Methodology Matters: Employing Phenomenography to Investigate Experiences in Computing Fields and the Application of Theoretical Frameworks

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***Abstract*—The goal of this research methodology paper is to discuss the utility of employing a phenomenographic approach towards empirical examination of experiences in computing fields, and to argue for the application of theory within the process. Phenomenography is a qualitative technique applied to describe the variations in how populations perceive and conceptualize an observable fact, circumstance, or event. In our work, we discuss the benefits and challenges of this methodology, and examine the different approaches that can be employed. Although deviations exist in the styles of treating the data, its analysis, and the interpretation, ultimately, the goal of phenomenography is to develop an outcome space which consists of critical features for the object under investigation. Unlike many other qualitative techniques, the analysis itself is not guided using theoretical frameworks or a priori coding, since categorizations are meant to emerge from the data. While theoretical frameworks are not used during the evolution of the outcome space, we do suggest ways they can be applied in other stages of the process. Theoretical frameworks are valuable tools for limiting the scope of the relevant data by focusing on specific variables and defining a particular viewpoint. When employing phenomenography, we describe how theoretical grounding can be useful during planning and data collection — when establishing research questions, developing interview scripts, or during participant selection — or as part of interpretation and explanation of the results. This work is intended to encourage future researchers investigating experiences in computer science education to use phenomenography, and to assist in demonstrating how theoretical frameworks can enhance the protocol without compromising the integrity of the data-focused analysis.**

***Index Terms*—Phenomenography, methodology, theoretical frameworks**

I. Introduction

Interpretive research can be applied to explore, analyze, and discuss social inquiry, deriving knowledge from the experiences encountered by individuals or groups [1], [2]. Phenomenography is a qualitative paradigm employed to develop an empirical understanding of the disparate ways of perceiving and conceptualizing an observable fact, circumstance, or event [3]–[5]. Unlike research methods (techniques to collect and/or analyze data) such as thematic analysis, phenomenography is considered a research methodology, a theoretically informed framework for conducting research. As such, it outlines not only the ontological and epistemological underpinnings, but also shapes the theoretical frameworks, research questions (focusing on the participants' experiences and perspectives), sampling strategy, and how data is collected, in addition to the analysis. Compared to first-person qualitative methodologies such as ethnographical and phenomenological studies which tend to focus on a researcher's perspective, phenomenography is considered a second-order approach that centers on participants' reflections and their interpretation of phenomena [6], [7]. A key epistemological assumption is that structural relationships exist amongst the variation in experiences [8].

To establish a discourse and gain insight into perceptions of the phenomena, data for phenomenography is often collected using semi-structured or open-ended interviews [8]–[13]. Although multiple approaches are taken to process, analyze, and interpret the resulting transcripts, the eventual goal of this methodology is to develop an outcome space, defined by critical features and categories of the phenomena under investigation [4], [13], [14]. Unlike many other qualitative techniques, the analysis itself is not guided using theoretical frameworks or a priori coding, since categorizations are meant to emerge from the data [11].

While theoretical frameworks are not used during the evolution of the outcome space, we do argue that they add value to this methodology, and offer suggestions on how they can be applied throughout the process. In this work, we discuss: 1) The usefulness of applying phenomenography towards the empirical examination of perceptions of experiences in computing fields; 2) Recommendations and guidelines for ensuring rigor in the process; 3) How and where theoretical frameworks can be applied when employing phenomenography; and 4) An example of how this technique and frameworks can be applied to drive understanding of students' experiences with the hiring process in computing.

First we describe an overview of phenomenography, dif-

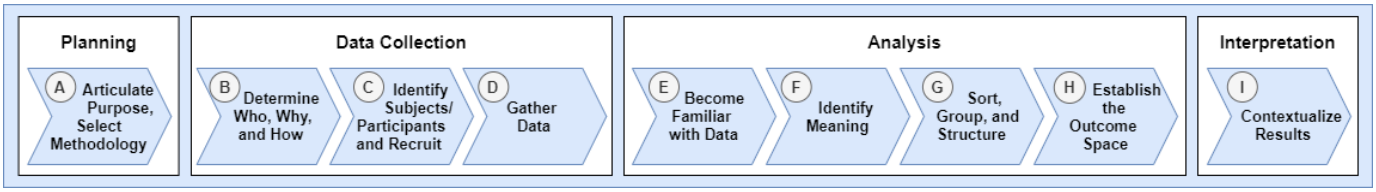

Fig. 1: Stages of Phenomenography

ferent approaches, and the background related to theoretical frameworks, including their purpose and importance, in Section II. Section III provides information about the procedures for undertaking and applying phenomenography and theoretical frameworks to questions in computer science education research. After this, we discuss the application of this techniques to an example pertaining to undergraduate students' job attainment experiences in Section IV. Finally, we provide a summary of the key points of this work and the value of phenomenography for qualitative investigation of experiences in Section V.

II. Related Work

A. Overview of Phenomenography

Phenomenography has been widely employed to assess the relationships between participants' and their conceptualizations of phenomena [7], [15]–[24]. Understanding arises simultaneously from reflection within each individual, as well as ascertaining the similarities and differences of collective experiences across groups of individuals to maximize variation in the ways experiences are felt and described [6], [15]–[17], [25]. Ontologically, phenomenography considers phenomena as shaped by the experiences of those engaging in it themselves and their perceptions of reality [26]. According to Bowden, there are four distinct stages in phenomenographic research including planning, data collection, analysis, and interpretation [12]. However, data analysis is often described using varying levels of granularity, and may include merely identification, sorting, contrasting and categorizing, and reliability checking, or additional phases such as familiarization, condensation, or grouping [26].

Although we acknowledge there may be different approaches [26], a broad overview of the phases in phenomenography are shown in Figure 1, synthesized from scholars in the field [8], [12], [27]–[29]. As is common in academia, first a problem is identified, the purpose articulated, research questions (RQs) developed, and a methodology is selected (A). Once phenomenography is chosen, it is important to determine who will be assessed, how this will be carried out, and to justify these choices in relation to the purpose (B). Then, participants or subjects are identified and recruited (C). Data are gathered next, whether using observation, interviews, or open ended-questionnaires (D). While the analysis process may vary by intended outcome, in general, it entails familiarization with the data (E), identification of meaning (F), sorting, grouping, and structuring of the experiences (G), and establishing the outcome space (H). The outcome space requires a categorical description and accompanying illustrative statements [3], [12]. Also, it may be represented using tables, diagrams, or figures [30]. Once the outcome space is finalized, the results are contextualized and described (I).

B. Developments in Phenomenography

The earliest research described as "phenomenographic" pertains to work conducted in the 1970s, and first appearing in a publication in 1981, by a group at the University of Gothenburg in Sweden under the guidance of Ference Marton [14], [31]. They sought to pragmatically assess "conceptions of various aspects of reality as the superordinate categories" [14, p. 189] to explore how variations in experiences result in differing learning outcomes in education [10], [18]. Marton's approach to analysis utilizes decontextualized excerpts which comprise a "pool of meanings" [31, p. 43]. The researcher then collects and sorts the quotes into cohesive categories, considering the dimensions of variation among the meanings.

As further disciples of the Swedish or "Gothenburg phenomenography," Hasselgren and Beach argue there are five distinct contexts of phenomenography: discursive, experimental, naturalistic, hermeneutic, and phenomenological [32, p. 197]. *Experimental* focuses on learning outcomes and understanding how students approach tasks. Phenomenographically, the outcome space is defined as "the qualitatively different ways of understanding the same phenomenon." Meanwhile, *discursive phenomenography* is related to Marton's description of "pure" phenomenography (although the authors argue there is no such thing), and considers discourse to provide "a collection of variegated and pragmatic responses to the demands of investigating a particular kind of research object under different conditions" [32, p. 197]. *Naturalistic phenomenography* takes an observational approach, without the researcher manipulating or interacting with the participants, and merely observing their interactions. Then phenomenography is employed in the analysis based on what was said or the actions seen. Meanwhile, in *hermeneutic phenomenography* the analysis is focused on exegesis, critical explanation or interpretation of literary or written text. Finally, *phenomenological phenomenography* considers the social and contextual nature of a study to understand the essence of the experiences involved. This variant necessitates exploration of the dissimilitude and overlap between phenemenology and phenomenography.

For clarification, we want to emphasize that although both phenomenography and phenomenology seek to understand experiences of phenomena, their focus, outcomes, and uses are distinct [10], [33]. Phenomenography addresses research that aims to describe the *variation* or different ways a group

TABLE I: Comparison of Marton and Bowden's phenomenographic approaches

	Original, Pure, or "New" Phenomenography: Marton (Sweden)	**Developmental Phenomenography: Bowden (Australia)**
Goal	Experiencing the phenomenon is described by a set of critical aspects/features that a learner is able to "discern," "be aware of," or "focus on" simultaneously	Research is designed with the intention that there will be practical outcomes, and aims to enable others to change their own experiences
Data Collection	Varied conceptions participants have about "same things"	Participants discuss "different things"
Data Analysis: Become Familiar with Data	Necessary; Analysis reliability checked by coding of independent researchers	Necessary; Analysis performed by team of researchers
Data Analysis: Identify Meaning	Quotes/excerpts selected to create a "pool of meanings"	Using whole transcripts, sections are considered "in situ"
Data Analysis: Sort, Group, and Structure	Ways of dealing with the task; Look for variation in the meanings of the "same thing"	Aims to create developmental outcomes to enable others to change their own experiences
Data Analysis: Establish the Outcome Space	Search for dimensions of variation in the pool of quotes, related in a hierarchy from less to more complex	Transcripts sorted in groups from less to most powerful; Structural links between categories investigated after the categories already determined

of people experience a phenomenon, whereas phenomenology seeks to clarify the phenomenon's structure and meaning, seeking *common* perspectives from a group of people [10]. Hasselgren and Beach argue that some early work may have been misclassified due to a lack of the formal label of phenomenography at the time [32]. Instead, they posit that "most phenomenographers tend to view the descriptions of outcomes of learning as the phenomenographic enterprise, phenomenological criteria concern questions directed toward the essences of experiences, for instance experiences of learning" [32, p. 199].

Researchers often distinguish between Marton's approach to pure phenomenography (also referred to as original or "new" [34], [35]) and an approach defined by Australian researcher John Bowden, "developmental phenomenography" [36]. Bowden considers practical applications and the use of outcome spaces. Rather than focusing on individual quotes, Bowden considers whole transcripts, which are grouped based to maintain their context on the entirety of the interview [12]. The researcher then seeks shared meanings amongst the "different things." Although other styles and variations later emerged, given the foundational contributions of these two disparate approaches, we present a broad comparison in Table I. Researchers may also employ a combination of Marton and Bowden's approaches towards phenomenography [24], [35], selecting aspects of each where appropriate in their context.

C. Theoretical Frameworks: What and Why

Educational research is often guided by theoretical frameworks. Theoretical frameworks are established paradigms used to provide context and structure to a research plan, grounding work in recognized theories, and offering insight into the "factors most likely to have an effect" when considering situations where it is impossible to control for every variable [37]. Strong theoretical frameworks can "reveal existing predispositions" researchers may have about their inquiry, and are considered advantageous throughout all phases of research — including planning, data collection, analysis, and its interpretation [38]. They can be used to inform the overall aims, construct research questions, during methodological selection, to identify limitations or threats to the validity, and to emphasize the research's utility. It has been argued that employing theoretical frameworks, along with rigorous methods, can improve the quality of research, add strength to interpretation of the results, and can help to develop knowledge, understanding, and complex insights [37], [38]. While researchers may struggle to select which is appropriate for their purposes, it is critical to bear in mind there may be multiple options which are applicable [37]. However, depending on the goal and/or design of the work, some frameworks may be more suitable than others.

D. Theoretical Frameworks in Phenomenography

Although scholars undertaking phenomenography may utilize theoretical frameworks to answer research questions about a phenomena or students' experiences, they do not always make their application explicit. Furthermore, given the inductive nature of coding in phenomenography, they are not able to be applied during analysis itself. As such, when theoretical frameworks are employed, it is typically during the planning or interpretation (where the results are linked back to the overarching framework) phases. In Table II, we summarize several prior works in computing and engineering that employed phenomenography. We include information about the phenomenon they investigated, which framework(s) they used, and where they mention applying these frameworks within the process. While these are not the only researchers in these fields who have utilized phenomenography, it should be mentioned that frequently frameworks are not discussed, or it may be ambiguous how or where they are applied. This is something that future researchers should contemplate, and try to remedy.

III. Methods

In this section, we describe options to be contemplated in different stages of the methods when employing phenomenography. To ensure fidelity of the inquiry, it is important that the researcher consider the desired target and goal of the work. As mentioned previously, there are multiple approaches to phenomenography, depending on the investigation and context [32]. Throughout the process, it is important to make deliberate decisions, and to document the rationale behind these choices.

A. Sample/Population

Researchers disagree on a prescriptive sample size for phenomenography [30]. While some scholars claim approximately 15-20 informants is sufficient to understand the phenomenon

TABLE II: Summary of phenomenographic inquiries conducted in computing and engineering, in terms of the topic, theoretical framework guiding inquiry, and where applied

Author(s): Reference(s)	Phenomenon of Interest	Framework Applied	Phase(s) Applied (Details, Where Indicated)
Kinnunen & Simon: [17], [39], [40]	What are instructors' perceptions of students' success?	Bandura's theory (1997) of self-efficacy	Interpretation (contextualizing results)
Dringenberg: [20]	Engaging with ill-structured problems, which have been defined as having the characteristics of engineering work, including a lack of information given, ambiguity within the process, multiple possible solutions and flexible means of evaluating solutions	Adaptation of Jonassen's classification of problems	Interpretation (situate the phenomenon of interest within the wide range of problem solving literature)
Peters: [22], [41]	How students experience participation in CS and IT	Lave and Wenger's social theory of learning and identity	Planning; Data collection (protocol development); Interpretation
Smith: [24]	The qualitatively different ways that African American undergraduate women in engineering experience faculty mentoring	Intersectionality	Planning (RQ development, methodology selection); Data collection (participant selection); Interpretation
Mendoza Garcia: [35]	Descriptive path for the ability to address complex socio-technical systems, ways problems seen and approached	Variation Theory	Planning (methodology selection); Interpretation
Salzman: [42]	Students' experiences with transition from pre-college engineering programs to first-year engineering	Self-Determination Theory	Interpretation (Yet author states work not initially guided by this theory, the results aligned with aspects of it)
Jordan et al.: [43]	How Navajo engineers experience, understand, and apply engineering design and practice in the context of their culture and community	Culturally responsive perspectives; Border-crossing framework (by Aikenhead)	Planning (methodology selection); Data collection (participant selection and protocol development); Interpretation

in question and to find variation [10], [13], [44], phenomenographic studies have been conducted with as few as 6 participants [19]. Other researchers have noted that rather than trying to obtain a precise count, they focus on reaching saturation [5], [30]. Saturation is defined as the point where a researcher has sufficient data to establish an "in-depth understanding" [45], and where no new conceptions emerge [46]. However, in phenomenographic studies, variation is considered key to reconciling informants' accounts and to developing a "nuanced picture of relevant experiences within a cohort" [6, p. 73].

Given the critical role participants' perceptions play in developing an understanding of the phenomenon, it is recommended that selection is done with consideration of the goal [15]. As such, variation and purposive sampling are considered central facets in phenomenography [47]. Purposive sampling refers to the non-random selection of participants based on the researchers' judgment, and prior knowledge of the subjects.

B. Data Collection

Data collection for phenomenographic investigation is often conducted with semi-structured interviews [10], [11], [13], [48], although open-ended questionnaires, think-aloud methods, or observation may also be employed [26]. Given that interviews are the most common choice [9], [12], we focus primarily on their particulars here.

The content/outline for interviews must be designed in advance, and typically includes open-ended questions to explore the phenomena. To probe deeper on particular subjects and to spur reflection, follow up questions are also common, which limits the usage of entirely fixed and structured protocols [16]. The conversation may also naturally veer off track, leading to the evolution of extemporaneous thoughts and topics [15]. It is also suggested that individuals can be encouraged to discuss their experiences in depth until both the interviewer and participant reach a mutual consensus on the phenomenon [1], [25].

Pilot interviews are also considered a form of practice which are vital to data collection for several reasons [28], [48]. They afford researchers the opportunity to hone their technique, such as being transparent about the goal and mitigating judgement in reactions [5], [28]. Additionally, pilot studies can be important to confirming the structure of the protocol, and to ensuring that the questions achieve commentary aligned with the intended topic [28].

C. Data Analysis

When employing phenomenography, Bowden argued that analysis should wait until all interviews have been conducted [28]. This serves to avoid introduction of new content, and potential overt and subconscious alterations to the protocol that may otherwise bias the responses. When interviews are used for data collection, they are also recorded for accuracy, and then transcribed verbatim for the analysis [49], [50].

Reading of the transcripts occurs over multiple rounds, beginning with an initial pass to gain familiarity, and then additional rounds to extrapolate meaning, identify categories, refine them, and then to construct relationships among them [17]. To solve problems and answer research questions, phenomenography utilizes outcome spaces, which can be applied to identify thresholds for meaningful experiences [20], and to create distinct categories of conceptions [17], [22], [25], [49]. *Outcome spaces* are defined as "categories of description, which are logically related to each other" [17, p. 213]. It should be noted that categories are meant to identify variations that arise from conceptions within a particular group of informants, rather than the conceptions of a particular

individual [48]. Typically the logical relations in the structure of the outcome space are defined visually and presented hierarchically, linearly, or as branching [48].

While there are not constraints on the amount of categories that should exist, Marton's assumption that there are a limited amount of qualitaitively different ways that phenomena are experienced and understood has been described as implying there should only be a "few" [31]. Although "few" is open to interpretation, Cummings points out that more recent developments of outcome spaces typically remain limited to seven unique categories or less [34]. However, researchers may also organize a smaller number of thematic headings, and then choose to represent the categories of description as sub-themes, which may result in larger overall amounts [7].

Bowden recommends that multiple researchers evaluate the transcripts identified to ensure consideration of additional perspectives and to strengthen the quality of the analysis [28]. There are two separate ways for doing so, via a coder reliability check or dialogic reliability check [49]. Coder reliability check is described as "two researchers independently code all or a sample of interview transcripts and compare categorizations." As an alternative, dialogic reliability check, entails finding an "agreement between researchers is reached through discussion and mutual critique of the data and of each researcher's interpretive hypotheses." However, Åkerlind argues it may not always be feasible for multiple researchers to perform the analysis (e.g., in the case of doctoral dissertations), and notes that "high-quality phenomenographic research can be accomplished as an individual researcher working on one's own" as well [48]. However, in the case of a single researcher conducting the analysis, Walsh suggests that it is important for the researcher to state their own positionality, and to perform critical self-reflection to describe theoretical leanings, assumptions, and relationships to the field under investigation to ensure trustworthiness and make potential biases and preconceptions more transparent [51].

D. Applying Theoretical Frameworks to Phenomenography

We encourage researchers to employ phenomenography to investigate participants' interpretations of experiences in computing fields, and to apply theoretical frameworks throughout the process, as possible. Utilizing theoretical frameworks and explaining how and where will help to contextualize the study and provide awareness of how existing theory is relevant to the inquiry [37]. Strong frameworks can also be used to specify which variables influence phenomena of interest.

It should be noted that for this particular methodology (phenomenography), theoretical frameworks cannot be applied during the analysis itself since categorizations are meant to emerge from the data. However, they can be applied during planning, data collection, and interpretation. Given that Bowden considers the phenomenographic research process complete upon development of the outcome space [11], this ensures rigor is maintained in the analysis while still offering opportunities for theoretical application with subsequent use of the categories of description. Antithetically, it should be mentioned that since theoretical frameworks can inform the questions asked, it is impossible to completely perform the analysis without any impact from them.

E. Validity and Reliability

It is impossible to completely eliminate bias, however, it is important to mitigate it wherever possible [28]. According to Walther et al. [2], there are five kinds of validation for data collection and analysis in qualitative inquiry: communicative, pragmatic, theoretical, procedural, and process reliability. In phenomenography, Åkerlind contends that communicative and pragmatic are especially critical [48].

Communicative validation is established by knowledge generation "in the social context under investigation" [2], and the ability to persuasively argue these findings to the community, through seminars, conference publications, and journals [18]. When applying this to phenomenography, establishing communicative validity requires that the interpretation goes beyond the explicit content of the interview, to establish a deeper understanding and logical structure. This interpretation is based on the collective responses rather than the individual, to establish an outcome space that is "defensible" when disseminating the results.

Pragmatic validation refers to the extent of utility and applicability of the results to its target demographic [48]. This is often described in the values of the insights obtained, as opposed to seeking "theoretical purity" [52]. While obviously this is important to establish in phenomenography, the way of doing so is contextually dependent.

Theoretical validation refers to developing an alignment between the phenomena under investigation and establishing a resultant theory or knowledge. To establish this form of validity, it is critical to consider decisions throughout the process of phenomenography. For example, purposive sampling can be applied to ensure maximum variation [28]. Furthermore, analysis should be conducted using guidelines established by the larger community [3], [9], [28], [48].

Procedural validation describes integration of validation strategies within the design [2]. To ensure this validity, it is important to document the steps undertaken in the phenomenographic inquiry [52]. When feasible, multiple researchers may be involved to perform checks and additional perspectives in the analysis, as described by Bowden [28]. Furthermore, it has been argued that "the outcomes of phenomenographic analysis need to be presented with sufficient extracts to delimit the meaning of the category fully" [52].

Process reliability describes using an iterative process for data gathering, and again providing explicit documentation and procedures [2]. While data collection itself must occur in phenomenography in a single phase, iteration is common throughout the analysis, particularly as content is sorted, grouped, and structured to establish the outcome space [28].

IV. An example of Phenomenography Analysis Applying Theoretical Frameworks

In this section, we describe an example of how theoretical frameworks can be applied when using phenomenography.

Our goal here is not to provide extensive detail of how this methodology should be employed, but to describe our study and provide understanding of a potential approach undertaken. Along the way we discuss how the chosen theoretical frameworks shaped design decisions during planning, reinforced purposeful sampling and protocol development during data collection, and benefited our interpretation of outcome spaces.

Our larger research questions were motivated by understanding students' experiences with the hiring process and job attainment in computing (our phenomena). In particular, we focused on the experiences of populations underrepresented in computing, women, Black/African American students, and Hispanic/Latinx students. Three theoretical frameworks served as the guiding lens for our inquiry: intersectionality, community cultural wealth (CCW), and identity theory. We first describe these frameworks, to provide a foundation of what they are/represent. Then, we describe how aspects of each were employed throughout the phenomenographic inquiry.

A. Theoretical Frameworks Guiding the Research

1) Identity theory: Although identity is considered a complex construct defining who an individual is, and the roles they hold that change over time, in our work, we focus primarily on social identity (in terms of students' gender, race, and ethnicity) and disciplinary identity, more specifically, computing identity [53]. We consider computing identity in terms of four sub-constructs: interest, sense of belonging, recognition, and competence/performance. Interest is used to refer to students' engagement with a computing field or computing topics. Sense of belonging describes the feelings or acceptance or belonginess within the computing community, or computing groups and organizations. Recognition refers to the internalized acknowledgement received from communication with others, such as faculty, peers, mentors, or family, on computing topics. Finally, competence/performance describes the confidence a student has in their own abilities and understanding on computing topics or in computing fields.

2) Intersectionality: Describes how "power relations influence social relations across diverse societies as well as individual experiences in everyday life" [54]. Although it considers social categorizations such as race, ability, age, ethnicity, first generation status, etc. that may be defined, it argues that these components of an individual coalescence to define perceptions and affect interpretation rather than serving as independent constructs. While intersectionality considers multiple facets that may contribute to phenomena of oppression, we focus primarily on the social aspects of gender, race, and ethnicity, and the circumstantial aspect, in reference to being a student, caregiver, or parent as they pertain to experiences with hiring and preparation.

3) Community Cultural Wealth: Developed by Yosso [55], CCW builds on critical race theory to describe the inherent capital minoritized populations harness to combat oppression. We use CCW to celebrate how students overcome obstacles in their pathway to computing and during the hiring process. There are six types of interconnected cultural capital described by this framework [55]: Aspirational, Navigational, Resistant, Familial, Social, and Linguistic. Aspirational capital refers to pursuing success despite real and perceived barriers. Navigational capital considers using strengths and skills to maneuver through systems and social institutions (here referring to universities, or the computing industry). Resistant capital describes knowledge and skills obtained through oppositional behaviors challenging inequality. Familial is defined by the forms of knowledge and support shared and passed on through the generations of family or kin, offering connections to history, memory, culture, and community. Social capital refers to drawing on people and resources from one's network. Finally, linguistic considers how communicating in more than one language or style can develop intellectual and social skills.

B. Planning

Given the larger goal to understand job attainment in computing, our chosen frameworks drove the specific framing of the RQs in our inquiry: RQ1: *How do students leverage the cultural capital associated with their self-identified racial, ethnic, and/or gender identity to obtain a job in computing?*; and RQ2: *What do students feel would help to improve hiring in computing?*

Our aim and chosen frameworks also drove selection of the research methodology. Phenomenography was picked based on its ability to describe lived experiences, its emphasis on variation in experiences, and its second-order approach to uncovering understanding through the eyes of the participants. We sought to consider intersectionality of our participants and understand the unique perspectives each had towards our questions, given their own backgrounds and identity in relation to computing (considering identity theory). Rather than treating students as a monolith, we wanted to learn how they successfully navigated the hiring process to obtain a position, and to describe the forms capital they leveraged to provide recommendations for other students, educators, and industry on ways to improve the hiring process in computing and make it more equitable.

We specifically focus on discursive phenomenography, which includes the process by which conversations are transcribed, compiled, analyzed, and then interpreted to map "conceptions of the world in general of people in particular" [32, p. 197]. Rather than using a conceptual line of inquiry, discursive phenomenography seeks to describe phenomena [14] applying rigorous methods established through utterances, communication, and dialogue [56].

C. Data Collection

For data collection, we employed semi-structured interviews to explore how students experience the hiring process, and the unique situations that may contribute to preparation for technical interviews and their pathways in computing. Our theoretical frameworks were considered during development of the interview protocol, and in selection of our sample/population.

The interview protocol was derived using all three frameworks, to encourage participant sharing about different aspects

of their own perceptions, support they leveraged, and what they thought would improve the process and their preparation. While our goal in this paper is not to focus on the outcome, we do offer some examples to illustrate how frameworks were applied. In reference to understanding aspects of familial capital described by CCW we asked "Did you talk to your family about your decision to pursue a career in computing and did they influence you in any way?" To learn about the intersectional realities faced by students, whether racism and/or sexism, we also asked "Did you ever face any discrimination, either during your interview process or during your time in school?" Additionally, considering aspects of identity theory, in regards to interest, we asked "What made you want to pursue a career in computing?"

Participants were identified from a quantitative survey and were selected to maximize diversity, seeking students across a range of intersectional backgrounds and computing majors, including computer science (CS), computer engineering (CE), and information technology (IT). We applied purposive sampling to obtain approximately equal numbers of males and females, and to identify Black/African American, Hispanic/Latinx, White, and Asian students. Although participants can be categorized based on the sampling criteria, we did not intend for their experiences to be generalized to represent all students underrepresented in computing. Instead their conceptions were intended to describe ways that students from their intersectional background experienced the hiring process, and their pathways in computing. While we sought students with varying numbers of technical interviews completed and job offers, we limited our population to students that underwent at least one technical interview, and that received at least one job offer. The former criterion was set to ensure firsthand experience with the hiring process, and the latter to ensure that responses were not overly negative predicated solely on frustration and/or disappointment.

As recommended [28], a pilot study was undertaken with 3 participants to refine the interview protocol and ensure it elicited reflections about the phenomenon of interest. It also afforded the interviewer the opportunity to hone interviewing skills. However, this data was not included in the later analysis.

Data collection with the participants included 16 semi-structured interviews conducted via Zoom with a diverse population of students recruited from three metropolitan institutions in the southeast United States. Each interview lasted an average of 45 minutes. During the course of the interviews, participants were asked to recount their pathways to the field, hiring experiences, perceptions of diversity and inclusivity in computing, how they prepared for technical interviews, and the role of friends, family, and mentors in their academic decisions and support throughout the hiring process. Questions were given to understand the phenomena without trying to lead the participants. However follow up prompts were used to clarify participants' reflections and to encourage elaboration. The recorded transcripts were transcribed verbatim, so the entire conversation was available for context throughout the analysis process.

D. Analysis

Primarily the methodological decisions made in this inquiry aligned with Swedish practices of original, pure, or "new" phenomenography. The analysis conducted was guided in part by the aim to characterize positive and negative experiences during the hiring process, and to understand how different populations leveraged their own inherent capital to prepare, face, and eventually succeed at obtaining a position in a computing field (CS, CE, or IT). A pool of meanings was constructed from the transcripts. As previously mentioned, the resultant categories are meant to arise from the data, and as such, theoretical frameworks were not used during this phase.

E. Interpretation

Once the outcome space was finalized for each research question, the theoretical frameworks were applied during the interpretation phase to unpack and contextualize the results. We considered how intersectionality may factor into preferences, into feeling like a computer scientist, and into descriptions of experiences in school, interviews, and the workplace. In addition, we explored the support and influences that encouraged students to join computing, and to persist through the hiring process, seeking understanding through the lens of CCW. While we will not review all of the results, we describe some examples of how the frameworks were applied.

Students' intersectional backgrounds contributed to how they navigated social, educational, hiring, and workplace interactions. In the context of hiring and industry, students expressed gratitude whenever they felt like a company celebrated diversity, or when they saw others that looked like them. When considering the first research question and the ways students leverage capital to attain a job, one of the larger categories identified referred to intrinsic characteristics. Within this broad categorization, sub-categories such as confidence emerged, when students referred to being proud of what they have done or their abilities and feeling like they accomplished something or solved a problem well in computing. Along those lines, one of the quotes from Steve (a pseudonym) stated: "It helped get me over prepared for what ended up being the actual interview and I actually felt pretty confident going into that interview. Confident and hopeful, and it ended up turning out in my favor." In interpreting the meaning, we attributed confidence to aspects of performance and competence described by computing identity theory, which helped students succeed in the hiring process. We also considered using the preparation and resultant confidence as navigational capital the student leveraged for job attainment.

Another example identified refers to the sub-category of communication. Ramon, a Hispanic/Latinx male, described how being bilingual and speaking Spanish served as an asset with interviewers. He stated that "It helped if the interviewer was also a Latin person, I think it helped because it created that special connection between Latinos." Interpretation of this can be described not only by the shared intersectional identity that helped to form a bond, but also references how linguistic capital can be utilized during the hiring process.

In regards to the second research question, categories emerged surrounding problems students faced, and we sought to learn about conceptions of what would improve hiring in computing, and perseverance despite challenges. The chosen frameworks helped to understand the perceptions of the experiences students reported, such as those of Deanna, a Black female participant. She noted that although there may be a lot of employees at a company, she rarely saw other Black females, and that she could count them "on one hand." She mentioned encountering instances of racism and sexism, and spoke to how she leaned on her community, peers and faculty in the National Society of Black Engineers (NSBE), to cope with these encounters. In addition, she mentioned her own interest in seeing more diversity, and commented that:

> It definitely made it easier to approach the recruiters. I know for me, I feel more comfortable when I'm speaking to either a person of color and/or someone who is female, so that made it easier to approach the company.

Intersectionality served to describe Deanna's reported experiences, and the compounded instances of oppression she felt as a Black female in the field. However, to develop her resistant capital (described by CCW) to cope with the obstacles she encountered, Deanna leaned on her community in NSBE.

F. Value of Theoretical Frameworks

The chosen theoretical frameworks served as valuable guides to shape multiple phases of the inquiry in the example described. Considering aspects of social identity and computing identity were helpful in understanding how the experiences impacted participants, and influenced their interpretation of the hiring process and feelings of being a "computer scientist," "engineer," etc. Furthermore, community cultural wealth was advantageous when designing the interview protocol and contemplating prompts that may elicit different obstacles and supports critical to students' preparation and job attainment. It also was beneficial during interpretation, such as elucidating the value of bonding with interviewers using communication in another language, in terms of the shared expression of culture and the relationship to community ties as a form of linguistic capital. Intersectionality also served as a valuable lens through which we selected a diverse set of participants, and through which we were able to appreciate the nuances of multiple axes of injustice faced by women of color, and the importance of same gender and race/ethnic role models and/or mentors in students' pathways to a career in computing. Having these frameworks as a structure for the research, served to strengthen the entire research process.

V. Conclusions and Recommendations

In this paper we describe the methodology of phenomenography in detail. We provide an overview of the process, different approaches employed, and illustrate the variations in decisions throughout. We also discuss what theoretical frameworks are, and their importance to research. To provide clarity in how to approach future research, we gave an example from the field of computer science education to demonstrate the application of theoretical frameworks.

Based on the research presented, we would like to recommend the following guidelines for future inquiries:

- *Use theoretical frameworks in phenomenography:* Given the value that theoretical frameworks add, we encourage researchers to use them throughout phenomenographic inquiry. While it is critical to the integrity of the analysis not to force presumptions onto the data, and to allow the meaning to emerge from the participants' conceptions of the phenomena, this does not exclude allowing grounding other phases of the process, including planning, data collection, and interpretation in theory.
- *Document each decision and be deliberate about choices made:* To establish procedural validity and process reliability of the research, it is important to track each step and choice. While again, theoretical frameworks are not included in the analysis, places where they are applied should be clearly defined.
- *Be explicit about the use of frameworks when communicating results:* Researchers are not always clear in which frameworks they use (if any), or how they apply them. Given the value that theoretical frameworks add, we encourage researchers working to establish communicative validity to state assumptions and discuss their applications when presenting or publishing their findings.

Our goal was to illustrate that rather than providing a impediment or burden, theoretical frameworks can complement phenomenography and provide depth to the qualitative inquiry. We encourage researchers to consider their necessity and to always be deliberate in their choice and in describing their application. Furthermore, we hope that our example and the suggestions made encourage future researchers to employ phenomenography to examine students' interpretation of experiences in computing.

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