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Mentoring experiences of undergraduate students and faculty members in science, technology, engineering, and mathematics

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MENTORING EXPERIENCES OF UNDERGRADUATE STUDENTS AND FACULTY MEMBERS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

by

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MENTORING EXPERIENCES OF UNDERGRADUATE STUDENTS AND FACULTY MEMBERS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

Pamela Martínez Oquendo, Ph.D. University of Nebraska, 2023
Advisors: Chris Moore and Jenny Dauer

I present a comprehensive view of mentoring experiences of undergraduate students and faculty members in science, technology, engineering, and mathematics (STEM). In CHAPTER 1 I describe a brief outline of this dissertation. In CHAPTER 2, I present an interpretative phenomenological analysis of the lived experiences of former STEM undergraduate mentors of the Nebraska STEM For You (NE STEM 4U) afterschool mentoring program. In CHAPTER 3, I describe how the ramifications of faculty mentorship influence the science pipeline using a qualitative synthesis. In CHAPTER 4, I describe how the STEM faculty-student mentoring engagement involves a strong psychological support component using a case-study methodology. Chapter 5 outlines a brief conclusion of my dissertation. Overall, I found that a positive mentorship experience with faculty can encourage undergraduate students to stay in STEM fields.

DEDICATION

To Mom and Dad,

who taught me the power of education.

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PREFACE

CHAPTER 2 is published in *The Qualitative Report.* (Martínez Oquendo, P., VanWyngaarden, K.N., and Cutucache, C.E. Lived experiences of former stem undergraduate mentors of an afterschool mentoring program: An interpretative phenomenological analysis. *The Qualitative Report, 27 (10), 2157-2173.*

CHAPTER 3 is submitted for publication in the *Mentoring & Tutoring: Partnership in Learning* journal. (Martínez Oquendo, P., Vogel, M.D., and Cutucache, C.E. Undergraduate mentorship in science: A qualitative synthesis. *Mentoring & Tutoring: Partnership in Learning, Submitted February 2023.*

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CHAPTER 1

INTRODUCTION

Institutions of higher education are facing the challenge of supporting undergraduate student development in science, technology, engineering, and mathematics (STEM) majors. Chen (2013) found that almost 50% of STEM undergraduate students leave the field within six years. The development of undergraduate students in STEM can be improved by expanding access to high-impact practices, including experiential learning activities that occur outside of the classroom (e.g., after school programs, and mentoring experiences; Kuh, 2008; Snodgrass Rangel et al., 2021).

Research efforts are largely concentrated on the impact of mentoring programs on mentees (Nelson & Cutucache, 2017; Snodgrass Rangel et al., 2021). Conversely, a dearth of studies have examined the influence of STEM mentoring programs on undergraduate student mentors, such as focusing on the benefits of the program to the mentors and their motivations to take part in the program (Nelson & Cutucache, 2017; Snodgrass Rangel et al., 2021; Sommers et al., 2021), with Leavitt et al. (2021) being a notable exception. Still, several questions concerning the impact of mentoring programs on developing mentoring skills require further exploration as there is a lack of longitudinal research in the scientific literature about the impact of mentoring programs on the career opportunities and advanced schooling of former STEM mentors' post-graduation (Nelson & Cutucache, 2017). To date, few studies have focused on the impact of mentoring programs on former STEM undergraduate student mentors (i.e., Nelson & Cutucache, 2017). As STEM mentorship programs can assist with developing critical workforce skills, continued research regarding program outcomes, such as decisions regarding advanced schooling or education, career trajectories, and overall career

preparedness post-participation should be completed using larger sample sizes. These outcomes would be essential for understanding the decision-making processes undergraduate students in STEM undergo as part of their developmental process.

Apart from providing mentorship in after school STEM programs, undergraduates may also receive mentorship from STEM faculty. Findings from Johnson (2003) showed faculty mentors can support the development of students by providing a positive mentorship experience and educating mentees about the unwritten rules of the field. Faculty mentors can strengthen the interest of students in pursuing a career in science (Revelo & Loui, 2016). In academic settings, there is a "positive bias" perspective (Duck, 1994, p.8), where administrators believe faculty have the skills to provide a positive mentorship experience (Tenenbaum et al., 2001).

Findings from Johnson (2007) showed that one bad mentorship experience suffices to discourage students from pursuing advanced schooling and careers in science, which impacts retention rates in the field. Findings from Limeri et al., (2019) showed students perceive a lack of interest in faculty supporting their psychosocial and career development. The students in Limeri's study believed faculty lacked an intrinsic motivation to mentor. As a result, faculty were unknowingly discouraging students from pursuing advanced schooling and careers in science (Limeri et al., 2019). There is conflicting evidence in the literature about the mentorship experiences of students with faculty members in science. More studies should focus on how faculty mentorship influences the feelings of students toward science.

It is also important to explore the perspectives of STEM faculty toward undergraduate mentorship since the success and retention rates of undergraduates in

STEM may depend on the quality of the mentorship experience (Behar-Horenstein et al., 2010). Findings from Allen et al., (1997) showed mentors perceive more benefits than costs when engaging with mentees, such as taking on leadership roles, increased confidence and interpersonal skills, and feeling fulfilled and valued by helping students. Limeri et al., (2019) showed the mentorship experience of undergraduate students in STEM depends on the intrinsic motivation of faculty to mentor.

However, faculty may find that undergraduates are a source of frustration because the limited experience of students restricts the productivity of the lab group (Dolan & Johnson, 2010). Faculty feel pressured by institutions of higher education to bring more research funding, since research funding is often necessary for getting promotions in STEM disciplines at colleges and universities (McKinsey, 2016). Institutions of higher education should provide more support to encourage faculty to establish mentoring relationships with students (Davis et al., 2015).

My dissertation consists of a series of individual studies that aim to explore mentoring perspectives of undergraduate students and faculty in STEM. Each chapter presents a distinct study that contributes to the overall understanding of components that can support the development of STEM undergraduate students.

In CHAPTER 2, I begin presenting a study focused on exploring the perspectives of former STEM mentors of an after-school STEM program after graduation. This study is important because employer surveys identify gaps in STEM undergraduate students' skills, such as developing critical thinking and problem-solving, thereby impeding employment opportunities post-graduation (Whiting, 2021). It is essential to prepare undergraduate students for employment in STEM fields, as these fields remain in high

demand and offer competitive wages for economic stability across the nation (National Academy of Sciences, 2010; Stelter et al., 2020; Xu, 2016; Xue & Larson, 2015). School-based mentoring intervention programs have shown to foster professional development skills (e.g., communication skills, intrinsic desire to help others) that are essential for supporting the overall development of students in academia since mentoring programs play a significant role in participants' professional development (Irby et al., 2017; Kroll, 2017).

I investigate the perspectives of former STEM mentors of an after-school STEM program after college graduation. For this study, I investigated the following research questions: 1) How do former STEM undergraduate student mentors describe their perception of mentorship after engaging in an after-school STEM mentoring program? and 2) How do former STEM undergraduate student mentors describe the impact of an after-school mentoring program on their professional development? I used an Interpretative Phenomenological Analysis methodology to explore the perspectives of 26 former undergraduate students in STEM who graduated from a Midwestern university and took part in an after-school STEM mentoring program. I determined IPA was the best method for the study since it allowed me to explore, describe, and interpret how participants made sense of their experiences (Tuffour, 2017). According to Thompson (2021), IPA enables researchers to account for the impending evolvement of participants associated with the phenomenon, through the development of research questions, data gathering, and interpretation of findings. I collected the data using surveys and semi-structured interviews and conducted the analysis using thematic coding.

In CHAPTER 3, I examine the perspectives of undergraduate students toward faculty mentors in science. It is well-established in the literature, that individuals may have multiple mentors across their lifetime. Experienced individuals guide and teach younger generations about procedures to follow on the job and the unwritten rules of their chosen career path (Savage et al., 2004). Mentorship applies to a variety of fields, where the mentorship relationship is often a win-win situation for the mentor and the mentee (Joshi & Sikdar, 2015). The developmental growth of individuals is directly related to the quality of the mentorship received (Arifeen, 2010).

I present a study that examines the outcomes reported by undergraduate students in science about their mentoring interactions with faculty mentors. I used the 7 stages of Meta-ethnography developed by Toye et al., (2013; 2014) to guide my study. I considered meta-ethnography a suitable method for translating studies since it enabled researchers to examine the data using two overlapping approaches by a) aggregating the findings and b) interpreting and developing conceptual categories (Toye et al., 2013), thus blending multiple strategies for understanding the phenomenon. The study consisted of 16 published qualitative studies about the perceptions of undergraduates toward science faculty mentors. I collected data in the form of qualitative studies to identify concepts that can be translated into a line of argument. The findings of the study showed that the mentorship experience with science faculty influences how students perceive science and impacts the retention of students in science. The study consisted of 16 published qualitative studies about the perceptions of undergraduates toward science faculty mentors. I collected data in the form of qualitative studies to identify concepts that can be translated into a line of argument.

In CHAPTER 4, I discuss how faculty-student mentorship is essential for the development of undergraduate students in STEM disciplines. Scholars argue that the role of faculty mentors is to aid students' development (Mertz, 2004). Several benefits of faculty-student mentorship have been examined in the literature. Mentoring is key to providing students with opportunities that can promote their development (Ramirez, 2012) and increasing the attraction of mentees toward advanced schooling and careers in STEM (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017; 2018). Faculty-student mentorship is essential for providing opportunities for growth to students in STEM fields.

I capture the perspectives of STEM faculty toward undergraduate mentorship. I explore the following research questions: 1) How does STEM faculty provide mentorship to undergraduate students in STEM? and 2) Why do STEM faculty provide mentorship to undergraduate students in STEM? I used a case study methodology to develop the study. A case study is a qualitative method involving in-depth investigation of a phenomenon. The findings of case studies are generalized to theoretical propositions by making an argumentative claim about the phenomenon. The study population comprised six STEM faculty mentors from the University of Nebraska at Omaha. I collected data using surveys and semi-structured interviews. I analyzed my data using the four mentoring constructs discussed in the theoretical framework proposed by Crisp and Cruz (2009).

CHAPTER 5 concludes the dissertation by summarizing the key findings and contributions of each study and discussing the implications of the research. Overall, my studies provide valuable insights into various aspects of STEM faculty-student mentoring engagement. Specifically, the studies presented in this dissertation contribute to the

understanding of STEM faculty-student mentoring engagement and provide insights that can inform practice in the retention rates of undergraduates in the STEM fields at institutions of higher education.

CHAPTER 2

LIVED EXPERIENCES OF FORMER STEM UNDERGRADUATE MENTORS OF AN AFTERSCHOOL MENTORING PROGRAM: AN INTERPRETATIVE PHENOMENOLOGICAL ANALYSIS

Abstract

Studies have identified gaps in the development of undergraduate students in science, technology, engineering, and mathematics (STEM). Students lack communication and problem-solving, impeding employment opportunities post-graduation. It is essential to prepare students for employment in STEM fields, as these fields remain in high demand and offer competitive wages for economic stability. Research has revealed that students gain critical thinking and problem-solving skills through student mentoring experiences. Evidence surrounding the inclusion of active learning strategies for in-classroom pedagogy has expanded in recent years, but the support mechanisms beyond the classroom remain unclear. Herein, we followed students for a decade after participation in our mentoring pre-professional training program, Nebraska STEM for You (NE STEM 4U). This phenomenological study utilized interviewing techniques and descriptive statistics to demonstrate how a midsized, metropolitan university STEM mentoring program supported the development of NE STEM 4U participants. We found that engagement in an after-school mentoring program provided participants with a model of mentorship. Participants also developed transferable professional and personal skill sets, including communication, perspectives, conflict resolution, and professional development.

I. Introduction

Institutions of higher education face challenges in supporting undergraduate student development in science, technology, engineering, and mathematics (STEM) majors. Chen (2013) found that almost 50% of STEM undergraduate students leave the field within six years. Bettencourt et al. (2020) described how first-generation STEM students are at a disadvantage when deciding to pursue STEM schooling and careers due to factors associated with implications occurring in the life of the students before attending college. The development of undergraduate students in STEM can be improved by expanding access to high-impact practices, including experiential learning programs that occur outside of the classroom (e.g., experiential learning programs, and mentoring experiences; Kuh, 2008; Snodgrass Rangel et al., 2021). Research has revealed students gain content knowledge, critical thinking skills, organizational skills, and problem-solving skills by engaging in mentoring activities (Nelson & Cutucache, 2017; Nelson et al., 2017). More specifically, studies have shown that programs occurring outside of the classroom can support the development of undergraduate students in STEM. Findings from Theobald et al. (2020) show engaging in active learning activities while in college support the development and retention of undergraduate students. Findings from Jin et al. (2019) show experiential learning opportunities such as mentoring decrease attrition rates among science undergraduate students. Bonner et al. (2019) described how mentoring experiences can support the development of undergraduates pursuing a Bachelor of Science since the experience enables students to acquire skills to prepare them for the STEM workforce. Mentorship can be essential for STEM pre-professional training

programs because it enables undergraduate students to acquire skills that can benefit their personal lives and professional careers (Irby et al., 2017).

Research efforts are largely concentrated on the impact of mentoring programs on mentees (Nelson & Cutucache, 2017; Snodgrass Rangel et al., 2021). Conversely, a dearth of studies has examined the influence of STEM mentoring programs on undergraduate student mentors, focusing on the benefits of the program on the mentors and their motivations to take part in the program (Nelson & Cutucache, 2017; Snodgrass Rangel et al., 2021; Sommers et al., 2021), with Leavitt et al. (2021) being a notable exception. Still, several questions concerning the impact of mentoring programs on developing mentoring skills require further exploration as there is a lack of longitudinal research in the scientific literature about the impact of mentoring programs on the career opportunities and advanced schooling of former STEM mentors post-graduation (Nelson & Cutucache, 2017). To date, few studies have focused on the impact of mentoring programs on former STEM undergraduate student mentors (i.e., Nelson & Cutucache, 2017). As STEM mentorship programs can assist with developing critical workforce skills, continued research regarding program outcomes, such as decisions regarding advanced schooling or education, career trajectories, and overall career preparedness post-participation should be completed utilizing larger sample sizes. These outcomes would be essential for understanding the decision-making processes undergraduate students in STEM undergo as part of their developmental process, as well as informing the benefits of experiential programs to administrators at institutions of higher education in the United States and the world at large. In addition, collecting information from

mentors would support the mentors’ development in their continued engagement with mentorship programs.

II. Background

a. Literature Review

Employer surveys identify gaps in STEM undergraduate students' skills, such as developing critical thinking and problem-solving, thereby impeding employment opportunities post-graduation (Whiting, 2021). It is essential to prepare undergraduate students for employment in STEM fields, as these fields remain in high demand and offer competitive wages for economic stability across the nation (National Academy of Sciences, 2010; Stelter et al., 2020; Xu, 2016; Xue & Larson, 2015). School-based mentoring intervention programs have been shown to foster professional development skills (e.g., communication skills, intrinsic desire to help others) that are essential for supporting the overall development of students in academia since mentoring programs play a significant role in participants' professional development (Irby et al., 2017; Kroll, 2017). However, this requires students to demonstrate ample understanding of their developmental process through their perceived experiences throughout their participation in the program to identify the support students require to matriculate toward their intended goals (Kram, 1988; Ragins & Kram, 2007). Studies report that taking part in mentoring experiences supports the professional development of individuals; as the mentoring experience plays a vital role in the developmental process for the conceptualization of mentorship (Kram, 1988) and its implications for undergraduate STEM students upon graduation (Nelson & Cutucache, 2017).

It is essential to capture the perceptions of former undergraduate students in STEM about their engagement in afterschool STEM mentoring programs to understand how experiential learning activities occurring outside the classroom supported their development after graduation. Due to the lack of longitudinal studies in the literature, the development of a follow-up study can enable researchers to identify the larger implications of the school-based intervention programs on former STEM undergraduate students across their professional careers (e.g., careers, advanced schooling). There is a need to explore the targeted effect of mentoring programs after the student's graduation to support the development and long-term impact of experiential learning programs on individuals pursuing STEM fields. This qualitative research paper aims to describe the impact of a pre-professional training and experiential learning program for undergraduates wherein they serve as mentors for youth in an afterschool STEM program.

b. NE STEM 4U

The Nebraska STEM for You (NE STEM 4U) is a pre-professional program for undergraduates that provides undergraduates with the opportunity to serve as mentors for K-8 students by engaging in after-school STEM activities (Cutucache et al., 2016).

This study focuses on the professional development of former participants of NE STEM 4U and how they conceptualize mentorship. Our goal is to contribute to the larger body of literature about the impact of experiential learning programs, more specifically, mentorship interventions on undergraduate students in STEM post-graduation. We used the following research questions to guide the study:

1. How do former STEM undergraduate student mentors describe their perception of mentorship after engaging in an afterschool STEM mentoring program?

2. How do former STEM undergraduate student mentors describe the impact of an after-school mentoring program on their professional development?

c. The Context of the Researchers (Researcher Positionality)

The first author's (PMO) positionality stems from her previous experiences as an undergraduate and current doctoral student in science, both in Puerto Rico and the mainland US. As an undergraduate, PMO was mentored by various academics in the field of wildlife biology. PMO focuses on STEM education and learning at the undergraduate level for her doctoral studies. PMO currently provides mentorship to STEM undergraduate students on how to facilitate STEM experiential learning activities for K-12 students.

While completing her Bachelor of Science, PMO developed a strong interest in informal education in STEM-related fields. As the author progressed through her undergraduate education, many of her classmates dropped out of their Bachelor of Science. Most students who continued to pursue their degrees were involved in extracurricular activities that promoted their participation in STEM, such as research experiences and mentoring programs. For her preparation as a doctoral student, she is focusing on components that support the professional development of individuals pursuing schooling and/or careers in STEM-related fields.

The second author (KVW) is a speech-language pathologist by training who is currently a doctoral candidate studying educational leadership. In addition to her doctoral

education, she holds a dual bachelor's degree in Speech Communication and Political Science as well as a Master's degree in Speech-Language Pathology. She works in the international sector, serving as a speech-language consultant at international schools, where she works with families on a global scale. She is interested in how educators can provide meaningful and equitable experiences to learners of STEM who present with speech and/or language disorders. Her role as an educator innately involves mentorship; therefore, she believes that developing mentorship skills through informal and formal programming is an important line of research. KVW was involved in a clinical mentorship as a speech-language pathologist and mentor's students intermittently. She also has been involved in formal and informal mentorships as a mentor and mentee regarding qualitative research.

The anchor author, whose lab generated the intervention and has supported the intervention through acquiring funding, staffing, training, and continuity for the past decade (CEC) is a faculty member at the institution described herein. CEC has been the beneficiary of mentoring throughout her career--from her early days as an undergraduate research mentee to and throughout an academic career providing mentoring to undergraduate and graduate students, faculty, staff, and partnership via mentoring with community partners as well.

Importantly, the intervention described within this longitudinal study is at the site of origin but has now been replicated across the state of origin and will be replicated at international sites in 2022. The anchor author is a faculty member and biomedical researcher turned discipline-based education researcher. She is the founding director of the University of Nebraska at Omaha STEM Teaching Research and Inquiry-Based

Learning Center (UNO STEM TRAIL Center). The UNO STEM TRAIL Center is “an administrative unit, it provides resources and materials to undergraduates, graduates, and faculty members at UNO and lifelong learners (reaching K-12 and adult learners) beyond. The Center does not control any curricula, as it is not an academic unit, but it does catalyze course innovations as center affiliates work through colleges to study and implement curricular change” (University of Nebraska at Omaha STEM TRAIL Center, 2021). All researchers involved with the current study are concerned with supporting students of all ages as they matriculate through STEM programs by providing quality educational experiences.

d. Theoretical Framework

We selected Vygotsky's Zone of Proximal Development Theory (Vygotsky, 1934), Kolb's (1984) Experiential Learning Theory (ELT), and Piaget's (1964) cognitive development theory as the theoretical framework since the present study aimed to understand the way former undergraduate STEM mentors reflect on and subsequently make meaning about their experiences in an afterschool STEM mentoring program and its impact on their professional development post involvement. Vygotsky's Zone of Proximal Development Theory (Vygotsky, 1934) was utilized since the theory stresses the importance of a teacher or mentor in simplifying concepts as a mechanism to support student learning. Kolb's (1984) Experiential Learning Theory (ELT) allowed us to explore the learning process and developmental growth of participants in our sample (Sternberg & Zhang, 2014) about the experiential learning experience. Piaget's (1964) cognitive development theory enabled the researchers to further explore the critical thinking and transferable skills participants developed while taking part in NE STEM 4U

(Fischer, 1980). We used Piaget's (1964) cognitive development theory to explain the impact of the participants' acquired skills on their professional development (e.g., careers, advanced schooling).

III. Method of Research

a. Qualitative Design

We followed the philosophical orientation of interpretivism to co-construct knowledge through interactions with participants and to make sense of the participants' experiences (Bhattacharya, 2017). Interpretivism can be described as "a methodological approach to social scientific study informed by such philosophies as phenomenology and hermeneutics, which focuses on how humans make meaning of their worlds." (Schwartz-Shea & Yanow, 2020, p. 2). We used interpretivism to combine our interpretations with the interpretations described by the participants. Additionally, we used an interpretative phenomenological analysis (IPA) to understand and interpret the participant's experiences (Smith et al., 1999). The IPA methodology allowed us to capture the participants' perceptions about the phenomenon of interest. We used IPA to explore our question of inquiry by capturing the extent to which an afterschool experiential learning program impacts participants long-term. The NE STEM 4U program offered a starting point to explore the larger impact of the program on former STEM undergraduate student mentors. The data were examined in two stages utilizing a double hermeneutic interpretation process, which allowed the researchers to blend the participant's and researcher's perspectives about the phenomenon (Pietkiewicz & Smith, 2014; Smith et al., 1999). The double hermeneutic effect allowed the researchers to take into consideration their reflexivity as investigators and second-order interpretation of the

participant's responses in the development of the study to contribute to the further mixing of interpretation and making of meaning (Mills et al., 2010).

IPA was the best method for the investigation since it allowed the researchers to explore, describe, and interpret how participants made sense of their experiences (Tuffour, 2017). This accounts for the impending evolvement of participants associated with the phenomenon, through the development of research questions, data gathering, and interpretation of findings (Thompson, 2021). This idiographic technique allowed us to focus on the specific objectives of the program to obtain an in-depth analysis of the perceived lived experiences of former STEM undergraduate student mentors involved in an after school program and its impact on their professional development. The goal was to capture the essence of the participant's experiences and how they make sense of them, allowing the researchers to explore the phenomenon without limiting the participant's responses to a singular direction. Subsequently, the analysis was conducted using the qualitative software program, MAXQDA (2022 ed.).

b. Participants

We recruited former participants from the NE STEM 4U program. Specifically, participants were past undergraduate students majoring in a range of STEM disciplines (i.e., biological sciences, chemistry, physics, mathematics, engineering, and business/economics) who participated in an afterschool STEM mentoring program at a midsized metropolitan university in Omaha, Nebraska, United States. Participants were between the ages of 18 and 26 when they engaged in the mentoring program, but at the time of the study, participants were between the ages of 22 and 32. All demographic information was self-selected by the participants. While participants were provided the

opportunity to identify as non-binary, all participants identified as either male or female. An array of racial/cultural backgrounds (e.g., Asian, Hispanic, African American) were present in the data set. The number of participants and percentages associated with these categories can be found in Table 1.

Table 1. Participants Demographic Information

Description	n	(%)	Description	n	(%)
Sex*			Highest degree obtained*		
Female	13	50	Advanced degree	10	38
Male	13	50	Bachelor's degree	16	62
Race			Current profession or schooling		
White	21	81	Non-STEM	1	4
Person of color*	5	19	STEM	25	96

Notes. Participants could select to identify as non-binary or not report their sex; however, all 26 participants identified as either female or male. None of the participants reported having intersex characteristics. We combined racial backgrounds and the acquisition of master's and doctoral degrees to protect the identity of the participants.

c. The Setting of the Site of Intervention

The study was conceptualized in Omaha, Nebraska, United States. The population of the city of Omaha consists of 50.7% females and 49.3% males, including 66.2% White, 14.1% Hispanic, and 12.1% Black individuals (U.S. Census Bureau, 2021). Specifically, the study was conducted at the University of Nebraska at Omaha (UNO). UNO has an undergraduate student population of 54% females and 46% males, of which 25% are underrepresented minorities (IPEDS, 2019). Undergraduate students include 64% White, 14% Hispanic, and 7% Black (IPEDS, 2019). UNO has a higher female percentage of undergraduate students. Still, the gender distribution of the participants of

the study mirrors the identified gender of the population of Omaha. UNO's undergraduate student body closely mirrors Omaha's population race demographics. Compared to Omaha (66.2%) and UNO (64%), the study had an overrepresentation of Whites (81%).

Former STEM undergraduate participants of the mentorship program, NE STEM 4U were recruited for this study. NE STEM 4U provides undergraduates with the opportunity to serve as mentors for K-8 students by engaging them in after-school STEM activities. Undergraduates provide mentorship to just over 500 youth each year. NE STEM 4U is a pre-professional program for undergraduates started in 2012 as a pilot, with full expansion in 2013, with over 150 undergraduate STEM student mentors taking part in the intervention since its inception.

d. Data Collection

We recruited participants for the study by sending an invitation to 81 past graduates/alum that served as mentors in the NE STEM 4U afterschool mentoring program while enrolled at UNO. Past studies have revealed the response rate of former participants of programs is 15-39% (Allen, 2003; Eby et al., 2005); thus, the researchers expected approximately 25 participants to agree to take part in the study. To participate in the present study, participants were required to be former mentors in the NE STEM 4U program; thus, no current participants of the program did not meet the inclusion criterion to participate in this study. A non-randomized criterion-based purposeful sample selection was utilized to represent the perspectives of participants, as opposed to targeting a specific population (Smith et al., 2009).

We interviewed 26 former STEM mentors using a semi-structured interview schedule containing questions drawn from Nelson and Cutucache (2017; Table 2). Nelson and Cutucache's (2017) study explored the perceptions of former undergraduate students in STEM of the NE STEM 4U mentoring program; however, the study was limited to seven participants. This study aimed to further develop the interview questions posed by Nelson and Cutucache (2017) to further investigate the impact of NE STEM 4U on former participants of the program.

A doctoral graduate student completed and recorded the interviews. Interviews were transcribed verbatim to analyze and interpret the transcripts using the hermeneutic phenomenological model proposed by Heidegger (1927). We utilized the analytical IPA process by Smith et al. (2009) to code and analyze transcripts. The coding and analysis process of the transcripts followed an interpretative phenomenological analysis approach.

Table 2. Interview Questions for Participants in the Longitudinal Study on the NE STEM 4U Intervention

Interview Questions

1. What does it mean to be a mentor?
2. Have you engaged in mentoring in your profession or current position?
    a. What does that mentorship look like?
3. Do you have mentors?
    a. Who are those people and why do you feel they are your mentors?
4. How do you perceive and describe the impact of the NE STEM 4U program on your professional development, both personally and professionally?

e. Data Analysis

First, the first and second authors immersed themselves in the data by reading and re-reading the transcripts while listening to the audio recordings. This provided a more

comprehensive analysis by focusing on the participant. Second, the authors engaged in initial noting to generate initial notes and detailed comments on the data. We started by noting comments on the most complex transcript (Smith et al., 2009) based on the data read in the first step. In the third step, we developed emerging themes that both reflected a description of the participant's perspectives and the researcher's interpretation of the data; thus, applying a double hermeneutic analysis. The themes were organized chronologically in the order they emerged. This iterative process was then used across all participants. We utilized a codebook, which was developed as themes emerged after reviewing all cases. After developing the codebook, each author coded the cases independently.

f. Trustworthiness

We meet the validity criteria for our IPA study by asking KVW to conduct an independent audit to consider legitimate accounts about the responses from the participants that were both systematical and transparent. As discussed in the ethical considerations, KVW was not part of the data collection process of the study, nor was she involved at any point in the NE STEM 4U. We further ensured the trustworthiness of the study by completing inter-coder reliability with all twenty-six transcripts using the codebook. To ensure accuracy, each transcript was coded independently by the first and second authors. In the initial coding stage, coders showed an overall agreement of 51%. We solved disagreements through discussion, ultimately reaching an overall agreement of over 95%. The description of codes evolved throughout the coding process as examples were found in the data. After redefining the codes, all previously coded transcripts were re-examined to code the data with the newly defined codes. The coding was a highly

iterative process, involving prolonged engagement and exposure to each participant's individual transcript, allowing researchers to discuss their interpretations of the data. We ensured the trustworthiness of the findings by crystallizing the data using multiple ways of collecting data, including semi-structured interviews, inter-coder reliability, and employing the researcher's reflexive journal (Love et al., 2019). The first author engaged in reflective research diary notes after each interview and during the phenomenological interpretative process of analysis to account for and identify the researcher's orientation and biases (Love et al., 2019; Smith et al., 2009).

IV. Ethical Considerations

The Institutional Review Board at the University of Nebraska Medical Center/the University of Nebraska at Omaha approved the study protocols, procedures, and (protocol #711-21-EX). The first author (PMO) interviewed participants who gave full informed consent to participate in the study. Before and during the interview process, participants were encouraged to inform the first author (PMO) if they had questions or inquiries about the study. The researcher informed the participants that they could withdraw from the study at any time if they felt uncomfortable or unable to continue taking part in the interview and that withdrawing from the study would not impact the participant's relationship with the researchers, university, or NE STEM 4U. Pseudonyms were created by the first author (PMO). To ensure confidentiality, the other co-authors (KVW, CEC) were blinded from the participant's personal information and were not part of the transcription process for the interviews. The first author (PMO) attempted to utilize names that were not gender-specific and that were culturally neutral, to mitigate the risk of bias. As the third author is the principal investigator and the director of the NE STEM

4U program (CEC), she did not have access to the participants' information. Additionally, she did not participate in data collection or analysis, only in data presentation, visualization, writing, and editing.

V. Findings

We used our codebook to identify the conceptualization of mentorship and skills gained and interpreted by the participants via the experiential learning activity. We found that engagement in an after-school mentoring program provided participants with a model of mentorship. Participants developed professional and personal skillsets that promoted their overall development as STEM professionals. None of the participants share concerns or negative consequences from their experience in the program. Our themes include communication, perspectives, conflict resolution, and professional development.

a. Assertion 1: Engagement in NE STEM 4U Provided Program Participants with a Model of Mentorship

Involvement in NE STEM 4U provided participants with a model of how-to mentor. Seven program participants noted that Dr. Sisu, the program director, served as their mentor and subsequently taught them about mentorship. For example, Pongo stated that Dr. Sisu was a mentor to him and his involvement in the program and relationship supported his mentoring skills. He stated that involvement in the program, "helped me mentor a lot of kids that I wasn't really used to, I wasn't really used to being around kids. But it helped me grow, being more professional and more mature around kids and trying to make them become the best versions of themselves in the present and also the future."

Program participants noted that participation in the program offered an introduction to mentorship. For instance, Stika stated, “NE STEM was a great low-pressure introduction to mentorship and what it means to be a good mentor,

which is that you're trying to meet the students where they're at and develop a positive relationship and shape them positively in any way that you can, even if it's just a tiny bit, or if it's a lot. Anything you can do is good.” Involvement in the program offered an introduction to mentorship that program participants may otherwise not have been privy to.

b. Program Involvement and Conceptualization of Mentorship

Participants connected NE STEM 4U and the program director of NE STEM 4U, Dr. Sisu, to mentorship throughout the interview, suggesting that participation in the program impacted perceptions of mentorship. Across the 26-participant dataset, 23 participants mentioned NE STEM 4U, describing it as a positive experience. In the case of Sitka, a Ph.D. student in biological sciences, NE STEM 4U was an impactful experience shaping his overall perception of what mentorship is. This experience-based approach offered a deepened perspective regarding how mentorship should look. These findings align with Piaget’s (1964) cognitive development theory since program participants constructed meaning through their involvement in the program:

> It has a lot more impact than I ever would have thought when joining NE STEM. In NE STEM in general, I learned what it means to be a mentor. Because the reason that I specified the two definitions of mentor that I gave earlier, which one is that its mentee focused and the kind of older version his mentor focus is

> because I thought that I was going to help people learn about, these middle school kids learn about science and go-to polish for science. And when I went to the schools, I realized that they just really wanted to have fun. (Sitka)

One participant, Naveen, a Ph.D. candidate in biological sciences, made note of NE STEM 4U when conceptualizing mentorship and how he began thinking about the role of mentorship during his time at NE STEM 4U. His experiences as well as his relationship with the program director, Dr. Sisu, resulted in an improved conceptualization of mentorship*:* “And I've remained in contact with Dr. Sisu and have got a lot of my early training in mentorship and my philosophy on mentorship through those early years in NE STEM” (Naveen).

Dr. Sisu was mentioned on 19 occasions by seven different participants, suggesting that she had a mentor-mentee relationship with over 25% of the individuals who participated in the program in either a formal or informal capacity. Several participants overtly noted that Dr. Sisu served as a mentor or currently serves as a mentor even after graduation. For instance, Naveen revealed that he remains in contact with Dr. Sisu. Pongo, a post-baccalaureate student and pharmacy technician, echoed that he also currently maintains contact with Dr. Sisu, who serves as a mentor. Anita, who was pursuing a degree as a physician assistant but is transitioning to business, indicated that Dr. Sisu served as a mentor, but Lady has not stayed connected with Dr. Sisu to the same extent as when she was in NE STEM 4U. Lady, a current undergraduate student, and former NE STEM4U participant, also mentioned that Dr. Sisu served as a mentor both personally and professionally. Dr. Sisu modeled mentorship, which served as a mechanism to train program participants who went on to experience how to mentor:

> I feel I can also go to Dr. Sisu for personal issues. I don't seem to have very many personal issues. I guess that's a blessing of mine, but I do have a good support network at home and things like that outside of that as well. I don't know your account like your mom, and you know people like that but they're also mentors and people that I look up to. (Lady)

c. Assertion 2: Participants Developed a Professional and Personal Skillset after Participating in an After-School Mentoring Program

We asserted that involvement in an undergraduate STEM mentorship program would foster skills that could be translated into careers. This was supported by participants with a unanimous consensus that NE STEM 4U developed an array of transferrable skills, such as communicating with individuals from diverse backgrounds and improving understanding of basic STEM content knowledge. This supports the assertion that program involvement may result in long-term benefits that support individuals as they matriculate past the context of an undergraduate degree. For example, current high school teacher Sarabi said: “I have to communicate with other teachers and case managers and administration every single day. NE STEM 4U perfectly prepared me for that more than I thought it would.”

d. Communication and Transferable Skills

Anastasia revealed NE STEM 4U fostered the acquisition of skills that supported her organizational and management skills. Anastasia's statement serves as an example of how NE STEM 4U allowed her to extend the skills she acquired during her time in the program to professional settings beyond her undergraduate years. Anastasia also

described how she gained skills that can be used and applied with other populations, regardless of the setting, revealing NE STEM 4U enables participants to obtain transferable skills such as communication. Her experience aligns with Kolb's (1984) ELT since she was trained, was reflective about the skills that were being developed, learned from her experiences, and subsequently generalized her experiences to other contexts:

> Professionally, I definitely developed organizational skills, having the responsibility of reaching out to community partners and facilitating events helped me to gain that skill of how to act and interact within a professional environment. I think probably those are the main ones. The interpersonal skills that more so came from really paying attention to classroom management, and how those skills can be translated to more general situations. And then professionally, just in terms of organization and management. (Anastasia)

Florian accredited his experience with NE STEM 4U in fostering communication skills, as he noted that he has differing perceptions than children and thus learned how to communicate more effectively with an array of individuals while also developing his understanding at a fundamental level. Like Anastasia, Florian thought more critically about his own understanding of the material he taught. He also made the connection that students require guidance to succeed, which aligns with Vygotsky's (1934) work on the zone of proximal development. His communication was critical for supporting students who may otherwise not be able to independently understand concepts:

Another benefit that I got from my involvement in NE STEM...There's moreover from a professional viewpoint is thinking about science at a more fundamental level. Because I think in a normal class setting, in my class, college class setting, when you're

learning about science, there are certain things that we tend to take for granted. Versus when you're trying to explain a concept to an 11-year-old. That 11-year-old doesn't have the same set of assumptions that you do. You really have to boil it down and go very deep into fundamentals and try to build the entire thing from scratch. I think that has helped me in that setting, in that sense too, to improve my ability to think about science at a deeper and more fundamental level. (Florian)

e. Perspectives and Conflict Resolution

The NE STEM 4U mentoring program enabled participants to acquire skills consistent with the highest stage of self-authorship, contextual knowing, by obtaining skills such as conflict resolution, taking other people’s perspectives, and applying these perspectives to how they conceptualize mentorship. For example, Giselle revealed her experience at NE STEM 4U enhanced her ability to solve problems by gaining new perspectives from others. Giselle's perceptions about NE STEM 4U demonstrated she gained experiences that promoted the acquisition of attributes that supported the development of her self-authorship:

> I think the NE STEM program was helpful for me in developing how to work with others in a collaborative sense in teaching. Not only teaching with other people, but also in a way of developing lesson plans, collaborating, bouncing ideas off of each other, mentoring new people on the position. (Giselle)

Sebastian, however, described NE STEM 4U as it exposed him to a population of students that are in different situations than him growing up. NE STEM 4U allowed Sebastian to get involved with students from backgrounds that differed from his; thus,

enabling him to have access to various viewpoints. Sebastian identified circumstantial differences between him and the OPS students he mentored; however, exposure to these individuals revealed that all children have similarities regardless of context. NE STEM 4U exposes participants, such as Sebastian, to environments that they may not otherwise have known existed. This opportunity provided new experiences that allowed him to further construct his own perceptions of the world around him, which aligns with Piaget's (1964) cognitive development theory:

> I came from a small town, and then coming here and going into the under-funded schools or schools that I guess didn't have the resources to teach as well as maybe my school did growing up. I never really saw things like that when I was growing up. You get an appreciation for some of those kids, because they might not be in the best situation, but they're still really good kids. And they're just the same as when I was growing up. (Sebastian)

f. Professional Development

Although participants in the NE STEM 4U program are financially compensated for the time spent mentoring K-8 grade students, one participant, Pongo, elected to volunteer for NE STEM 4U despite having the opportunity to be paid for his time. Pongo revealed that he believed that volunteering for NE STEM 4U assisted his professional development. Pongo's experience revealed NE STEM 4U contributed to his professional growth as a mentor because after engaging in the program his beliefs about mentorship shifted toward a student-centered approach to best support their development:

> Dr. Sisu gave me one of the biggest opportunities that I had, which was NE STEM 4U. And it wasn't just based on that I needed some extracurricular activities to apply for medical schools. But on top of that, when I actually volunteered there in NE STEM 4U, I feel like it developed me in a really professional way. And then it helped me mentored a lot of kids that I wasn't really used to, I wasn't really used to being around kids. But it definitely helped me grow, being more professional and more mature around kids and trying to make them become the best versions of themselves at the present and also the future. (Pongo)

Sarabi made note that NE STEM 4U has benefited her as a classroom teacher as it has taught her necessary administration skills as well as supported her ability to work with children. The program exposed her to children from an array of backgrounds and supported her ability to initiate and sustain relationships, a necessary skill for any educator. While she did not explicitly connect her role to mentorship, she did speak about the benefit of the program:

> And then professionally, the mentoring it helped me. Obviously, I'm a teacher. I'm working with kids. It helped me with working with kids. And being in that professional environment, but still being able to make and maintain these relationships with the kids, better at that professional level. But then also NE STEM 4U, I don't know if this applies because I was also an officer, which blends in with the mentoring, but it was just... NE STEM 4U was my first experience with being held accountable for a big job and making sure that I'm communicating with the right people, which is something that I have to do every

> day. I have to communicate with other teachers and case managers and administration every single day. NE STEM 4U perfectly prepared me for that more than I thought it would. (Sarabi)

VI. Discussion

We investigated participation in an experiential learning program by providing a decade-long, longitudinal reflection on the impact metrics of the program. The data presented herein demonstrate that the NE STEM 4U program provides tangible benefits beyond a student's participation. For example, the program helped participants develop skillsets that could be applied to experiences as they enter an advanced schooling program or the workforce. Participation in NE STEM 4U supported students to explore skillsets they may otherwise have not been exposed to in their undergraduate experience. Taken together, NE STEM 4U provided a safe space for students to develop a skill that otherwise could not be independently learned, thus providing a zone of proximal development (Vygotsky, 1934).

Likewise, participants also were involved in mentoring; therefore, engaging in experiences that support learning (Kolb, 1984; Piaget, 1964). This practical application allowed participants to extend knowledge beyond theory, resulting in an intellectually stimulating and hands-on opportunity. All participants noted that they developed skills, including skills in the areas of communication, conflict resolution, administration, and perspective-taking while deepening their fundamental understanding of science, which is consistent with findings in previous works (Bonner et al., 2019; Nelson & Cutucache, 2017).

For example, Esmeralda expressed NE STEM 4U aided her ability to communicate complex medical concepts with a population that does not have her clinical background. Likewise, Giselle expressed that she acquired transferable communication skills such as teaching in NE STEM 4U that she used for her doctoral training in nursing. Similarly, Anita revealed her time in NE STEM 4U provided her with communication skills that allowed her to explain complex topics interactively. Kenai, who is the vice-president at a technology start-up company, described that involvement in the NE STEM 4U program supported his professional development by demonstrating the importance of patience. This skill set has been important as he engages in business opportunities.

In addition, some participants noted how NE STEM 4U fostered their overall development, including broadening perspectives. For example, Anastasia noted that NE STEM 4U supported her understanding of conflict resolution, specifically in applying this skill to her current context as a medical student since her role relies on working with a team of people to resolve problems. Anastasia also stated she learned leadership and classroom management which have been helpful as she has matriculated into her career. This was evidenced when she reported how these skills are being used currently.

We asserted that involvement in an undergraduate STEM mentorship program would foster skills that could be translated into careers. This was supported by participants with a unanimous consensus that NE STEM 4U developed an array of transferable skills, such as communicating with individuals from diverse backgrounds and improving understanding of basic STEM content knowledge. It is noteworthy that all participants acknowledged that they had obtained or developed beneficial, transferable skills post-involvement in the NE STEM 4U program. This supports the assertion that

program involvement may result in long-term benefits that support individuals as they matriculate past the context of an undergraduate degree. This assertion is supported by the following statement from Sarabi: “NE STEM 4U perfectly prepared me for (the workforce) more than I thought it would.”

In relation to mentorship, the participants described how the skills acquired while taking part in NE STEM 4U allowed them to effectively support mentees and learners from backgrounds that either resembled or differed from theirs. Florian expressed how the mentorship skills he learned at the NE STEM 4U program allowed him to tailor the way he provides mentorship and guidance to students from various educational levels. For example, by describing basic knowledge and background associated with science topics to K-8 students, as opposed to providing university-level concepts. As described by Florian, this phenomenon is opposed to the explanations he would provide to STEM undergraduates because it is expected that students at this level possess a basic understanding of scientific topics.

a. Strengths

There are several strengths to our research project. A wide range of career stages and academic degrees were represented in the project, including employed individuals and students pursuing advanced degrees. These factors may have added diversity to the broader applications of pre-professional STEM programs across multiple fields after college graduation. Participants from NE STEM 4U have been studied for multiple years, providing distinct perspectives on the program's evolution.

b. Limitations

The study has several limitations. Our study was conducted with individuals who attended the same institution to pursue their bachelor's degree in STEM; therefore, the participant's perspectives may be limited to the experiences acquired while completing college in a single institution. We acknowledge the bias in these data because they are inclusive solely of one location (i.e., the metropolitan university participant in NE STEM 4U), and only over 10 years. Due to the nature of conducting the interviews years after college graduation, the participants may have been influenced by external factors and experiences. Because of this, we may not have captured all details pertaining to the phenomenon under study.

VII. Conclusion

The findings of the study shed light on the importance of taking part in pre-professional STEM programs while in college. Taking part in an experiential learning program such as NE STEM 4U can provide undergraduate students with an array of transferable skills. Participants may continue to use these skills after college graduation while engaging in the workforce and pursuing advanced schooling. The study demonstrates how regardless of major or career stage, pre-professional programs have a positive impact on the professional development of participants.

Future studies should focus on analyzing programmatic data about the experiences of participants in mentorship using mentoring theories such as the Triangular Model of Mentor Competence proposed by Johnson (2003). Using existing mentoring theories could aid to inform the development of codes relevant to the experiences of participants with mentees in relation to factors such as emotional balance, relationship structure, and peer mentorship, among others.

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IX. Student-faculty mentorship engagement in science

In the previous section (CHAPTER 2), I discussed the benefits STEM undergraduate students obtain after engaging in a STEM after-school program. In CHAPTER 3, I will explore the perspectives of science undergraduate students toward science faculty mentors. The following study gathers the viewpoints of science undergraduate students from multiple institutions of higher education. I aim to capture the influence science faculty have on science undergraduates and its implications in the decision-making processes of students to pursue advanced schooling and careers in science. Overall, I aim to capture how faculty influence the feelings of students toward science.

CHAPTER 3

UNDERGRADUATE MENTORSHIP IN SCIENCE: A QUALITATIVE SYNTHESIS

Abstract

The developmental growth of individuals is directly related to the quality of the mentorship received. Mentoring is a common practice in higher education institutions and scientific fields. Students reach out to faculty members who are working on topics that match their research interests. Our study aimed to develop a qualitative synthesis of studies about the mentorship experience of undergraduate students in science with faculty mentors. We used the stages of Meta-ethnography to guide our study. Meta-ethnography involves identifying concepts from qualitative studies that can be translated into a line of argument. We screened 2,888 titles and abstracts, 71 full texts, and included 13 studies in the synthesis. We identified nine conceptual categories, which were organized into two themes: positive experience and negative experience. Our model conceptualizes the outcomes of faculty mentorship on students. Our model shows faculty mentorship has many ramifications that influence the decision of students to pursue advanced schooling and careers in science. Experiences in mentorship with faculty influence how students perceive science and prematurely impact the retention rate of students in science. Our model highlights how faculty mentorship influences the feelings of students toward science. The mentorship experience with faculty mentors is key to supporting retention and increasing the scientific pipeline. Faculty's negative actions and behaviors toward mentees discourage students from the sciences. While a positive mentorship experience can encourage students to stay in the field.

I. Introduction

Individuals may have multiple mentors across their lifetime. Experienced individuals guide and teach younger generations about procedures to follow on the job and the unwritten rules of their chosen career path (Savage et al., 2004). Mentorship applies to a variety of fields, where the mentorship relationship is often a win-win situation for the mentor and the mentee (Joshi & Sikdar, 2015). The developmental growth of individuals is directly related to the quality of the mentorship received (Arifeen, 2010).

There is no consensus among scholars about a universal operational definition of mentorship (Jacobi, 1991). Scholars use a multitude of definitions for the construct of mentorship (Johnson et al., 2007). In some cases, entities and scholars define mentorship to support their research. For example, the National Academies of Sciences, Engineering, and Medicine (NASEM, 2020) defines mentorship as "a professional, working alliance in which individuals work together over time to support the personal and professional growth, development, and success of the relational partners through the provision of career and psychosocial support" (p. 2). Galbraith and Cohen (1996) defined mentorship as "a one-to-one interactive process of guided developmental learning based on the premise that the participants will have reasonably frequent contact and sufficient interactive time together" (p. 5). While there are many definitions of mentorship in the literature (e.g., Johnson 2003; Kram, 1983), we choose to focus on the definition provided by O'Neil and Wrightsman (2001), where the researchers believe mentorship starts "when a professional person serves as a resource, sponsor, and transitional figure

for another person (usually but not necessarily younger) who is entering that same profession" (p. 113). Ultimately, mentoring is the process where a more experienced individual may provide personal and professional support to a less experienced individual (Russell & Adams, 1997).

There are two primary types of mentoring: formal and informal mentorship. Formal mentoring involves identifying mentors and mentees using established criteria, documenting the number of hours of mentor-mentee interactions, and setting a deadline for the mentoring experience (Joshi & Sikdar, 2015). There are several issues associated with formal mentoring (Kram & Bragar 1992) since mentors are expected to follow predetermined guidelines during the mentorship relationship. In academic settings, research has shown that faculty do not respond well to instructions on how to mentor their students (Johnson, 2003). There is debate over how formal mentoring imposes a mentorship style on mentors and mentees. As an alternative, researchers have proposed that mentees should start the mentoring interaction by identifying mentors who match their interests via informal mentoring (Eby & Allen, 2002). Informal mentoring enables mentees to identify mentors who show "potential" (Johnson et al., 2007) since students can work with mentors who can support their development.

II. Background

a. Literature Review

Informal mentoring is a common practice in higher education institutions. Students reach out to faculty members who are working on topics that match their research interests. Faculty mentorship has been proposed to be a key to retaining students

in science (Joshi et al., 2019). Students gain several benefits from faculty mentorship (e.g., Behar-Horenstein et al., 2010; Chan, 2008), including discussing career goals (Jacobi, 1991), providing guidance in research settings (Johnson, 2003), and defining clear expectations for the undergraduate mentorship experience (Shellito et al., 2003). Pioneering findings from Kram (1983) show mentees seek to identify mentors that can provide psychological support (e.g., counseling, validation) and career support (e.g., networking, training). Findings from Aikens et al., (2016) showed faculty mentors support the intellectual development of students by describing the importance and impact of the research mentees are conducting. Faculty mentors can also serve as role models (Jacobi, 1991). Some faculty members show resistance toward becoming role models to students because they are not comfortable being in that position (Olson & Nayar-Bhalerao, 2020). Faculty members felt uncomfortable about the prospect of being an example to be imitated by students, both personally and professionally.

Findings from Johnson (2003) showed faculty mentors can support the development of students by providing a positive mentorship experience and educating mentees about the unwritten rules of the field. Mentoring interactions are highly complex (Johnson & Huwe, 2002) because best practices in mentorship involve scaffolding the experiences of students to support their development (Boysen et al., 2020). According to Tenenbaum et al., (2001), a “positive bias” perspective implies the favorable judgment of individuals in their ability to accomplish specific actions. Academic administrators believe faculty have the skills to provide a positive mentorship experience where this assumption stems from a "positive bias" perspective (Duck, 1994, p.8).

Findings from Johnson (2007) showed that one bad mentorship experience suffices to discourage students from pursuing advanced schooling and careers in science, which impacts the retention rates in the field. Findings from Limeri et al., (2019) showed students perceive a lack of interest in faculty supporting their psychosocial and career development. The students in Limeri's study believed faculty lacked an intrinsic motivation to mentor. As a result, faculty were unknowingly discouraging students from pursuing advanced schooling and careers in science (Limeri et al., 2019). Faculty mentors can strengthen the interest of students in pursuing a career in science (Revelo & Loui, 2016). Still, there is conflicting evidence in the literature about the mentorship experiences of students with faculty members in science. More studies should focus on how faculty mentorship influences the feelings of students toward science. Our study aimed to develop a qualitative synthesis of studies about the mentorship experience of undergraduate students in science with faculty mentors. We investigated the following research question: What outcomes are reported by undergraduate students in science about their mentoring interactions with faculty mentors?

III. Methodology

We used the 7 stages of Meta-ethnography developed by Toye et al., (2013; 2014) to guide our report. We considered meta-ethnography a suitable method for translating studies since it enabled researchers to examine the data using two overlapping approaches by a) aggregating the findings and b) interpreting and developing conceptual categories (Toye et al., 2013), thus blending multiple strategies for understanding the phenomenon. Meta-ethnography involves identifying concepts from qualitative studies that can be translated into a line of argument.

a. Data Collection - Meta-ethnography Stages

1) Getting started: Establishing the rationale and objective of the study

Noblit and Hare (1988) describe this stage of the study as identifying a topic of interest in the field. The rationale for our study is that there is conflicting evidence in the literature about the mentorship experiences of undergraduates in science with faculty mentors since student's report having positive and negative interactions with faculty (e.g., Houser et al., 2013; McCoy et al., 2017). It is essential to develop a line of argument to synthesize findings from multiple studies, identifying overlapping and contradictory evidence about mentorship experiences in undergraduates in science.

2) Deciding what is relevant: Completing the literature search, screening, and quality appraisal of articles

We employed a comprehensive literature search strategy to include full reports of studies focusing on the experiences of undergraduate students in science with faculty mentors. Since meta-ethnographies rely on high-quality reports, the inclusion criteria comprised full published articles of qualitative studies. The primary goal of the literature search was to identify articles reporting the outcomes of the experiences of undergraduate students with faculty mentors. We limited the search criteria to include articles in the English language published between the years 2010 to 2020. We excluded studies conducted in the years 2021 and 2022 to avoid biases and skewed findings because of the COVID-19 pandemic. We conducted a literature search on the electronic databases ERIC (ProQuest) and Web of Science. We supplemented the study search by completing

backward citation searching and by searching for related articles using the academic resource, Google Scholar (Haddaway et al., 2015).

We used the Population, Intervention, Comparison, Outcomes (PICO) framework as a reference for developing the study research question and identifying words for the literature search (Methley et al., 2014). The literature search targeted undergraduate students in science (Population) taking part in mentoring experiences (Intervention) and focused on qualitative findings (Outcomes). We opted to exclude the Comparison section of the framework from the article search to maximize the potential number of relevant records identified from the databases. We used the 3-stage search words and strategies for identifying relevant qualitative articles proposed by Shawn et al., (2004) for the Comparison section of the PICO framework, including thesaurus, free-text, and broad-based terms. We completed three searches using the 3-stage search strategies proposed by Shawn et al., (2004), one search for each strategy. The purpose of implementing this approach was to maximize the number of relevant reports included in our study. The combination of literature search terms used in the PICO framework can be found in Table 1.

Table 1. Population, Intervention, Comparison, Outcomes (PICO) framework

P	(undergraduate student* OR college student* OR higher education OR postsecondary OR university student* OR institutions of higher education OR higher education institute* OR HEI* OR college* OR universit*) AND (STEM OR science OR technology OR engineering OR mathematics OR STEAM OR STEMM) AND

I	(ment*) AND
C	1) Thesaurus (stage 1) (qualitative research OR qualitative stud* OR research methodology OR questionnaire OR survey OR focus groups OR discourse analysis OR content analysis OR ethnographic research OR ethnological research OR constant comparative method OR qualitative validity OR purposive sampl* OR observational research OR field stud* OR theoretical sampl* OR phenomenology OR phenomenological research OR life experiences OR cluster sample*) 2)Free-text (stage 2) (ethnograph* OR phenomenol* OR grounded theor* OR grounded stud* OR grounded research OR grounded analys?s OR life stor* OR action research OR cooperative inquir$ OR cooperative inquir$ OR co-operative inquir$ OR emic OR etic OR hermeneutic* OR heuristic* OR semiotic* OR data saturat* OR participant observ* OR social construct* OR postmodern* OR post structural* OR interpret* OR action research OR co-operative inquir* OR humanistic OR existential OR experiential OR paradigm* OR field stud* OR field research OR human science OR biographical method* OR qualitative validity OR purposive sampl* OR theoretical sampl* open-ended* OR unstructured* OR narrative* OR life world OR conversation analys?s OR theoretical saturation OR lived experience* OR life experience* OR cluster sampl* OR theme* OR thematic analysis OR constant comparative OR discourse analys?s OR discurs* OR narrative analys?s) 3)Broad-based (stage 3) (findings OR interview* OR qualitative) AND
O	N/A

The first author (PMO), a doctoral student, screened the titles and abstracts of the extracted articles in the literature search. Upon encountering uncertainty about including studies, the anchoring author (CEC) provided insight after reading the titles and abstracts. We included qualitative articles that focused on the impact of faculty mentoring on

undergraduate student mentors. We implemented an appraisal evaluation of studies to assure the articles' findings were found on the participants' experiences and grounded on inductive reasoning (Toye et al., 2013). The authors used the Critical Appraisal Skills Programme (CASP, 2018) for appraising qualitative research as Toye et al., (2014) suggested. We classified the articles into three categories: fatally flawed, satisfactory, and key paper (Toye et al., 2013; 2014). A fatally flawed (FF) paper comprised weak methodologies involving inconsistent research design and data analysis, while a satisfactory paper (SAT) contained information lacking connection to the synthesis. Key papers (KP) included conceptually rich findings that could contribute to synthesizing qualitative studies. PMO completed the appraisal of articles. PMO consulted any questions about the quality appraisal of studies with CEC and implemented the feedback to the selection of papers. PMO and CEC used their scientific expertise and researcher positionalities to inform the selection of studies for the project (see Martínez Oquendo et al., 2022). The quality appraisal yielded the following results: FF=6 (26%), SAT=6 (26%), and KP=11 (48%). Only articles categorized as satisfactory papers or key papers were potential studies for the data analysis. Fatally flawed articles were excluded from the study. Table 2 shows a description of the excluded studies. Seventeen articles advanced to stage three.

Table 2. Excluded studies

Author, Year	**Field**	**n**	**Data collection**	**Methodology**	**Category**
Daniels et al., 2019	STEM	17	Semi-structured interviews	Grounded theory	FF

Gildehaus et al., 2019	Science	24	Focus groups	Non-mentioned	FF
Gross et al., 2015	STEM	25	Interviews, Questionnaires	Grounded theory	FF
Marrero et al., 2017	STEM	*N/A	Focus groups	Non-mentioned	FF
Phiri, 2019	Engineering	14	Survey	Non-mentioned	FF
Quan & Eby, 2016	Mathematics	9	Semi-structured interviews	Case-study	FF

*Note: Marrero et al., 2017 doesn't mention the number of participants in their study.

3) Reading the studies: Identifying relevant concepts

We uploaded PDF versions of the selected studies into qualitative software, MAXQDA Analytics Pro 2022, to keep track of our analytical decisions. PMO and MDV read the reports to decide which articles aligned with the study research question. Ultimately, 13 studies were used for the data analysis. In this stage, PMO and MDV identified and differentiated first and second-order constructs to eventually develop third-order constructs (Noblit & Hare, 1988; Schutz, 1962). First-order constructs are the participant's interpretations and responses to the questions posed by scholars via interviews, focus groups, and surveys, among other methods, from the published articles. Second-order constructs are the researcher's interpretations of the participant's responses, commonly known in qualitative research as findings. Researchers abstain from interpreting first-order constructs since the goal is to re-interpret findings from published articles. The data used for meta-ethnographies are the second-order construct developed by the original researchers of qualitative studies. The findings from the meta-ethnography are the third-order constructs, which are the interpretations of second-order constructs.

The process for identifying and developing constructs for the meta-ethnography can be found in Figure 1.

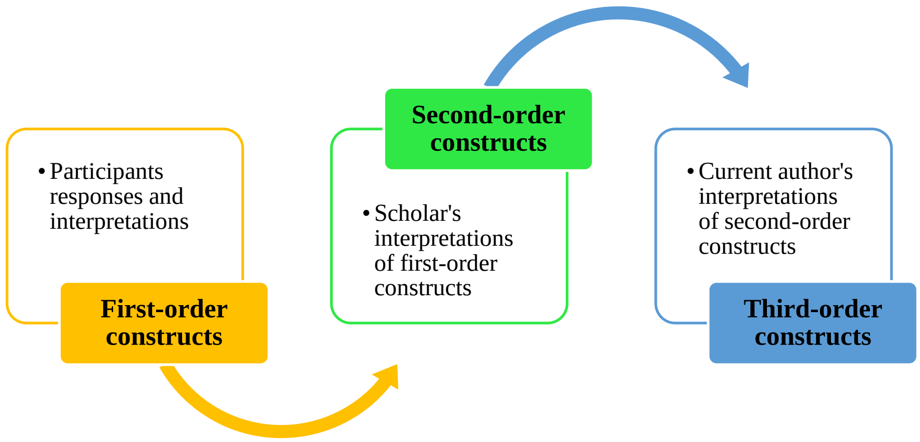

Figure 1. Identification and development of constructs (adapted from Toye et al., 2017)

4) Determining how the studies are related: Developing a list of metaphors and ideas using second-order constructs

PMO determined how the studies were related using the developed list of second-order constructs (Noblit & Hare, 1988) by comparing the differences and similarities among studies.

5) Translating studies into each other: Organizing themes into conceptual categories

PMO analyzed the data using constant comparison analysis (Figure 2) to develop conceptual categories (Creswell & Guetterman, 2019). Constant comparison analysis aims to distill the translatable concepts into themes (Walters et al., 2006).

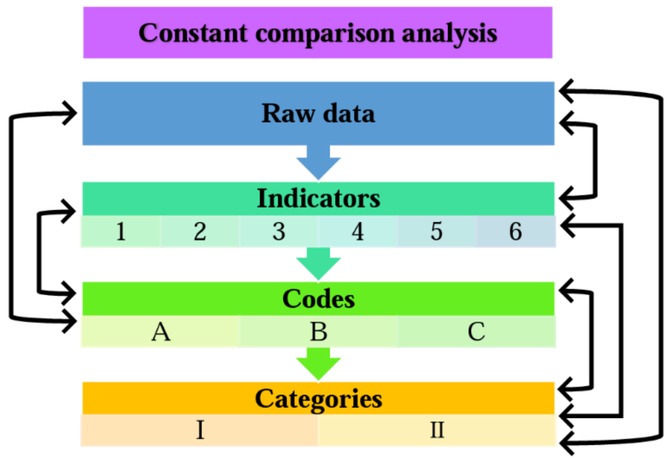

Figure 2. Constant comparison analysis (adapted from Creswell & Guetterman, 2019)

6) Synthesizing translations: Making meaning of the conceptual categories

PMO organized the themes into a conceptual model. We intended to develop an interpretative line of argument grounded in the data (Noblit & Hare, 1988).

7) Expressing the synthesis: Disseminating the findings

We developed a line of argument to include "similar and contrasting ideas from primary studies" (Toye & Barker, 2020, p. 4) using the conceptual model, which allowed us to accept and rebut translatable ideas simultaneously.

IV. Results

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to record the inclusion process of articles (Page et al., 2021). Figure 3 shows the systematic search process during the study. We screened 2,888 titles and abstracts and 71 full texts. We assessed 23 articles for quality appraisal. We excluded 4

studies because of the misalignment of the reports with the research question. We included 13 articles in the final analysis.

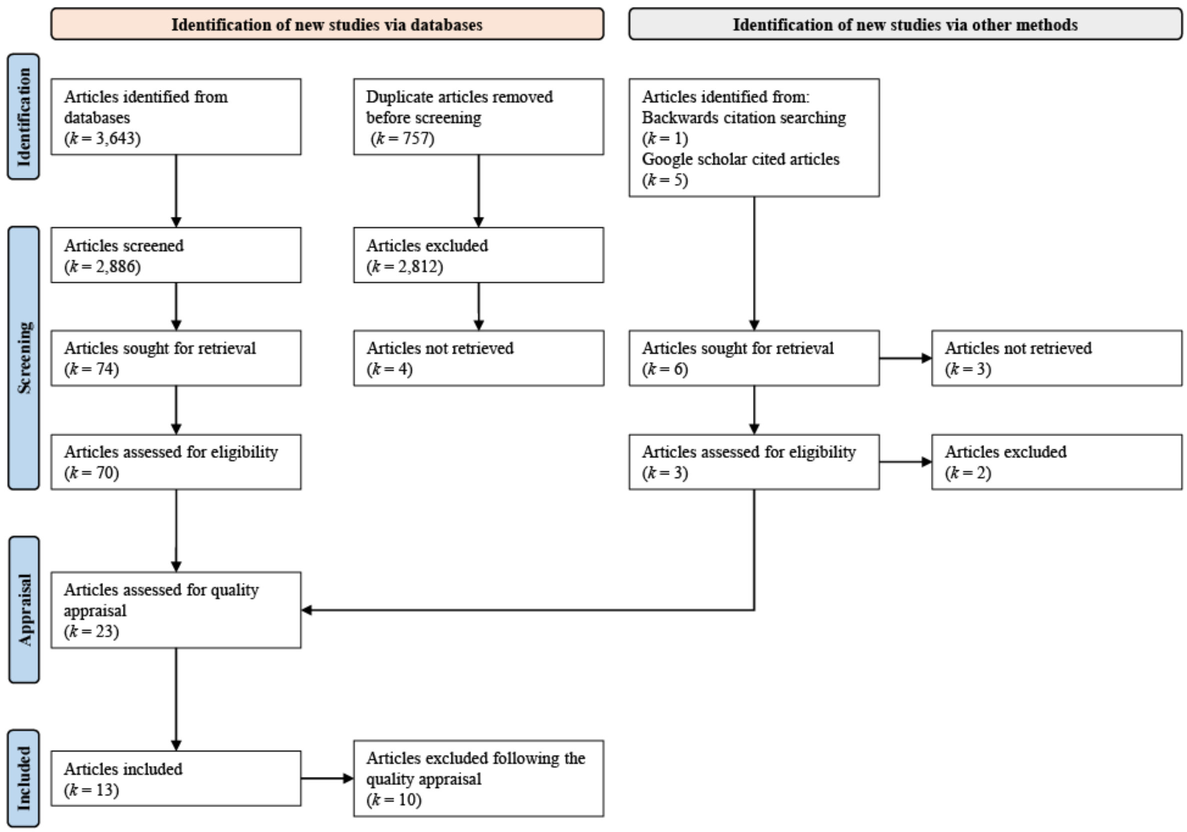

Figure 3. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

We identified the attributes of the studies while completing the quality appraisal. Table 3 shows the field of focus, the number of participants (n), data collection strategy, methodology used in the data analysis, and the results of the quality appraisal of the included studies. The studies included the experiences of 281 undergraduate students from colleges and universities in the United States.

Table 3. Attributes and quality appraisal results of the articles

Author, Year	**Field**	**n**	**Data collection**	**Methodology**	**Category**
Bruthers & Matyas, 2020	Science	25	Interviews	Narrative	SAT
Burt et al., 2020	STEM	20	Interviews	Thematic analysis	KP
Byars-Winston et al., 2020	Science	15	Semi-structured interviews	Phenomenology Case study Thematic analysis	KP
Houser et al., 2013	Science	23	Focus groups	Thematic analysis	SAT
Jackson, 2013	STEM	5	Semi-structured interviews	Thematic analysis	SAT
Limeri et al., 2019	STEM	33	Semi-structured interviews	Thematic analysis	KP
Listman & Dingus-Eason, 2018	STEM	6	Semi-structured interviews	Phenomenology	KP
Majocha et al., 2018	STEM	5	Interviews	Interview study	KP
McCoy et al., 2017	STEM	31	Semi-structured interviews	Case-study	SAT
McMahon et al., 2019	STEM	20	Focus groups	Non-mentioned	KP
Prunuske et al., 2016	STEM	15	Focus groups	Phenomenology	KP
Thiry & Laursen, 2011	STEM	73	Semi-structured interviews	Non-mentioned	KP
Trott et al., 2020	STEM	10	Semi-structured interviews	Non-mentioned	KP

PMO identified nine conceptual categories, which were organized into two themes (Figure 3): (1); Positive experience (2), Negative experience.

Figure 3. Conceptual categories organized into themes

Eight concepts did not align with our research question and/or were lacking sufficient data to make any claims for the study; thus, we opted to exclude them from our data analysis. Table 4 shows the excluded concepts.

Table 4. Concepts excluded from the analysis

Excluded concepts	
1. Communication	5. Personality of mentors
2. Time commitment	6. Physical appearance of mentors
3. Intrinsic motivation	7. External mentors
4. Lack of motivation	8. Future mentors

Descriptions and examples of the themes of positive experience and negative experience can be found below:

a. Positive experience - Support from faculty mentors promotes the development of undergraduate students

The theme of positive experience describes the interdependence of the support provided by faculty in the development and feelings of belonging in students. Students felt supported when the faculty took their time to provide orientation to students on how to accomplish personal achievements in science, such as entering graduate school. The guidance and support provided by mentors enabled students to feel better prepared for future challenges in their professional trajectories.

> *The mentors supported students via actions by engaging in regular meetings with students and providing information about external research opportunities that could aid the professional development of students and graduate school admission chances of mentees. (Majocha et al., 2018)*

Students welcomed the idea of feeling like they belonged in science. The feelings of belonging extended to being present at lab meetings or conducting experiments. Students needed to feel like the faculty mentors wanted them to be in the scientific environment, even after graduating college in areas such as graduate school.

> *Students appreciated the successful attempts from faculty in making them feel more included in lab efforts. (Majocha et al., 2018). Belonging or inclusiveness was important. Examples included in-person interactions with their peers, feeling respected, accessibility, guidance, and investment of mentors and the lab team. (McMahon et al., 2019)*

Feelings of belonging with the support received by faculty created a snowball effect that increased the retention of students in science. Students believed in staying in an environment where they felt supported and as if they belonged there. The support

provided by faculty started feelings and/or encouraged students to continue in the sciences and pursue advanced degrees in the field. Most students expressed their interest in attending graduate school, which may lead to a higher number of students and retention rates in science long-term.

> *Mentors served as a resource for helping students think about career and graduate school possibilities and mentors' encouragement is important for students to hear (Thiry & Laursen, 2011). The mentor is key for supporting the retention of students in STEM fields. (Houser et al., 2013). This may have allowed students to gain essential skills to navigate potential advanced schooling and/or careers in science. (Listman & Dingus-Eason, 2018)*

The development of students was also associated with the retention of students. Mentees needed to know and feel their mentors believed in their abilities to conduct experiments using trial and error. Students sought to find solutions to scientific problems by overcoming obstacles that emerged while performing experiments in the lab with the help of their mentors. The combination of experiencing failure and the support provided by faculty enabled students to develop scientific reasoning and pivot when experiments failed.

> *The mentors have prioritized the student's insight over following rules and protocols. The students were not required but were encouraged to engage in the exploration of the projects. The mentors encouraged creativity and ideas. The students were provided support for developing ideas that had the potential to be communicated with the scientific community via conferences or manuscripts. (Houser et al., 2013) Emotional and personal support by being accessible,*

> *available, and receptive to students' ideas to help students be willing to take intellectual risks. (Thiry & Laursen, 2011).*

Making miscalculations and errors got students thinking about the cause of those mistakes. Students experienced the daily activities of scientists. Faculty mentors guided students in the process of finding solutions to problems until mentees were able to problem-solve on their own. Positive engagements with faculty mentors made students more receptive to pursuing advanced schooling and careers in science, while also promoting the development of students by guiding them through the scientific process.

b. Negative experience - Lack of support from faculty mentors hinders the development of undergraduate students

The theme of negative experience describes how the lack of support from faculty members in mentorship hindered the scientific development of students. The unrealistic expectations from faculty mentors during the research made students feel as if they didn't belong in science, which ultimately impacts the retention rate in scientific fields.

Lack of support covered many areas in the mentorship experience. Many students expressed being left alone during the research process. Faculty mentors expected students to conduct experiments without training, which left students feeling like science was not as rigorous as they initially thought it was.

> *Mentors were a source of frustration for students. An unpleasant experience with a mentor can ruin the entire mentoring experience for students. (Houser et al., 2013). The unavailability of the mentors had a direct negative impact on the project being developed by the mentees. The lack of guidance from mentors*

caused projects to go off track and for mentees to perform tasks that didn't align with the project because of a lack of knowledge and direction. Students were forced to guess what was the correct approach to take given the circumstances or to decide the next steps for the project without having a proper idea of what they were doing. The students strongly believed all the mistakes made throughout the project could have been avoided if the mentor had been available to answer questions about the project (Limeri et al., 2019).

In contrast, some students found the scientific process was not a process at all. Students felt like data-producing machines that didn't know why they were doing what they were doing. Students were not aware of the importance of the research they were conducting nor felt like they were learning or acquiring any skills or knowledge. Students were executing menial tasks or completing repetitive tasks every time they were in the lab, with no mental stimulation.

Some students expected the research process to be continuously and intellectually challenged by learning new things constantly via their engagement in the project. Still, students found that doing research involves repeating daily tasks to get data. Students were following protocols, which didn't allow them to expand their knowledge toward new learning experiences or stimulate/advanced their learning. Students were just repeating the same tasks without variation in their routines, which didn't match the student's expectations about research. (Limeri et al., 2019)

Scholars argue that performing experiments involve step-by-step directions that do not challenge students at the intellectual level (Modell & Michael, 1993). These

recipe-like activities expose students to an inaccurate representation of scientific research (Cox & Davis, 1972). These activities impede students from taking part in authentic research experiences, which involves scientific process of developing research questions, making mistakes, analyzing results, and interpreting findings (Modell & Michael, 1993). There may be an existing argument that the scientific process involves repetition, which may be the reason students felt there was no variation in their daily tasks at the lab. However, students felt that being scientists involved more than just doing the same thing every day.

Students from my sample wanted to feel like "real" scientists by using critical thinking skills to solve problems. Students believed they could engage in problem-solving but could not resolve scientific challenges. The students were unable to engage in the scientific process of developing research questions, making mistakes, analyzing results, and interpreting findings; therefore, students were not participating in authentic research.

The unrealistic expectations in research led students to believe science involves surrendering having a personal life to conduct research.

> *Students described faculty as sometimes too ambitious with their projects and expected students to stay in the lab more time than initially discussed for the sake of the research. It seems the faculty didn't understand or take into consideration the commitments students had outside of the lab, which may include academics, part-time jobs, and personal life. (Prunuske et al., 2016)*

Students felt the lack of work-life balance was an invisible problem in science since they were expected to agree to stay in the lab for extended hours without protesting. Ultimately, students viewed science as a self-sacrificing field.

Students felt their mentors didn't care about them professionally and personally. Students developed feelings of helplessness because of the power dynamics that exist in student-faculty relationships. The interactions with faculty mentors made students feel like they didn't belong in science. The lack of motivation from mentors impacted the professional development of students. Mentees felt they were not good enough or deserving of becoming scientists. Students believe becoming scientists was an unachievable goal because of their engagements with mentors. The idea that scientists don't make mistakes may have left students with the depiction that scientific research is a process where experiments always work and there is no room for error.

> *The students interpreted the absenteeism of the mentors as a sign of not being worthy enough for the mentor's time. The students felt the mentors didn't care about them or their development as professionals in scientific fields. The students felt they were not good enough to pursue science. The lack of interest from the mentors in the development of the mentees installed in them the perception that they didn't belong in the science. Ultimately, the unavailability of mentors impacted the sense of belonging of students to science. Students may think: I am not made to be a scientist. Scientists don't make mistakes in the lab, but I do. I can't be a scientist. (Limeri et al., 2019)*

Lack of support and lack of development in combination with unrealistic expectations from faculty and a lack of feeling of belonging from mentees resulted in a lack of retention of students.

> *Developing relationships with mentors impacted every stage of the mentee's professional path, including the area of expertise, graduate school, and careers. The outcomes of mentoring relationships went beyond the program, showing how a single mentor can impact the professional path, STEM pipeline, and retention of students in the sciences. The interaction of mentors with students is key for the future of science since a person might deter students from continuing in the sciences. Students who have one bad mentorship experience may decide to leave science because of their unpleasant experience with a mentor. However, it may also be the case that having one good mentor could outweigh a bad mentorship experience. Still, if the student's first mentorship experience is a negative one, this could lead students to leave the sciences without hesitation because of the rough introduction they receive in the sciences in their first and only mentorship experience. (Trott et al., 2020)*

The mentorship experience with faculty mentors is key for supporting retention and increasing the scientific pipeline. The combination of multiple negative actions and behaviors (e.g., lack of support, lack of development) from faculty toward mentees deters students from the sciences. Students who initially sought to pursue advanced schooling and careers in science will change majors to engage in nonscientific fields. Negative experiences with faculty will also cause students who were unsure of what career path to

pursue to never again consider the sciences as a potential professional trajectory to take part in.

c. Conceptual model – The mentorship experience with faculty influences the decision of students to stay in the sciences

We developed a conceptual model (Figure 4) to visualize the outcomes of faculty mentorship on students. The findings of meta-ethnographies go beyond conceptual categories. Our model shows faculty mentorship has many ramifications that influence the decision of students to pursue advanced schooling and careers in science. Experiences in mentorship with faculty influence how students perceive science and prematurely impact the retention rate of students in science. Our conceptual model highlights the protagonists and antagonists impacting the experience of undergraduate students in science. Our model demonstrates the struggles students with negative mentorship experiences undergo as they navigate college and the experiences of students who have positive mentorship experiences. Finally, our model highlights how faculty mentorship influences the feelings of students toward science.

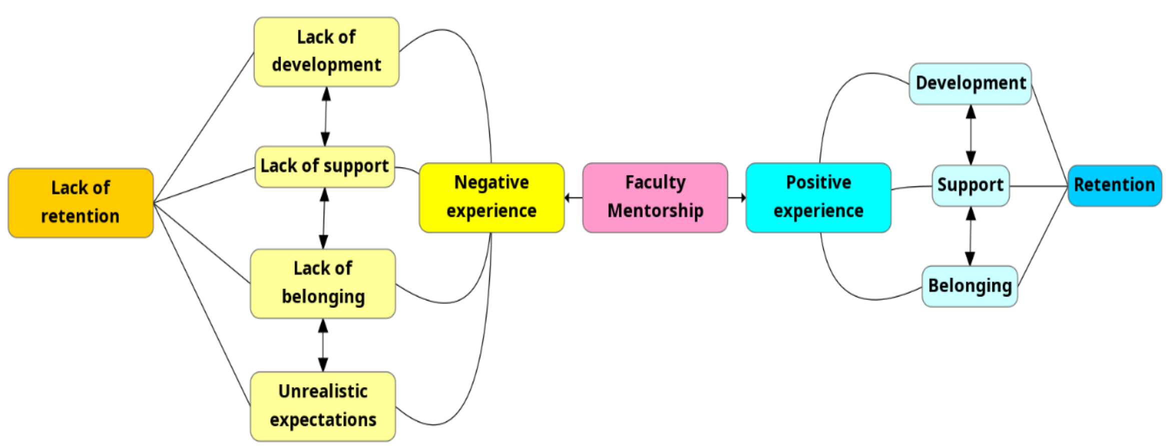

Figure 4. Faculty mentorship conceptual model

V. Discussion

The present study presents two conceptual categories: positive experience and negative experience. These categories can aid in identifying factors that influence the feelings and retention rates of undergraduate students in science that engage with faculty mentors. In particular, the ramifications of taking part in a mentorship experience where mentees feel supported and are engaging in experiences that foster their development and feelings of belonging in science. The study also presents feelings of lack of support and lack of development from students toward faculty mentors.

Our findings show how the mentorship experience of undergraduate students with faculty mentors can influence the decision of students to stay in science. Our findings show students appreciate the support provided by faculty. Faculty mentors are essential for the development of students because of their dedication to the mentoring process. The willingness of faculty to provide a positive experience may depend on the responsibility they have toward the development of their students. Exposing mentees to opportunities that can promote their development and increase their feelings and belonging in the field has a direct impact on the decision-making process of students to persist in science. All of this is also true when students have a negative experience with faculty.

Negative mentorship experiences can instill feelings of unworthiness in students. Mentees may feel that engaging in science is a waste of time. Students may feel faculty mentors are uninterested in supporting their professional competence. Some students may feel that science is not a rigorous process, and that faculty don't provide the guidance

mentees need to succeed in the field. The perceived unrealistic expectations of students to the demands of faculty mentors may leave mentees with feelings of lack of work/life balance in professional mentoring relationships. Negative interactions with faculty mentors can lower the expectations of students toward science; thus, impacting the perception and feelings of belonging of mentees toward the field.

There are several similarities between our piece of work and the findings from Kram (1983). For example, Kram found mentees seek to engage in mentoring activities that can support their psychological and career functions. Findings from our study parallel the findings from Kram because mentees sought to increase their professional development via the support of faculty mentors. Similarly, the positive mentorship experiences perceived by students overlap with findings from Revelo and Loui (2016), because faculty mentors can strengthen the interest of students in pursuing a career in science. The negative mentorship experience of students from our study coincides with findings from Johnson (2007) and Limeri et al., (2019) because bad mentorship experiences can discourage students from pursuing advanced schooling and careers in science.

VI. Conclusion

We can draw important mentorship considerations and implications from the study. Findings from this study will inform the impact of faculty mentorship on undergraduate students in science. The findings will also expand on outcomes of existing knowledge on the application of methods for synthesizing the qualitative output of

undergraduate mentoring. The support provided to students by faculty mentors may be the key to increasing retention rates in scientific fields. It is essential to proactively hire and/or seek faculty members that can provide a positive mentorship experience to students. It is counterintuitive that faculty members pursue a career that involves daily engagements that support the development of students, but neglect to provide mentees with opportunities for growth. The behaviors and actions of faculty toward mentorship may evolve as they navigate academic careers (e.g., assistant professor, associate professor, professor). Research is needed to comprehend and identify factors that support the development and behaviors of faculty for providing students with a positive mentorship experience. There may be a connection between the career stage of faculty and the type of mentorship provided to students since mentoring actions and behaviors are likely to have a direct impact on the retention rates of students in science. Future research should address the intrinsic motivation and lack of motivation of faculty mentors in providing mentorship as they progress in their academic careers. On the other hand, it is possible that students perceive a source of poor mentoring from faculty members because of the structural elements that disincentivize or create barriers for faculty to provide good mentorship. Future studies should explore the barriers faculty members face in providing a positive mentorship experience for students.

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Faculty-student mentorship engagement in STEM

In the previous section (CHAPTER 3), I discussed the perspectives of science undergraduate students toward science faculty mentors. The following study gathers the perspectives of STEM faculty toward undergraduate mentorship. I aim to identify STEM faculty actions and behaviors that may influence the retention rates of STEM undergraduate students at institutions of higher education. My objective is to present the intrinsic motivation STEM faculty have toward student mentoring in STEM. I also explore the benefits undergraduate mentees may obtain from faculty-student mentorship in STEM fields.

CHAPTER 4

THE PERSPECTIVES OF STEM FACULTY TOWARD UNDERGRADUATE MENTORSHIP: A CASE STUDY

Abstract

The purpose of this study was to capture the perspectives of science, technology, engineering, and mathematics (STEM) faculty toward undergraduate mentorship. We addressed the following research questions: 1) How does STEM faculty mentor undergraduate students in STEM?; 2) Why do STEM faculty mentor undergraduate students in STEM? We used a case study methodology to answer our research questions. A case study is a qualitative method involving the in-depth investigation of a phenomenon. We recruited participants by sending a survey to faculty members in STEM in the College of Arts and Sciences at the University of Nebraska Omaha (UNO). Our sample consisted of six STEM faculty members from UNO. We used the theoretical framework proposed by Crisp and Cruz (2009) and deductive reasoning to develop a pre-defined list of codes for the study. We identified four themes: 1) Providing psychological support to students, 2) Elevating the professional independence of students, 3) Supporting the professional path of students, and 4) Learning from the behaviors and actions of faculty. We found that the STEM faculty-student mentoring engagement involves a strong psychological support component. We limited our data collection to STEM faculty members from a single institution. A future study could focus on capturing the perspectives of STEM faculty from multiple colleges and universities. As institutions of higher education are aiming to increase the retention rates of undergraduates in STEM, universities should hire STEM faculty who care about the psychological welfare of

students. Employing and maintaining STEM faculty who value and support students as individuals is paramount to retaining undergraduates in STEM fields. Additionally, the STEM faculty-student mentoring engagement presents a reciprocal relationship, in which faculty also get benefits from mentoring students. This aids in the retention of faculty at institutions of higher education as well.

I. Introduction

Faculty-student mentorship is essential for the development of undergraduate students in science, technology, engineering, and mathematics (STEM) disciplines. Mertz (2004) suggested that the role of faculty mentors is to aid students' development. Several benefits of faculty-student mentorship have been examined in the literature. Mentoring is key to providing students with opportunities that can promote their development (Ramirez, 2012) and increasing the attraction of mentees toward advanced schooling and careers in STEM (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017; 2018). Faculty-student mentorship is essential for providing opportunities for growth to students in STEM fields.

Researchers in STEM disciplines have argued faculty mentors may not fulfill the mentorship responsibilities depicted in the literature (e.g., Johnson, 2003; Olson & Nayar-Bhalerao, 2020). There is debate about using the word "mentor" at institutions of higher education (Ramirez, 2012) since faculty avoid being role models to students (Olson & Nayar-Bhalerao, 2020). Faculty members might feel "intimidated" by the idea of becoming role models for students because mentors may still be figuring out their personal and professional paths in life (Olson & Nayar-Bhalerao, 2020)

In contrast, faculty might feel privileged to be role models for undergraduates in STEM. Mentors' intrinsic motivation to support undergraduates may be why STEM faculty choose to serve as role models. Mentorship involves a significant time investment (Revelo & Loui, 2016), and there is no compensation for the time spent mentoring students (Schwartz, 2012). Stills, findings from Olson and Nayar-Bhalerao (2020) showed faculty mentors unintentionally become role models for students, by providing psychological and career support to undergraduates. Undergraduates look up to mentors for adopting actions and behaviors students may implement with their own mentees later in their personal and/or professional lives. Therefore, having a faculty mentor that can serve as a role model may be more important for students than having a faculty "mentor" that only focuses on the research performed in the lab.

Mentoring experiences with faculty have been shown to promote the retention rates of undergraduate students (Behar-Horenstein et al., 2010) and play an important role in the engagement of mentees in their fields (Boysen et al., 2020). Faculty-student mentorship promotes positive outcomes for mentees (Pascarella & Terenzini, 2005). Mentors can support students' psychological and career development (Fuesting & Diekman, 2017). Kram's (1983) pioneering findings on mentorship showed mentors provide psychological functions (e.g., role modeling, confirmation, counseling, friendship) and career functions (e.g., sponsorship, exposure, visibility, coaching). Similar findings from Jacobi (1991) showed mentors provide emotional, psychological, and career advice and serve as role models to mentees. Multiple studies have shown mentorship has many ramifications, suggesting mentors fulfill multiple roles when engaging with students. Findings from Behar-Horenstein et al., (2010) demonstrated

mentorship provides students with essential resources to succeed in their academic endeavors. Mentorship promotes activities such as listening (Galbraith & Cohen, 1996), communication (Chan, 2008), discussion of career goals (Stelter et al., 2020), and providing clear expectations for the mentorship relationship (Johnson, 2002). Faculty are tasked with fulfilling many roles as mentors and completing academic and administrative responsibilities.

Several scholars have provided definitions for mentorship in the literature. Rhodes (2002) defined mentorship as a relationship "between an older, more experienced adult and an unrelated, younger protégé – a relationship in which the adult provides ongoing guidance, instruction, and encouragement aimed at developing the competence and character of the protégé" (p. 3). Galbraith and Cohen (1996) defined mentorship as "a one-to-one interactive process of guided developmental learning based on the premise that the participants will have reasonably frequent contact and sufficient interactive time together" (p. 5). While NASEM (2020) defines mentorship as "a professional, working alliance in which individuals work together over time to support the personal and professional growth, development, and success of the relational partners through the provision of career and psychosocial support" (p. 2). While there are many definitions of mentorship in the literature, we focused on a definition that targets the transitional stage of students from undergraduates to advanced schooling and/or employment in STEM disciplines. We used the definition provided by Roberts (2000), where a mentor is "a formalized process whereby a more knowledgeable and experienced person actuates a supportive role of overseeing and encouraging reflection and learning within a less

experienced and knowledgeable person to facilitate that person's career and personal development" (p. 162).

There is a plethora of research that captures the perceptions of students toward faculty mentorship in STEM (e.g., Aikens et al., 2016; Ceyhan & Tillotson, 2020; Dolan & Johnson, 2010). Still, more studies are necessary to capture the perceptions of STEM faculty in the mentorship relationship with undergraduate students in STEM. We aimed to capture the perspectives of STEM faculty toward undergraduate mentorship by answering the following research questions: 1) How does STEM faculty mentor undergraduate students in STEM?: 2) Why do STEM faculty mentor undergraduate students in STEM?

II. Background

a. Literature review

Findings from Olson and Nayar-Bhalerao (2020) demonstrated faculty mentorship promotes increased graduation rates of students in STEM disciplines. Hamilton et al., (2019) carried out similar work, where researchers found mentorship improves the retention rates of students. Direct interaction with faculty via mentorship can enhance students' critical thinking skills and increase mentees' desire to persist in STEM disciplines (Joshi et al., 2019; Moghe et al., 2021). Faculty are essential for supporting the intellectual development and conceptual knowledge of students. Findings from Aikens et al., (2016) showed faculty enable students to interpret the importance of STEM in society. Students gain knowledge about the unwritten rules of the field via interaction

with mentors (Johnson, 2003; Moghe et al., 2021), which may enable mentees to better navigate challenges within STEM disciplines.

Davis and Jones (2017) showed mentorship also impacts the perceived research competence of students. Developing a faculty-student mentorship relationship allows students to have a greater sense of belonging and perception of themselves as researchers (Davis & Jones, 2020; Moghe et al., 2021). Still, the success and retention rates of undergraduates in STEM may depend on the faculty-student mentorship quality and interaction (Behar-Horenstein et al., 2010). Findings from Allen et al., (1997) showed mentors perceive more benefits than costs when engaging with mentees, such as taking on leadership roles, increased confidence and interpersonal skills, and feeling fulfilled and valued by helping students. Limeri et al., (2019) showed the mentorship experience of undergraduate students in STEM depends on the intrinsic motivation of faculty to mentor.

However, faculty may find that undergraduates are a source of frustration because the limited experience of students restricts the productivity of the lab group (Dolan & Johnson, 2010). The lack of motivation of faculty to serve as mentors is perhaps exacerbated by the lack of support from colleges and universities (Davis et al., 2020). Faculty feel pressured by higher education institutions to bring more research funding, since research funding is often necessary for promotions in STEM disciplines at colleges and universities (McKinsey, 2016). Institutions of higher education should provide more support to encourage faculty to establish mentoring relationships with students (Davis et al., 2015). Academic administrators should reward the faculty who provide mentoring to students (McKinsey, 2016) since mentorship impacts the time faculty can dedicate to

other academic tasks (Adedokun et al., 2016). A reward system may include providing additional financial compensation as an incentive for supporting students via mentorship. Faculty may also receive accolades and/or recognition awards as a form of appreciation for their accomplishment as mentors. Institutions of higher education may also reduce other time barriers for faculty in exchange for mentoring, such as fewer teaching hours. In addition, departments can consider the achievement of faculty in undergraduate mentorship for academic promotions, such as acquiring tenure status at the university.

b. Theoretical framework

We used the theoretical framework proposed by Crisp and Cruz (2009) to guide the study. Crisp and Cruz (2009) provide four mentoring constructs that have been explored in previous research (e.g., Crisp, 2008; Crisp, 2009; Nora & Crisp, 2007). Crisp and Cruz (2009) described the following four mentoring constructs: 1) psychological and emotional support, 2) support for setting goals and choosing a career path, 3) academic subject knowledge support aimed at advancing a student's knowledge relevant to their chosen field and (4) specification of a role model.

Psychological and emotional support entails providing moral support, listening, problem-solving, offering assistance, and establishing a reciprocal mentor-mentee relationship. Mentors receive feedback from mentees (Kram, 1988), as they see them as equals. Mentors offer support for building the self-confidence of mentees (Schockett & Haring-Hidore, 1985).

Support for setting goals and choosing a career path involves evaluating the strengths and weaknesses of mentees for their professional development. Mentors aim to

explore the ideas and beliefs of mentees to guide them in making career-related decisions (Levinson et al., 1978). Mentors engage in the development of mentees as they enter early adulthood by providing support and suggestions on personal actions (Cohen, 1995).

Academic subject knowledge support aimed at advancing a student's knowledge relevant to their chosen field refers to advancing the knowledge of mentees about the field. Mentors support the academic success of mentees, as well as provide mentees with basic skills to initiate their engagement in the field (Kram, 1988). Mentors engage mentees in challenges that support their intellectual development (Schockett & Haring-Hidore, 1985). In this construct, mentors aim to show mentees the concept of accountability by owning mistakes and taking credit for their accomplishments (Kram, 1988). Mentors encourage mentees to share their achievements with others and provide networking opportunities, as well as protect mentees from issues happening within the field (Schockett & Haring-Hidore, 1985). Mentors serve as sponsors for students by providing assistance and support along the professional trajectory of mentees (Levinson et al., 1978).

The specification of a role model refers to "the ability of the mentee to learn from the mentor's present and past actions as well as his or her achievements and failures" (Crisp & Cruz, 2009, p. 540). Mentors share life experiences to support the development and decision-making processes of mentees for subjects about careers. The pair may further develop their relationship by personalizing the mentorship experience (Kram 1988). Mentees learn by observing the behaviors and actions of mentors, including conflict resolution, engaging in partnerships, and managing work-life balance (Schockett & Haring-Hidore, 1985).

Olson and Nayar-Bhalerao (2020) suggested STEM faculty may not fulfill the four constructs proposed by Crisp and Cruz (2009) while providing mentorship to students. We argue that STEM faculty will perceive they support the four constructs proposed by Crisp and Cruz (2009) since mentors may fulfill many roles while engaging with students.

III. Methodology

We used a case study methodology to answer our research questions. A case study is a qualitative method involving the in-depth investigation of a phenomenon. Case studies establish analytical generalizations instead of statistical generalities. The findings of case studies are generalized to theoretical propositions by making an argumentative claim about the phenomenon. Our study used the three major phases of case study research designs, including 1) defining and designing the study; 2) preparing, collecting, and analyzing individual data; and 3) analyzing data as a group and concluding. Figure 1 shows the research design for our study.

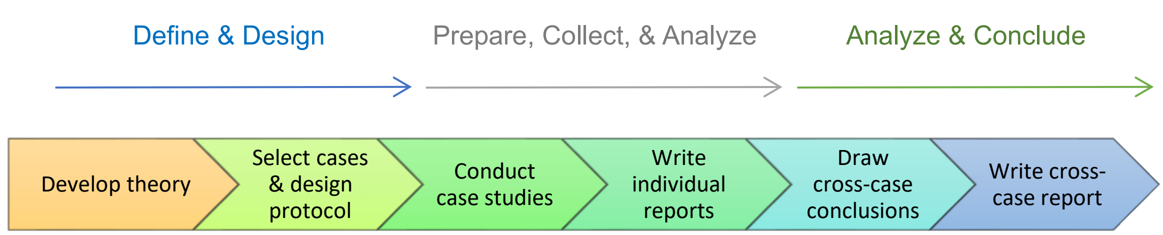

Figure 1. Case-study research design

a. Recruitment of participants

We recruited participants by sending a survey to faculty members in STEM in the College of Arts and Sciences at the University of Nebraska Omaha. The University of Nebraska Omaha is classified as a high research activity institution (R2) by the Carnegie Classifications of Higher Education Institutions. We purposely selected faculty who have a reputation for supporting undergraduate students. Survey questions included demographic information and the STEM field practiced by the faculty members. Our sample consisted of six faculty members at the University of Nebraska Omaha from the STEM fields. Our participants included faculty at various academic ranks, including full professors, associate professors, assistant professors, and instructors. We have refrained from providing any other demographic information about the faculty members to protect the identity of the participants.

b. Data collection

We used two sources of evidence for data collection: archival records (i.e., surveys) and interviews. The multiple sources of evidence corroborated findings about the phenomenon. We developed an interview protocol representing the study's line of inquiry. Interview questions were based on the findings and recommendations for future research from Olson and Nayar-Bhalerao (2020) (Table 1). PMO performed semi-structured interviews with participants. PMO transcribed the audio recordings verbatim using a combination of transcription programs and revisions by researchers.

Table 1. Interview questions of the study

Interview Questions
1. How do you provide mentorship to undergraduate students?
2. Why do you implement mentoring for undergraduate students?
3. How would you describe yourself as a mentor?
4. Why would you describe yourself as a mentor?
5. How do you think undergraduate students would describe you?
6. Why do you think undergraduate students would describe you that way?
7. How would you describe your purpose as a mentor?
8. Why would you describe your purpose as a mentor?
9. How do you believe you embrace the identity of a mentor?
10. Why do you believe you embrace the identity of a mentor?

c. Data analysis

We used the theoretical framework proposed by Crisp and Cruz (2009) and deductive reasoning to develop a pre-defined list of codes for the study. We used deductive reasoning because our project sought to test a theoretical proposition. As per O'Leary (2007), "Deductive reasoning moves from general theory down to particular examples" (p. 7). We examined the data "to ascertain whether there is any credible evidence that its premises and predictions are indeed valid" (Beighton, 2021, p. 7).

We analyzed the data using a constructivist approach. We sought to capture the perspectives of participants about the phenomenon by co-constructing knowledge and explaining the meaning of the candidates' responses. We assessed the quality of the research design by implementing a) internal validity; b) external validity; and c) reliability. By making inferences about the data, internal validity explains how and why events lead to outcomes. External validity identifies theoretical frameworks that align

with the research questions. Reliability establishes a protocol to replicate studies. Case studies are difficult to replicate; however, providing instructions on how studies were developed can maximize opportunities for replication. The data was analyzed using theoretical propositions. We followed the theoretical proposition established at the beginning of the study, which was based on the aim of the project, research questions, and literature review. Olson and Nayar-Bhalerao (2020) suggested STEM faculty may not fulfill the four constructs proposed by Crisp and Cruz (2009) while providing mentorship to students. We argue that STEM, faculty can support the constructs proposed by Crisp and Cruz (2009) since mentors may fulfill many roles while engaging with students. Therefore, our theoretical proposition – STEM faculty will perceive they fulfill the four constructs suggested by Crisp and Cruz (2009) in the faculty-students mentorship relationship – was traced among participants.

d. Inter-coder reliability

We triangulated our findings by implementing inter-coder reliability. The inter-coder reliability examines "the degree to which different raters or judges make consistent estimates of the same phenomenon" (Multon & Coleman, 2018, p. 863). We aimed "to assess the extent of agreement between two coders who independently code the same materials using the same coding scheme" (Yan, 2020, p. 2). We used the joint probability method to establish the percent agreement. The percent agreement "is measured by the percent of times two coders agree with each other on their coding decision" (Yan, 2020, p. 3). We used a minimum of 80% agreement as acceptable inter-coder reliability. After solving disagreements through discussion, we reached a percent agreement of 96%.

e. The reflexivity of researchers

The experiences of researchers impact the research process (Peshkin, 2000) and the reflexivity of scientists. We examined our reflexivity by considering how researchers impacted the study, as well as how the study impacted the researchers (Medved & Turner, 2011). Before starting the data collection and analysis, we examined our professional and life experiences. The first author (PMO) reflected on her professional trajectory as an undergraduate student in biology and as a Ph.D. candidate in discipline-based education research. As a doctoral student, PMO is focusing on the faculty-student mentorship relationship in STEM disciplines. PMO collected and analyzed the data being informed by scientific literature focused on mentorship, as well as using her mentorship experience with STEM faculty.

The second author (MDV) reflected on her professional journey as a research faculty member in the social sciences. As a faculty member who oversees graduate research assistants and, therefore, engages in the mentor-student relationship, MDV was intentional to bracket her own experiences of being a mentor while coding and reviewing the interview transcripts for this study. Nonetheless, MDV's professional and life experiences of being a mentor and mentee influenced her understanding and interpretation of the study findings.

IV. Ethical considerations

This study was reviewed and determined to be exempt by the Institutional Review Board at the University of Nebraska Medical Center/the University of Nebraska at Omaha and the University of Nebraska-Lincoln (IRB # 0037-23-EX). The first author (PMO) interviewed the faculty members for the study after obtaining the informed consent of the participants. PMO informed the participants that they could withdraw from

the study without impacting the relationship with the researchers or the university. PMO attempted to provide gender-neutral pseudonyms to the faculty members to protect the identity of the participants. To exercise confidentiality, PMO was the only researcher who had access to the demographic information of participants. MDV only had access to the clean and de-identified transcripts.

V. Findings and discussion

We used the four mentoring constructs described by Crisp and Cruz (2009) to guide our study, which resulted in four themes: 1) Providing psychological support to students, 2) Elevating the professional independence of students, 3) Supporting the professional path of students, and 4) Learning from the behaviors and actions of faculty. We found that the STEM faculty-student mentoring engagement involves a strong psychological support component. The faculty in our sample possessed an intrinsic motivation to mentor undergraduates, which strengthens the desire to elevate the professional independence of students. Faculty perceived it was their responsibility to initiate students in the STEM fields by providing career support, even if the chosen professional path of undergraduates differed from their own. Faculty believed in engaging with students at the personal level. The faculty believed the mentoring relationship went beyond academics, as mentees are more than just students. Faculty sought to set an example for students for being true to themselves inside and outside the university. A detailed description of the themes is given below.

a. Providing psychological support to students

Mentorship engagement transcends the academic support faculty provide to students. Faculty members in STEM go beyond the responsibilities found in their job description to provide psychological support to STEM students. Undergraduates in STEM may experience problems at home and/or a desire to better understand who they are and what they want in life. Despite not having the expertise in dealing with the personal issues of students, faculty members provide psychological support by listening to the problems of mentees. Avery's statement suggests that the ability to connect with students on a personal level is crucial in addressing their needs, particularly in times of crisis. It underscores the importance of a human-centered approach to education, which recognizes the complexity and nuance of individuals' lives and experiences.

> *Personal life gets in the way. It pops up. It bubbles up. Regardless of how much you want to stay focused... I work with kids [students] that have crises and when they do, they come to me, or I notice it. I try to give them some advice. Usually, it's in the form of listening to them and living our feelings and our fears, and asking them if they need help. (Avery)*

After listening to the problems presented by the undergraduates, STEM faculty may decide that the needs of the mentees transcend the expertise of mentors. Depending on the severity of the situation exposed by the mentees, faculty can advise undergraduates to seek psychological aid at the university. As such, mentors act as intermediaries between undergraduate students and the psychological services provided by the university. For some students, faculty intervention is often essential in encouraging students to seek the psychological aid needed to complete a bachelor's degree.

> *I almost universally refer them to the psychological services on campus. I keep a brochure in my office for their facility and I let them take a picture of it, so they have the contact information. I had one student whom I felt needed immediate help and I called the psychological services on campus while they (the student) were sitting in my office. I told the psychological services on campus: You need to talk to this student. I left my office so the student could have a private conversation with that facility. I feel like I helped them [the student] personally because if their personal needs are not met, nothing else is going to matter to them. (Hunter)*

Faculty members in STEM empower the psychological support of undergraduate students in STEM by being selfless. Mentors perceived students need mentors that seek the well-being of the mentees over anything else. Faculty felt that good mentors prioritize the student's best interests over their own career ambitions. Mentors may consider themselves part of the family of the students since the bond and/or relationship of faculty with mentees is not just about academic commitments. Mentors highlight the importance of relationships in the educational experience and how a mentor can make a significant impact on a student's life. Robin's statement suggests that mentorship can provide emotional support and a sense of community that goes beyond the academic setting.

> *A professor aligns with the job function, which is to go to class, teach, and grade the student, and at the end of the semester, you get your attendance and absences. A mentor goes beyond that. A mentor tries to understand each of their students. That's the difference between a professor and a mentor. A mentor guides you through your academics and what's going on in your life. A professor aligns with*

> *the job description of teaching and grading, and that's it. A mentor is like a friend or a family member you have around campus. (Robin)*

The advice and guidance given by faculty members to students goes beyond what is expected of them academically. Faculty-student interaction has expanded from merely providing instructional support to undergraduates to offering advice on personal matters, too.

b. Elevating the professional independence of students

The STEM faculty had an intrinsic motivation to mentor students. Faculty who possessed an internal desire to mentor would tailor the mentoring experience for each student and avoid using a "cookie-cutter" method with mentees. Faculty want students to be independent in their professional growth and not depend on a mentor to make career choices and/or engage in specialized experiences.

> *We published a paper and the third conference they presented at was this last summer. The people came up to them and said: This is the best I've ever seen an undergraduate do. We didn't think they were undergraduates. The crazy thing about this is that I did almost nothing. I just gave them the inspiration. I encourage them. I supported them here and there, but quickly they took off. When they did this presentation at this conference, I literally did nothing. My name is not even on it. It's great! They have done things with this I don't even know. I hear about them later, like: Yeah, we went to this elementary school and did this presentation. That's the pinnacle, for me. When I have become redundant. I've done a good job. (Avery)*

Mentors acknowledged every student is different. Faculty need to use multiple approaches to develop the professional independence of students. The faculty tailored the mentoring experience for students by assessing the professional and personal needs of mentees. Limiting the mentoring experience to the academic or professional responsibilities of students restricts the mentorship faculty can provide to mentees. Faculty need to see the “whole” student to provide the mentorship mentees need to excel. Ultimately, it takes time to know a student well enough to provide a tailored mentorship experience. Robin identifies themselves as a mentor and affirms their commitment to serving in this capacity. This suggests a personal sense of responsibility and a desire to make a difference in the lives of the students.

> *Every student is unique. Each of your mentees is unique. Understanding matters as a mentor. You must create time; see that every student has value. As a mentor, you want to make sure that you are there when they need you. You have to be patient. As a mentor, I see those skills in myself. I’m understanding. I’m patient. Time is important for a mentor, and I try to listen to every student. It takes extra dedication. It’s extra time you need to put into these. Once you are committed to doing this, you see through. I see myself as a mentor. I serve as a mentor. (Robin)*

Faculty in STEM were motivated to train and provide professional advice to undergraduate students. Participants aided the professional development of students by providing feedback on essays to pursue advanced schooling and resumes/CVs to enter the workforce. Faculty perceived students needed someone to guide them through the process of transitioning from college to the workforce. Robin indicates a deep sense of purpose and motivation to make a positive impact on the lives of their mentees. Overall, Robin

emphasizes the importance of personalized guidance, career development, and a deep commitment to the success of their students.

> *But you want them to graduate and pick a job or enroll in a job position in their field. I want to see a computer science graduate that I mentor take up the role of a software engineer when they graduate. I want to see an information systems student take up a role as a data analyst or data scientist when they graduate. This is the reason I took extra time to better understand and mentor them through life, how to manage, and how to balance academics with life... Such that they can enjoy their state. It's personally my passion. It's my goal to see students succeed and pick up a job role in their field of study. (Robin)*

The goal of STEM faculty was to foresee the success of their students after college graduation. Faculty sought to prepare mentees for the personal and professional challenges undergraduates may face at different stages of their lives. The mentorship STEM faculty was providing to STEM undergraduate students went beyond academic and professional preparation. The objective of the faculty was to get students ready for the struggles they could face in life.

c. Supporting the professional path of students

Faculty in STEM perceived they had a responsibility to aid in the initiation of students in STEM. The support STEM faculty provide to students could take many forms, as the professional needs of students varied on the skills, abilities, experience, and knowledge of the mentees about how to take part in STEM. Mentors provide guidance

and recommendations to students about how to approach professionals and resources in STEM to set mentees up for success in their field of choice.

> *I get a lot of requests from students asking if they can join my lab to do research. I don't have room for them. I send them a message saying: I'm not recruiting actively, but I'm always willing to have a conversation with you about how to get into doing research. The vast majority of them take me up on that offer. They come to my office or in the past, I just ask them: what it is they're looking for? What they're trying to accomplish?... I make suggestions on how to go search, how to find them, how to approach them, how to write the emails, and how to look at what they're trying to do and get themselves into that position. (Hunter)*

Faculty provide undergraduates in STEM with the guidance to make their own choices. Faculty believed students make their own path in the STEM fields. Faculty strive to endorse the professional route that students have selected, even if it differs from their own. The purpose of the mentors was to support the professional development of students in STEM, even if the faculty didn't agree on the chosen professional path of undergraduates. The faculty avoided judging the professional choices of mentees, as they acknowledged the undergraduates had their own autonomy and motivations for the choices they were making.

> *I want my students to do what they want to do to succeed in the way they want to succeed… My path is not necessarily the path that they need to take. My purpose is to help them understand: These are the options of what we can do… My purpose is not to create 2,000 duplicates of me. (Indiana)*

Faculty advised mentees about the professional decisions undergraduates may face in their careers. The faculty not only provided psychological support but also encouraged students to progress in their careers, no matter the circumstances. Faculty believed they supported the potential changes in the professional path of students. Mentors were preparing students for the demanding career and personal choices ahead of them, as these decisions can influence one another. The faculty sought to encourage students to keep moving forward when the odds were against them, even if it meant shifting their career trajectory later in life. For example, by recognizing that decisions are not inherently right or wrong, Hunter encourages individuals to approach decision-making as a process of growth and self-discovery.

> *But most of life is filled with right and left decisions. Not right or wrong decisions. You cannot get it wrong, it's just a decision. You make a decision, and you move ahead wherever it takes you. If you need to reconsider, you make another right or left decision. But you never get it wrong. You cannot get it wrong. Whom I marry? What job do I take? What major do I do? Where do I go? None of those decisions are wrong… It's just a decision and once you've made it, don't look back. If you need to reconsider, just make a new pivot.* (Hunter)

The faculty believed their purpose was to serve as facilitators for the success of undergraduates. Mentors supported and encouraged the current and future chosen professional path of students. Faculty wished that mentees would keep in mind the guidance and recommendations they gave as students advanced in their professional paths. There was a strong internal drive among STEM faculty members to assist students

in their professional endeavors, and faculty never sought recognition for the impact they had on mentees.

d. Learning from the behaviors and actions of faculty

Faculty in STEM surpassed their professional responsibilities by engaging at a personal level with undergraduates outside of work hours. Faculty believe that their interactions with students were not limited to the academic engagement. Mentors encouraged undergraduates to share professional and personal problems with them. The role of the faculty was to aid and inspire students to become successful. Mentors wanted the undergraduates to see mentors as human beings who also have had personal and professional problems. The faculty aimed to guide students on how to overcome challenges.

> *I've had students whose car gets totaled, and I have driven to their house and picked them up for work because they couldn't show up. If a student has to go to the doctor, I encourage them to get the help they need as opposed to giving them grief for not being in the lab, which I've seen other investigators do. It's hard for me to count the number of times… I just listen to their problems. Sometimes I share challenges that I've had in my life and career... But they can be motivation to the student to see that they can overcome obstacles. I tend to be pretty transparent about challenges I've had. (Hunter)*

Faculty were honored to serve as role models to undergraduates in STEM. Faculty believe in the prospect of inspiring students to become successful STEM professionals just like them. Mentors perceived mentees needed to engage with a person whom

undergraduates aspired to become and/or follow in their footsteps. Faculty aimed to inspire undergraduates to enter STEM by setting a vivid example for mentees, demonstrating that they could achieve STEM career ambitions, regardless of background, such as race or socio-economic status. For example, by sharing their personal experiences, River aims to motivate and inspire their students to strive for success and overcome any obstacles mentees may face. River highlights the importance of representation and the role it can play in breaking down societal barriers and promoting diversity and inclusion.

> *I know that the position I'm in and when students see me whether it's been here at college or in middle school, it's like why I have this [person of color] in front of me who's accomplished, who's been there, done that type thing. I like being that because I know it helps dispel a lot of prejudices. It dispels a lot of uncertainties. It dispels a lot of ignorance. Ignorance in the sense of just people not knowing. I can't tell you the number of parents… They were shocked that their children told the truth. That they (the students) have a [person of color] that's an engineer. (River)*

Transparency and sincerity were key for setting an example in the faculty-student relationship. Mentors believed in being their true selves with undergraduates inside and outside the university. Faculty sought to show students who they truly were as individuals, not just as professors. Just like faculty showed who they were as people to students, faculty encouraged mentees to show their true selves to others without fear of judgment.

> *I'm an open book. I think that's part of it, too. When students see that, they are open. They are for real about what they're saying. It's not an act… This is who I am. If they [the students] were sitting in my den with me watching a football game, it's like, 'That's Dr. River from class.' It's still the same person because I'm still holding you to the expectations that I have in the course. I'm going to hold you to the expectations I have for you in your own life. You set those expectations and you hold people to them. I can't hold people to things if I'm holding back on everything. (River)*

STEM faculty were pleased that mentees sought their advice, as it enabled them to guide students toward success. Faculty saw it as important to show students they could succeed while remaining true to who they were. Mentors believe in encouraging undergraduates to become better versions of themselves by learning from the actions and behaviors of mentors toward students.

e. Strengths, limitations, and future research

Our study shows that, according to the faculty mentors interviewed, the primary role of STEM faculty mentors is to provide psychological support to undergraduate students in STEM. The project also shows that the motivation of STEM faculty to mentor students can be present at any academic rank (e.g., instructor, assistant professor). We limited our data collection to STEM faculty members from a single institution classified as a high research activity institution (R2) by the Carnegie Classifications of Higher Education Institutions. A future study should focus on capturing the perspectives of STEM faculty from multiple institutions of higher education with different Carnegie Classifications. Our study was also limited by the limitations of the absence of clear

details regarding the specific type of mentorship faculty offered to students (e.g., academic advising, lab work, independent research project, and the capacity of instructing). In order to gather a comprehensive understanding, a study in the future ought to include the viewpoints of STEM faculty regarding the approaches used by mentors to guide their students in different types of mentorship.

Our project combined the perspectives of faculty from the four STEM fields. Future studies should depict the opinions of faculty from each of the STEM fields in more detail to explore differences in faculty members' approach to and motivation for mentoring based on the specific STEM field. Our study was also limited by the selection of STEM faculty who have a reputation for supporting undergraduates and have an intrinsic desire to mentor students. A subsequent study should concentrate on noting the viewpoints of STEM faculty who adhere strictly to the roles and responsibilities defined in the job description of a professor. A study of this type would display the views of STEM faculty who are hesitant to provide psychological and emotional assistance to undergraduates, as faculty may perceive this action as not a part of their job.

VI. Conclusions and implications for practice

Our study aimed to capture the perspectives of STEM faculty toward undergraduate mentorship. Olson and Nayar-Bhalerao (2020) observed that STEM faculty members were becoming unintentional role models for undergraduates in STEM, even though faculty were not supportive of this. Faculty members might feel "intimidated" by the idea of becoming role models for students because mentors may still be figuring out their personal and professional paths in life (Olson & Nayar-Bhalerao, 2020). On the contrary, our study revealed that faculty members were honored to serve as

role models for students. Mentors believed students should look forward to imitating the mentoring behaviors of faculty, even with subordinates of their own someday. We argue that the disagreement between the findings of Olson and Nayar-Bhalerao (2020) and our study's findings is because our sample consisted of STEM faculty who believed the faculty-student mentoring relationship expanded beyond academics. Our participants expressed that the psychological and emotional support provided to undergraduates surpassed the typical mentorship expectations of sharing academic subject knowledge and providing career guidance to mentees. It is worth noting that since all the faculty in our study are affiliated with the same institution and college, more research is needed with STEM faculty from other institutions to further generalize these findings and dispute findings from Olson and Nayar-Bhalerao (2020) with more certainty.

For the faculty in our sample, excelling in academics was secondary to ensuring the emotional well-being of students. As institutions of higher education are aiming to increase the retention rates of undergraduates in STEM, universities should hire STEM faculty who care about the psychological welfare of students. Employing and maintaining STEM faculty who value and support students as individuals is paramount to retaining undergraduates in STEM fields. Additionally, the STEM faculty-student mentoring engagement presents a reciprocal relationship, in which faculty also obtain benefits from mentoring students. This aids in the retention of faculty at institutions of higher education as well.

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CHAPTER 5

DISCUSSION & CONCLUSION

The purpose of this doctoral dissertation was to investigate various aspects of the STEM faculty-student mentoring engagement and its implications for STEM undergraduates at institutions of higher education. This was accomplished through a series of individual studies, each of which explored a unique aspect of the field.

Chapter 1 introduced the research topic and outlined the research objectives, motivation, contribution, and structure of the dissertation. The research topic of this dissertation was the mentoring experiences of undergraduates and faculty in STEM, which is an important and timely topic that can impact the retention rates of students in the STEM fields. The research objectives investigated the mentoring engagement between undergraduates and faculty in STEM fields and its implications for the retention rates of STEM students at institutions of higher education. The structure of this dissertation was organized as follows.

Chapter 2 investigated the perspectives of former STEM mentors of an after-school STEM program after college graduation. Findings demonstrated that regardless of major or career stage, STEM pre-professional training programs have the potential to positively impact the professional development of STEM undergraduate students after college graduation. the idea being that programs that share these aspects would be expected to produce similar outcomes. This highlights the need for the engagement of STEM students in extracurricular STEM programs to promote the undergraduate's personal and professional development. The study has several limitations. My study was

conducted with individuals who attended the same institution to pursue their bachelor's degree in STEM; therefore, the participant's perspectives may be limited to the experiences acquired while completing college in a single institution. I acknowledge the bias in these data because they are inclusive solely of one location (i.e., the metropolitan university participant in NE STEM 4U), and only over 10 years. Due to the nature of conducting the interviews years after college graduation, the participants may have been influenced by external factors and experiences. Because of this, I may not have captured all details pertaining to the phenomenon under study.

In Chapter 3, I explored the perceptions of science undergraduate mentees in the student-faculty mentoring engagement. These findings showed that a positive mentorship experience with science faculty promotes the development of undergraduate students, while a negative mentorship experience hinders the development of mentees in science. My study was limited to academic literature published between the years 2010 to 2020. I opted to exclude academic articles published after 2020 to avoid biases and skewed findings because of the COVID-19 pandemic. A future study should compare the perceived experience of science students in mentorship with faculty before, during, and after the COVID-19 pandemic. My study was also limited to the field of science. A future study should explore the perceptions of students with faculty mentors from each of the STEM fields. This type of study has the potential to provide scholars with valuable insights into how students interact with faculty members in various STEM fields.

Chapter 4 captured the perspectives of STEM faculty toward undergraduate mentorship. For the faculty in our sample, excelling in academics was secondary to ensuring the emotional well-being of students. As institutions of higher education are

aiming to increase the retention rates of undergraduates in STEM, universities should hire STEM faculty who care about the psychological welfare of students. My study was limited by the data collection of STEM faculty members from a single institution classified as a high research activity institution (R2) by the Carnegie Classifications of Higher Education Institutions. A future study should focus on capturing the perspectives of STEM faculty from multiple institutions of higher education with different Carnegie Classifications. My study was also limited by the limitations of the absence of clear details regarding the specific type of mentorship faculty offered to students (e.g., academic advising, lab work, independent research project, and the capacity of instructing). In order to gather a comprehensive understanding, a study in the future ought to include the viewpoints of STEM faculty regarding the approaches used by mentors to guide their students in different types of mentorship.

My studies provided valuable insights into the field of study by shedding light on gaps in the development of undergraduate students in STEM fields and the importance of mentorship in addressing these gaps. My research has broader impacts on various aspects of STEM education and the future of the field. By identifying gaps in undergraduate students' development, such as communication and problem-solving skills, I highlighted the need for targeted interventions and support mechanisms to bridge these gaps. This has implications for educational institutions, policymakers, and industry leaders who are invested in preparing students for employment in STEM fields. My research also emphasizes the importance of mentorship in facilitating the development of critical thinking and problem-solving skills among students, which are essential for their success in the STEM workforce. This knowledge can inform the design and implementation of

mentorship programs in academic institutions, helping to create a supportive environment that enhances students' experiences and retention in STEM disciplines. Ultimately, my research has implications for the broader scientific community by promoting a better understanding of the factors that influence students' decisions to pursue advanced schooling and careers in science as well as the role of mentorship in shaping their perceptions and experiences in the field.