomenon. His recommended guidelines are conducted in the following phases: (1) selection of utterances based on criteria relevance—the group of utterances formed from this selection is referred to as the *pool of meanings*; (2) interpretation of the pool of meanings; (3) sorting and arranging utterances into categories of description; (4) differentiating between and refining categories; and finally, (5) defining categories with supporting quotes. Marton's suggested guidelines for phenomenographic analysis was adopted and followed stepwise as the analytical framework for this study.

The first phase of analysis involved the selection of utterances from each interview transcript regarding participants' conceptions of STEM and STEM clubs. Utterances were typically one to two sentences in length and included segments or partial phrases stemming from sentences. This was to ensure that sentences with multiple meanings could be analyzed and represented in the data set as such. The extracted utterances from the transcripts were grouped together, without any stakeholder designations, in a separate file forming a pool of meanings (of 240 utterances) for preliminary coding.

The second phase involved interpretation of the pool of meanings, which also consisted of writing memos to find similarities and differences among utterances, both as a whole (dataset) and as they related to the transcripts. Analysis proceeded to the third phase to sort and rearrange utterances into categories of description. Utterances were first grouped into preliminary categories across the pool of meanings based on similarities. Moreover, analysis of collective meanings across the data was a focal point when grouping the utterances into the preliminary categories. For example, the utterances 'I think that imparting knowledge about how STEM is applied in the world today is integral in a STEM club' and 'I feel like a stem club should teach them things that they're not necessarily going to experience, whether its whole to kind of expand their learning and their knowledge' were sorted into a preliminary category called 'STEM exposure.'

If utterances diverted or differed from those within existing preliminary categories, a new category was created. In a few instances, utterances were dropped completely due to the irrelevance to the data as a whole. Twenty-eight utterances were uncategorized and therefore dropped, resulting in the final remaining 212 utterances sorted into seventeen preliminary categories (see Appendix B). The fourth phase of the analysis involved differentiation and refinement and involved a more focused view on relationships among and between the preliminary categories. As a result, some preliminary categories were combined, consolidated, or collapsed depending on the collective meanings across the utterances, resulting in seven hierarchical categories. Finally, the fifth and final phase of the analysis involved assigning definitions and supporting quotes to each of the core categories. Sub-category coding was performed to provide greater visualization of the utterances associated with the larger categories. Stakeholder designations were added back to the coded utterances for data visualization purposes. The tiered categories and their explanations, with supporting quotes, are provided in the results section.

To ensure trustworthiness of the analyses in qualitative phenomenographic research, communicative checks (Kvale, 1996) were carried out to verify the research methods and interpretations of the data with other members of the research community. As such, the first author of this study employed bracketing (as explained previously) by examining and evaluating presuppositions of the phenomenon of study (i.e., what is STEM and STEM clubs), documented these processes through audits (see Appendix A and Table 1), and verified categories of description with the co-author, a member of this research community. Pragmatic validity checks were also employed to ensure the usefulness of the outcomes of the study (Kvale, 1996). As such, this study also serves as a response to NRC's (2014) call to improve STEM learning in informal learning spaces by involving all stakeholders' conceptions (rather than single groups) in CUP-based STEM clubs. Regarding trustworthiness in interview analysis, authors combined data, stripping off the stakeholder designations in creating the pool of meanings and developing categories. This process was repeated until final categories were established. Researchers (i.e., authors of this article) also met monthly to discuss data and analytical methods, as well as shared data over a secure online database. Last, the second author double coded the data set analyzed by the first author for full agreement.

Results

Stakeholders' Conceptions of STEM

Completion of analysis resulted in an outcome space of three hierarchical core categories of description (fifty-one utterances), which were labeled as follows: Category (1) *Indifference Towards STEM* with fourteen utterances; Category (2) *STEM as a Holistic Discipline* with eleven utterances; and Category (3) *Applicability and Usefulness of STEM* with twenty-six utterances. Table 2 defines these core categories of description for stakeholders' conceptions of STEM, supported by examples of utterances extracted from the data across this outcome space.

Table 2

Core Categories of Description for Stakeholders' Conceptions of STEM

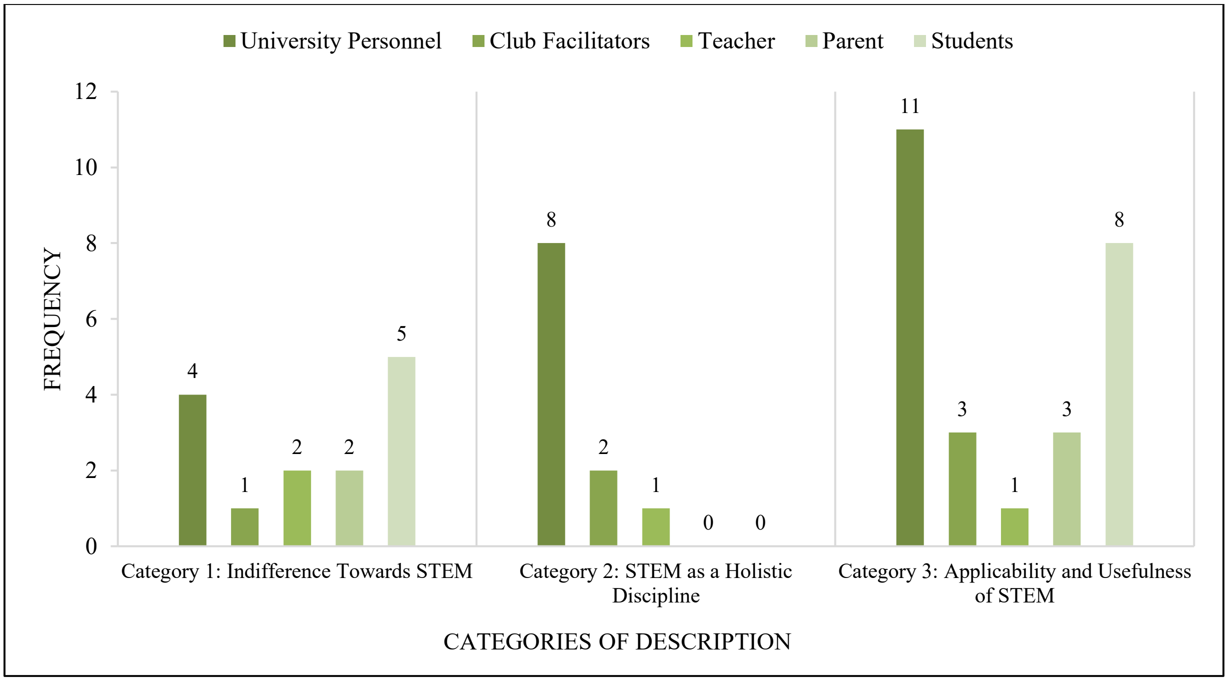
Core Category	Definition	Examples of supporting quotes (utterances)
Category 1 (*n* = 14) Indifference Towards STEM	Stakeholders had no knowledge of understanding of STEM or considered STEM in its individual disciplines or merely an acronym.	UP1: "…in STEM, I feel you need to be in one of the four disciplines of science, technology, engineering and mathematics." T: "I know what it stands for: science, technology, engineering and math and just having kids to be able to apply those four things in."
Category 2 (*n* = 11) STEM as a Holistic Discipline	Stakeholders' conceptions of STEM were that the disciplines were integrated or interrelated in some aspect.	UP2: "I think it's more integrated. I think that they all overlap. I think it's hard to do any of them without the other." CF1: "…STEM implementation is addressing a problem through the use of interdisciplinary skills in STEM."
Category 3 (*n* = 26) Applicability and Usefulness of STEM	Stakeholders conceptualized STEM as applicable and useful in real-life situations for home, school, and for the future.	UP4: "I would stress STEM is everywhere – and everyone is active in STEM, even if it is not framed as STEM." P: "Things that will benefit them in school." S3: "You need help like in engineering. What if you build a car? You need help? You can't do that all by yourself."

Note. UP = university personnel, CF = club facilitator, T = teacher, P = parent, S = student.

Next, Figure 1 displays a frequency chart of utterances per tiered category by stakeholder group on their conception of STEM.

Figure 1

Frequency of Utterances Per Tiered Category by Stakeholder Group on Their Conception of STEM



More utterances were captured from community stakeholders as compared to university-affiliated personnel for Category 1, with data from students comprising the highest frequency of utterances regarding their indifference towards STEM. The reverse was true for Category 2 and Category 3 in that university personnel provided more utterances than community stakeholders about STEM being a holistic discipline and its applicability and usefulness. No utterances were captured from the students or the parent for Category 2, suggesting they did not conceptualize STEM as a holistic discipline. The sections following Figure 1 provide descriptions of these categories, elaborating further as to what distinguished higher-tiered categories from the previous categories, as well as differences in conceptions between university and community stakeholders.

Category 1: Indifference Towards STEM

Fourteen utterances were assigned from the pool of meanings to this category of description. Findings from the data revealed that community stakeholders' conceptions of STEM were indifferent, as they did not know what STEM was or learning STEM was a priority. For example, two out of the three students indicated that they had never heard of STEM, while S3 communicated that she had "forgot what [STEM] stands for." The interviewed parent also articulated that she did not know the meaning of STEM, but that she was "getting a little bit from what [her son was] learning." Other stakeholders knew STEM merely as an acronym, as the interviewed teacher declared, for example, "I know what it stands for: science, technology, engineering and math and just having kids to be able to apply those four things in." Others mentioned STEM in reference to learning one of the individual disciplines (i.e., science, technology, engineering, or mathematics), rather than STEM as a whole. For instance, one of the university faculty members, UP1, asserted that "the pure definition can be in STEM, I feel, you need to be in one of the four disciplines of science, technology, engineering, and mathematics. So, like when we talk about the STEM disciplines, if you're studying biology, you're a

STEM student." The same sentiments were also echoed by two other university faculty members: UP2 and UP3. Meanwhile, one of the STEM club facilitators, CF2, articulated that "STEM is more science and math-based learning," without mentioning any regard to the technology or engineering components.

Category 2: STEM as a Holistic Discipline

Eleven utterances from the data pool were assigned to this category of description. Some stakeholders' conceptions of STEM differed from those articulated in Category 1 in that STEM was seen as an integrative and holistic discipline or a combination (i.e., multidisciplinary) of at least two of the individual STEM disciplines. All five university faculty members in this study referenced STEM as holistic or multidisciplinary. For example, UP4 stated, "when combined in the STEM fashion, there is an iteration and use of the shared relationships (among their respective knowledge, skills, or practices) that allow us to explore more convergence-based issues." Similarly, one of the community STEM club facilitators, CF1, articulated the synthesis among individual disciplines of STEM in tandem with other non-STEM related skills, stating that "STEM implementation is addressing a problem through the use of interdisciplinary skills in [each discipline of] STEM in conjunction with other cognitive and behavioral skills such as critical thinking, effective collaboration, clear and precise discourse, etc." The elementary STEM teacher also acknowledged the integration of STEM being necessary, whereas no utterances of integration or combination of disciplines were found among the interviewed parent and students of this study.

Category 3: Applicability and Usefulness of STEM

Category 3 constituted the largest amount of references made for this category of description, having a total of twenty-six utterances. The difference here between Category 2 and Category 3 in this outcome space is in regard to the applicability and usefulness of STEM. At Category 3, community stakeholders' conceptions of STEM were beyond that of merely learning the concept at the surface or definitional level. Due to nuanced variances of the twenty-six utterances within Category 3 of stakeholders' conceptions of STEM, three subcategories were formed to delineate the variation shown by stakeholder group. The three subcategories of Category 3 were related to the importance of learning STEM at home (n = 5), for school (n = 7), and their future (n = 14).

Subcategory of home-based skills. Five utterances were included in the data pool that were in reference to STEM learning that was attributed with home life. One utterance from UP3 in reference to applicability of STEM at home stated, "…taking things that they're learning in school and then figuring out how to apply them in a unique and exciting way." The remaining four utterances were from student participants on the ways they perceive STEM to be applied at home, referencing helping a parent with gardening (S2) and taking out the trash (S1) as STEM-related.

Subcategory of school-based skills. Utterances were also captured in regard to STEM learning that occurs in school. Five utterances described the learning of STEM soft skills in school that covers a wide array of disciplines including those outside of STEM (i.e., the humanities), while three utterances described the learning of STEM non-specific skills. An example of STEM soft skills, as referenced by UP5, include "working together, writing, speaking skills – in which they had to share their learning experiences with others." An example of a non-specific skill, like helping classmates in STEM, was described by S3.

Subcategory of future skills. Thirteen utterances from stakeholders related STEM applicability and usefulness in future skills. Four utterances described stakeholders' conception of STEM as a means for social advancement speaking to the inclusivity of STEM learning, as CF1 stated, "anyone and everyone is capable in learning STEM." STEM was also related to skills performed by those who worked in STEM disciplines; UP5 mentioned that "some individuals may define STEM as what I would describe as 'high-brow' STEM, referencing what scientists, engineers, and mathematicians do daily, probably in a work-setting." STEM was also related to the theme of money, with S1 making reference to an online game he played and perceived to have STEM-related content: "Then you get to make a character, and you have a lot of money." Another four utterances were coded as stakeholders' understandings of STEM as critical for success in future work. For instance, UP5 asserted that "knowledge in research and/or evaluation design is fundamental" in regard to STEM learning, while CF1 declared that "kids need to see the importance of the work that they are doing in STEM. Three utterances were in reference to the applicability and usefulness of soft skills in STEM. This subcategory involved stakeholders' conceptions of STEM as it related to soft skills that can be applied both in an out of school. For instance, S3 spoke to the importance of collaboration in STEM, and how it may be used to assist others: "how to work together, okay, and how to like help others whenever they need help." Last, commonalities in three utterances referenced other non-specific skills, focusing on the versatility of STEM for learning. For example, UP4 contended, "I would stress STEM is everywhere – and everyone is active in STEM, even if it is not framed as STEM."

Stakeholders' Conceptions of STEM Clubs

In regard to stakeholders' conceptions of STEM clubs, there were four hierarchical core categories which were labeled as follows: Category (1) *Non-STEM Related Space* with seventeen utterances; Category (2) *Promotion of STEM* with fifty utterances; Category (3) *STEM Club Learning Environment* with fifty-nine utterances; and Category (4) *Production Site of STEM Knowledge, Skills, and Enjoyment* with thirty-six utterances. Table 3 defines these core categories of description for stakeholders' conceptions of STEM Clubs, supported by examples of utterances extracted from the data across this outcome space.

Figure 2 displays a frequency chart of utterances per tiered category by stakeholder group on their conceptions of STEM clubs, highlighting differences in conceptions between university and community stakeholders. More utterances were captured from university-affiliated stakeholders than community stakeholders across all four categories. Utterances from all participants were captured in Category 1 and Category 2 regarding after school clubs being a space for non-STEM related activities and spaces that promote STEM, respectively. There were wide gaps in the frequencies of utterances between university-affiliated stakeholders and community stakeholders for Category 2 and Category 3, with university stakeholders making more utterances about the learning environment of STEM clubs. Although Category 4 still had more utterances captured from university-affiliated stakeholders, the gap among frequency differences was narrower between both groups, with student participants having about the same number of utterances as university personnel. Core categories 2, 3, and 4 were also coded into subcategories to delineate nuanced variances between utterances for data visualization. The four core categories in this outcome space are further described in the sections that follow.

Table 3

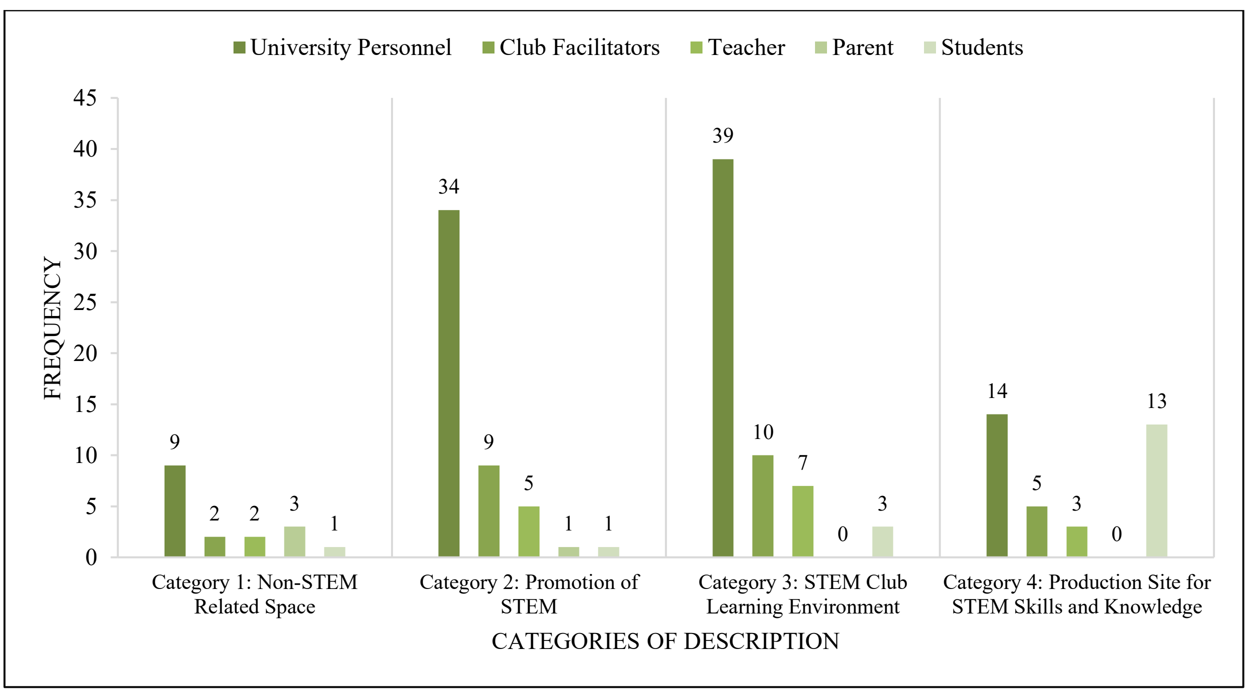
Core Categories of Description for Stakeholder's Conceptions of STEM Clubs

Core Category	Definition	Examples of supporting quotes (utterances)
Category 1: Non-STEM Related Space	Stakeholders conceptualized community STEM clubs as a safe space for students, regardless of content	P: "It's just something to do for fun." T: "It turned out to be a great thing for my higher thinkers for sure. [It] helped them emotionally because they would get frustrated."
Category 2: Promotion of STEM	Stakeholders conceptualized community STEM clubs as a space that provides students access to STEM, STEM professionals and careers, and STEM possibilities, or affect, for enhancing learning, inclusivity, and relevancy.	UP3: "The goal is to engage the average students that maybe don't have every other opportunity to engage with STEM." CF2: "I definitely noticed that the kids are excited to go to both the science and math clubs."
Category 3: STEM Club Learning Environment	Stakeholders conceptualized community STEM clubs as spaces that lie along the continuum of free choice STEM learning environments	CF1: "STEM clubs do not necessarily need to promote a static curriculum, although I do not see a problem to do so." S3: "At school like we don't have that many activities. But here it's fun because like, we do different activities for the math."
Category 4: Production Site of STEM Knowledge, Skills, and Enjoyment	Stakeholders conceptualized community STEM clubs as hubs that produce STEM knowledge, skills, and enjoyment of STEM within the club.	UP1: "You want an opportunity to expose the students to science and an opportunity to think critically, and to explore." S1: "We made tornadoes and stuff."

Note. UP = university personnel, CF = club facilitator, T = teacher, P = parent, S = student.

Figure 2

Frequency of Utterances Per Tiered Category by Stakeholder Group on Their Conception of STEM Clubs



Category 1: Non-STEM Related Space

Among the utterances assigned to Category 1, stakeholders in the CUP indicated that STEM clubs serve other purposes in addition to STEM-related content or activities. For instance, CF1 explained that in some cases, a STEM club is "a safe learning space for students who need to be kept occupied outside of normal school hours." This sentiment was also echoed in the interview with the parent participant, as she stated, "I think it's really good to have something [for the kids] to do," alluding to the fact that she was unable to pick up her son after school because she would still typically be at work at those hours. Furthermore, stakeholders indicated that the STEM club afforded an opportunity for students to establish rapport with adult mentors as role models. UP2 expressed, "If something's, you know, heavy on their mind, and it might not have anything to do with STEM, we can form those relationships with those kids."

Category 2: Promotion of STEM

Assignment of utterances for Category 2 pertained to STEM clubs as spaces that allow for the promotion of STEM. Category 2 is differentiated from Category 1 in that there were indications of STEM-related utterances to stakeholders' conceptions of STEM club, that these spaces provide a sense of direct or indirect exposure to STEM, specifically for underrepresented populations. As the teacher participant declared, STEM clubs are "exposing [kids] to things that they're not used to seeing or kind of being stretched in ways they're not used to thinking." However, due to the voluntary nature of the community STEM clubs, there are still challenges in recruiting critical learners. UP3 elaborated that "we kind of get the, you know, not the rock star students, not the lowest performing students, but somewhere kind of in between." Nonetheless, there is evidence that what is learned in STEM clubs is also being promoted at home, as the parent participant shared that her son "comes [home] to talk about what he's learned, like math, or like the science that's going on at the community center."

The utterances in Category 2 were further divided into subcategories to further capture how STEM is promoted through the club according to stakeholders' conceptions. Subcategories in Category 2 were in descending number of utterances: the inclusivity that STEM affords (n = 13); generating positive affect towards STEM through enjoyment and attitudes (n = 12), as well as cultivating interest and motivation (n = 8); gaining access to STEM professionals and careers (n = 10); engaging in STEM learning and enrichment (n = 8); garnering a relevancy of STEM (n = 4); and understanding of what is STEM (n = 2).

Category 3: STEM Club Learning Environment

Most utterances in regard to stakeholders' conceptions of STEM clubs were assigned to Category 3 which involved references to the STEM club learning environment. Utterances in Category 3 differed from Category 2 in that their attention was focused on the level of curriculum-based teaching that occurs within the STEM club. Utterances from the data revealed conflicting views within and between community members and university-affiliated personnel.

For instance, UP5 explained, "There should be a curriculum. It should build upon knowledge, skills, practices through hands-on, active experiences." However, UP4 disagreed stating, "I do not think there should be a static curriculum. This is strictly based on my definition of STEM clubs, which requires STEM club participants to be extremely fluid." Meanwhile, some stakeholders were ambivalent in regard to the decision of implementing a curriculum in a STEM club. CF2 stated, "I don't think that [STEM clubs] should necessarily be consistent because every club is catering to different kinds of people in different kinds of communities," while UP2 clarified, "The point is to have a club where we're really engaging them in those topics of STEM with any activity that we see fit for the age group."

While utterances were captured from the teacher and student participants, there were no utterances made by the parent participant that fit into this category. The utterances in Category 3 were further divided into subcategories to further capture emergent themes in relation to the STEM club learning environment according to the conceptions of stakeholders. Subcategories in Category 3 elucidated a continuum for how STEM clubs should be structured, from being completely informal (free-choice) STEM learning environments (n = 14), to being slightly structured, either guided by student-led, hands-on, enrichment (n = 13), or organized around a real-world, community-based problem (n = 11), to highly structured around a specific group or culture (n = 4), or a completely non-formal (specific curriculum) structure (n = 20).

Category 4: Production Site for STEM Skills and Knowledge

Finally, Category 4 for this outcome space was differentiated from Category 3 because this category encompassed utterances that referenced STEM skills and knowledge produced within STEM clubs, irrelevant of the STEM club curriculum, or lack thereof. Furthermore, across the stakeholder groups, there were consistencies in the understanding that STEM skills and content knowledge were learned in the STEM club. For instance, there were utterances in regard to the creation of some sort of product. The teacher participant indicated that in a previous community STEM club, students would "build cardboard and duct tape boats, that students would then get to race at the end of the week." Likewise, all students mentioned the construction of a tornado model to learn about weather, as S2 stated, "we made a tornado in a bottle." In addition to products, other soft skills and a sense of enjoyment were found to be present in STEM clubs evidenced by stakeholders' utterances. CF1 mentioned, "STEM clubs provide the opportunity to enhance global skills such as engagement, collaboration, and cooperation," alluding to soft skills acquired in STEM clubs. Meanwhile, UP3 stated that one former community STEM club student exclaimed, "And I had such a great time that I came back the next year, and now I've decided I want to be an engineer."

This category, more than any other category in this outcome space, revealed an almost equal amount of utterances between community stakeholders and university personnel. However, similar to Category 3, there were no utterances captured from the parent participant for this category. Subcategories in Category 4 were related in regard to what should be produced through STEM Clubs: knowledge (n = 16), shared enjoyment (n = 14), and skills (n = 8).

Discussion

The phenomenographical lens in the present study provided insight to the CUP stakeholders' community understandings of STEM and CUP-based STEM clubs. The analysis of the pool of meanings revealed three hierarchical categories for stakeholder conceptions of STEM: Indifference Towards STEM; STEM as a Holistic Discipline; and Applicability and Usefulness of STEM; and four hierarchical categories for stakeholder conceptions of STEM clubs: Non-STEM Related Space; Promotion of STEM; STEM Club Learning Environment; and Production Site of STEM Knowledge, Skills, and Enjoyment. There were three significant findings from the outcome space that warrant further discussion: (1) the varying degrees to which STEM is conceptualized among stakeholders; (2) stakeholders' beliefs that STEM learning is important for elementary students' futures, and afterschool community STEM clubs help promote that notion; and (3) stakeholders disagree on the learning structure of community STEM clubs.

Data suggests that there was a clear disparity between university personnel and community stakeholders' conceptions of STEM (see Figure 1). Surprisingly, university personnel in this study alluded to STEM as a more holistic discipline, contradicting what is stated in the literature that university personnel still conceptualize STEM as individual disciplines (Breiner et al., 2012). Nonetheless, Breiner and colleagues further elaborated that university personnel's conceptions of STEM are based on how STEM impacts their lives; revealing differences in this study between university STEM and STEM education faculty. That idea thus clarifies the context of this study that university personnel upheld a more integrative approach to STEM because such a conceptualization aligned with their intended learning outcomes for the STEM club; that is, informal learning via integrated STEM instruction.

As for community stakeholders, their conceptualization of STEM (Figure 1) was largely indifferent or they viewed it as generally helpful, suggesting only a rudimentary understanding of STEM. Meaning, stakeholders in the community were unaware of what STEM was in the first place. More specifically, the parent and two student participants have never heard of the concept of STEM, much less knew what the acronym stood for, reinforcing the idea that general citizens of the community do not know what STEM is (Angier, 2010).

Although the teacher participant was transparent in that she considered herself an elementary STEM teacher, she also expressed her concept of STEM merely as an acronym of the four individual disciplines. Given the increasing attention to and need for a more integrative approach to STEM (English & King, 2019), and considering that the community participants in this study were stakeholders of education at the elementary level (i.e., elementary teacher, parent of elementary student, and elementary student), there is an indication that the understanding of integrated STEM learning before the middle school years is needed. This is especially significant considering studies that have shown STEM integration being implemented at the elementary level helps to promote positive attitudes toward science in elementary students (Toma & Greca, 2018). The vast differences in a conceptualized understanding of STEM among stakeholders of the CUP, furthermore, implies that there may have been barriers and obstacles in stakeholder communication that need to be overcome (Bender, 2008). Reciprocity of understanding and substantial communication among CUP stakeholders on this particular finding would help mitigate, if not resolve, differences in conceptions of STEM. It is unsurprising then that since stakeholders hold contradicting conceptions of STEM, the same holds true regarding their conceptions of STEM clubs, as seen in the wide disparity of frequencies regarding conceptions of STEM clubs in Figure 2.

Although community stakeholders made more utterances to STEM utility at home and university personnel made more utterances to STEM utility at school, one aspect that stakeholders seemed to agree upon in regard to the conception of STEM related to the benefit of STEM for the future. The conceptualization of STEM among stakeholders was positive in that learning STEM would help promote skills that would be useful for students engaging in STEM in the long run. These soft skills include critical learning, problem solving, and collaboration—skills sought after by potential STEM employers (Prinsley & Baranyai, 2013). Moreover, stakeholders also agreed that community STEM clubs provide that space and opportunity for such STEM skills to be produced (see Figure 2), thus implying that fostering effective local community STEM clubs is beneficial not only for students, but also for the community as a whole. Indeed, as the demand for STEM skills by employers continues to increase, afterschool community STEM clubs are conducive informal learning environments to help nurture these skills in youth (Afterschool Alliance, 2015; Talafian et al., 2019).

One last significant finding from this study is that while stakeholders view community STEM clubs as significant vehicles in promoting and producing STEM learning, there were conflicting perceptions to the degree learning should be structured. Three out of five university personnel agreed with literature that afterschool STEM clubs should have a set curriculum in place (Feldman & Pirog, 2011), whereas other participants believed that STEM clubs should not be constricted to a standardized curriculum, such that learning in STEM clubs is fluid and student driven. For many of the CUP stakeholders, a sense of STEM enjoyment in a club setting was more important than the curriculum or instruction. This notion is supported in the literature that STEM clubs promote enjoyment due to hands-on experiences that are not provided in formal in-school settings (Krishnamurthi et al., 2014). However, research on effective STEM programs suggest that both the social and academic aspects of student STEM learning are positively impacted when balanced with focused objectives and curricula (NRC, 2015). In addition to consistent collaboration and communication, this research suggests that CUPs that engage in deeper conversation on the purpose of STEM clubs may establish clearer curricula and modalities for instruction to meet their elementary students' needs (knowledge, skills, and enjoyment) in STEM now and for the future.

Limitations

Phenomenography as a theoretical framework and methodological approach is often criticized for the potential bias inherent within the researcher's preconceived notions of the phenomenon (Ashworth & Lucas, 2000). Thus, to mitigate potential bias, bracketing (Tufford & Newman, 2012) was applied and accomplished through removal of stakeholder designation in the data analysis. We established credibility by building protocols and understandings from extant literature and used expert review. Inclusion of two researchers to review the data helped to mitigate introduction of bias (Trigwell, 2000; Walsh, 1994). Additional limitations included a small sample size and that participants for this study were associated with only one of the afterschool STEM clubs in the community. Sampling a larger number of stakeholders—especially teachers, parents, and students—would help determine a broader view of a community's varying conceptions of STEM. Furthermore, results examining conceptions from one afterschool community STEM club may only be significant for that geographical demographic.

Conclusion

Afterschool STEM programs have been shown to develop students' positive attitudes toward the STEM fields and interest in pursuing a career in STEM (Afterschool Alliance, 2015; Baran et al., 2019). Moreover, understanding stakeholders' conceptions of STEM is critical in establishing and sustaining the overall goals and objectives of community STEM clubs (Appel et al., 2020). The present study suggests the need for more substantive communication and collaboration among community stakeholders (i.e., university personnel, classroom teachers, community staff, parents, and students) for afterschool STEM club development and improvement (Davis et al., 2023). Evaluating and synthesizing stakeholders' conceptions of STEM would help contribute to afterschool STEM curriculum, thus strengthening the programming and implementation of STEM activities in afterschool STEM clubs. Considering stakeholder input toward afterschool STEM curriculum would enhance and inform positive outcomes in afterschool STEM clubs, thus making the clubs more attractive for student participation and parents' enrollment of their students (Salvatierra & Cabello, 2022).

The phenomenon of 'what is STEM' (Bybee 2010; Sanders 2008) and the experiences of students engaging in STEM learning within formal K-12 settings has been studied extensively (see NRC 2011; National Academy of Engineering & NRC, 2014; Shahali et al., 2016). What is less studied are the experiences of all stakeholders (students plus parents, teachers, university faculty, etc.) in informal settings such as community-based STEM clubs (Gottfried & Williams, 2013; Sahin et al., 2014). This article addressed that need through a phenomenographic examination of stakeholders' experiences in informal STEM learning via a CUP-based STEM club to explore commonalities and differences in their conceptions of STEM and experiences in informal STEM. This study found that community and university stakeholders hold varying conceptions of STEM but agree that afterschool STEM clubs are vital resources to promote STEM and enhance STEM-related life and soft skills.

However, data also disagreed in terms of the degree of curriculum structure in STEM clubs. Further studies are warranted in examining STEM clubs in various locations across various population groups to gain a clearer perspective of the STEM learning needs of a particular community.

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Appendix A

Questions for University Personnel	Questions for Teacher	Questions for Parent	Questions for Students
1. How do you define 'STEM?'	1. How do you define 'STEM?'	1. How do you define 'STEM?'	1. What do you think of when you hear 'STEM?'
2. How do you define a 'STEM club?'	2. How do you define a 'STEM club?'	2. How do you define a 'STEM club?'	2. What do you think of when you hear 'STEM club?'
3. What do you expect students to learn in STEM clubs?	3. What do you expect your students to learn in STEM clubs?	3. What do you expect your child(ren) to learn in STEM clubs?	3. What do you expect to learn when you go to STEM club?

Appendix B

Preliminary Categories of Description (n=17) in Alphabetical Order

Category
Acknowledgment of different definitions of STEM
Affective learning in STEM
Characteristics of STEM club
Contents of STEM club
Does not know STEM
Learner-centered STEM club
Prior experiences in STEM
Purpose of community STEM club
STEM clubs are thematic
STEM as individual disciplines
STEM as interrelated disciplines
STEM club learning environment
STEM exposure
STEM is a part of everyday life
STEM is professional work-setting related
Teaching-centered STEM club
Unfocused STEM clubs