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Inclusive STEM Education at Vassar College: Perceptions, Practices, and Lessons Learned from Teaching Under COVID-19

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Inclusive STEM Education at Vassar:
Perceptions, Practices, and Lessons Learned from Teaching Under COVID-19

A thesis submitted in partial fulfillment of the requirements
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Table of Contents

Abstract

The sudden outbreak of the COVID-19 pandemic has distributed our lives in every aspect. After a year of living under the 'new normal', we are finally seeing vaccinations becoming available, greatly benefits everyone at risks. This pandemic uncovered the importance of scientists, particularly life scientists, holding hands and working together to tackle life-threatening, global, and emergent health problems. However, what accompanies this 'new normal' are the pandemic are the distressing racism and hate crimes against black and Asian Americans that has happened across the country. International political confrontations also escalated the tensions against Asians in the country. As a consequence, foreign scientists, especially scholars from China or Chinese Americans, feel less secure in working in STEM fields in the United States. This has largely destroyed the long-standing harmonious and inclusive environment of the STEM community both domestically and internationally. These call for research that contributes to potential reforms to re-build a global STEM community that is collaborative, welcoming, and inclusive to all scientists. The Grand Challenges Program at Vassar College works towards such reforms to foster STEM inclusive excellence at the college, with one research direction of inclusive STEM pedagogy. This work aimed to study the inclusive teaching practices employed by Vassar STEM faculty, and faculty perceptions of inclusion. Interviews were conducted with four STEM professors from the departments of Chemistry, Biology, Mathematics and Statistics, and Computer Science. These interviews focused on discussing their inclusive pedagogy and reasons or philosophies behind employing such practices. In addition, a section was dedicated in investigating the impacts of COVID-19 in inclusive teaching and potential lessons that could be learned from hybrid or remote teaching experiences. A central finding of my study uncovered the fact that genuine care and a desire to get to know students and facilitate their growths is essential for successful inclusive teachings. The outcome of this work will provide critical insights into the status quo of inclusive STEM education at Vassar and suggest potential direction of reforms of improving inclusion and diversity of STEM community at Vassar.

Keywords: STEM Education; Inclusion and Diversity; Inclusive Pedagogy; Teaching Practices; STEM Inclusive Excellence; COVID-19

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Chapter One
Introduction

This work explores inclusive pedagogy employed by STEM faculty at Vassar College. This chapter will introduce what brought me to this work and the stories behind. As a STEM major, I am interested in topics related to STEM education, but the incentive of working on this research project actually came from multiple starting points.

1.1 COVID-19 and Personal Reflections as a STEM Student at Vassar College

As I am starting to write this chapter, the COVID-19 global pandemic has been part of our lives for more than a year. Different than the first generation of SARS pandemic, which happened exclusively in China in 2003, this pandemic is a global, continuing, and highly contagious epidemic that has caused over 3 million deaths till this day. To combat this pandemic, scientists around the world have been using all their collective power, knowledge, and tools in their repertoire to come up with drugs, pharmaceuticals, and therapeutic plans to treat infected patients. They have also been working hard in research to get vaccination available to everyone. This is a global and collaborative effort by worldwide scientists, doctors, researchers, pharmaceutical companies, and various health organizations. We have also witnessed the significance of science, especially life sciences, in our lives.

The COVID-19 pandemic calls for more scientists to work in biology, medicine, and related fields. I always believe that post-graduate level is a phase of critical transition: as students are getting out of high school, college is really where they start to explore their interests, to identify what they are passionate about, and to think about their future career paths. It is therefore of vital importance for universities to provide students with education that would allow such explorations to happen smoothly, efficiently, and enjoyably. As a STEM student myself, I constantly reflect upon my own exploration pathways and how I got to where I am today: how did I find my interests in chemistry? To what extent did the classes I take at Vassar and relevant research experiences shaped me and helped me identify my passion? What aspects of my Vassar STEM education did I enjoy and why?

These are the questions that I think about a lot, and I even talk to my friends who also study science but at other universities in the U.S. When I told them that in some of my science classes, I get to choose topics of my interests and guide a whole-class discussion, they were shocked; when I described how easily accessible my professors are outside of classes, they were surprised; especially when they learned that I work with my research advisor in research projects and can get our work published in peer-reviewed journals, they felt even more amazed. These unique opportunities are sometimes unavailable for students at large research universities.

Now I think about it, it was all about the teaching of my STEM professors at Vassar that enabled such diverse, innovative, also highly efficient teaching and learning modality that can rarely be otherwise found in research universities. That triggered me to exploring further into the specific practices that they have employed to make their classrooms welcoming and inclusive places.

1.2 The Grand Challenges Program

Last year, I was proud to join the efforts of promoting STEM inclusive excellence at Vassar *via* the Vassar Grand Challenges Program. The Grand Challenges Program is a HHMI-funded initiative that dedicates in fostering inclusive STEM education at the College. I joined the inclusive pedagogy student committee (we call it 'student catalysts') in which students meet, discuss, and organize events that act to promote inclusivity and diversity in the STEM teaching and learning at Vassar. The overall slogan of the Grand Challenges Program is *'Working as a Community to Face*

Global Issues.' As a core part of its endeavors, the program promoted curricular reforms of Vassar STEM courses that happened at departmental levels. For instance, in the department of Chemistry, the introductory-level classes reformed from the originally student-ability oriented to the now theme-oriented. Similarly, in the Department of Biology, courses have also incorporated elements of global issues such as climate change. Students participate in discussions, take leadership role in projects, and give presentations on relevant topics in class.

More importantly, all these efforts are paid to create an environment in the STEM community at Vassar that is comfortable for everyone – students and faculty alike – to explore, grow, and contribute both to the Vassar community and the fields of math and science.

1.3 Racism, Hate Crimes, and Political Confrontations affecting the STEM community

The COVID-19 pandemic has unfortunately uncovered and escalated some racism and hate crimes in the country. Black and Asian American communities have been unjustly treated and we have seen some divisiveness across the country, as people should be together fighting the virus (Bajak, 2021). In addition, international confrontations have complicated everything, especially when political interests distributing the scientific community. Recent news witnessed that the geopolitical competition between the U.S. and China has pervaded into the area of higher education and research in STEM fields. Just two weeks ago, on Apr. 21, 2021, Mingqing Xiao, a Professor of Mathematics at the Southern Illinois University at Carbondale (SIUC) was officially charged by criminal complaint for committing to a wire fraud and receiving grants from the Chinese government (U.S. Attorney's Office, 2021). This is exactly the accusation imposed on Gang Chen, Professor of Mechanical Engineering at MIT, which was later shown to be a false accusation since the grant money was directly received by MIT to promote collaborations between MIT and a university in China, instead of to Professor Chen personally (MIT News, 2021).

These accusations, coupled with the hate crimes against Asian and Asian Americans, created a common fear that is pervasive among Chinese scholars, Chinese Americans, and Asian Americans who work in the STEM fields in the U.S. (Waldman, 2021). Many of them are considering revoking their existing academic collaboration with Chinese institutes and some of them are even thinking about resigning their research positions in the U.S. This will undoubtedly impede the development of science and is for sure a breaker of harmony and long-standing collaborative environment of the global STEM community. For this reason, immediate remedy is needed and scientists and professionals around the globe should work together to rebuild an inclusive, safe environment for scientists to work in and contribute to the science fields.

1.4 This work

Given all these struggles we are dealing with, I could not help but wondering what I could do to contribute the (re)establishment of an inclusive STEM community. This research project provided me with a precious opportunity to explore the questions I proposed earlier. Starting from STEM course-level, this project investigates the inclusive teaching practices employed by STEM faculty at Vassar, their perceptions of inclusion, and reasons behind. Four professors from the departments of Chemistry, Biology, Mathematics and Statistics, and Computer Science teaching introductory (100-level) courses were invited for interviews where they were asked to talk about their inclusive pedagogy, their perceptions and philosophies behind inclusive teaching and learning. There was also a section focusing on COVID-19 and lessons learned from hybrid mode of teaching. The goal was to get an idea of how and why these STEM faculty are choosing to employ inclusive pedagogy, and what has been working well, what has not been working so well. From these lessons, I hope to contribute some insights to the Grand Challenges Program in designing ways to promote a more inclusive STEM community at Vassar.

As an undergraduate student pursing a dual degree in STEM (chemistry) and Education, this is an exciting project to me and I really enjoyed talking with STEM faculty at Vassar, even if I had never taken classes with some of them. At these conversations, they were telling me anecdotes and stories they probably have never talked to any of their students, and I could really feel that they genuinely care about teaching and care about their students. This work will for sure not be able to solve the long-standing injustices and problems in the global STEM community, but at least at a collegial level, I look forward to contributing some insights towards the inclusivity of the STEM community at Vassar.

1.5 Layout of this dissertation

This dissertation contains five chapters following abstract and acknowledgement. The first chapter introduces the starting points of this article – how I came to this work. It also introduces some backgrounds on which this project is based. Chapter two is a comprehensive literature review that contains overviews of objectives and challenges of undergraduate STEM education, some case studies of multiple STEM programs around the globe and their reform initiatives, and eventually, a section on diversity and inclusion in STEM education. The Third Chapter contains background information and describes the methodology used in this study. Chapter four summarizes the research findings with clustered themes along with interview excerpts. I specifically chose these excerpts because they best support the points I make in the discussions chapter and directly reflects why I came up with the themes and sub-titles of the sections. Most importantly, while these faculty teach at different departments and may not have direct communications amongst each other regarding inclusive pedagogy, recurring themes can be found during the interviews. It is also obvious that they are extremely passionate in creating learning environments that care and are centered around students. The final concluding chapter recaps the findings of this study, while providing some envisions of future inclusive STEM education at Vassar: what can happen, what could be focused on, and how to achieve these goals.

Chapter Two
Review of Literature on Higher Education STEM Programs

This literature review identifies the current situations, advantages and disadvantages, of undergraduate-level STEM programs, and explores the theories and actions behind reform initiatives of STEM program in higher educational institutions around the globe. In addition, this review also includes scholarly research that focuses on inclusion and diversity in university-level STEM programs.

2.1 An Overview of Objectives and Challenges of Undergraduate STEM programs

2.1.1 Ideal STEM Education Programs: What should be done?

Generally, when engaged in the studies of a discipline, students should be able to develop expertise in the subject, including content knowledge, problem-solving skills, habits of minds, and beliefs about the nature and relevance of the subject. Learning gains should be visible both at an individual course level, and across a curriculum or program of study as a whole (Wieman, 2017). I could not agree more: Beyond common scientific skills, the ultimate educational goal should be to have students understand and think about science in a way a scientist does. This includes appreciating the scientific process, relating ideas of STEM in real life, and developing curiosity with the natural world. It is therefore important at the program level, that the courses be purposefully designed and aligned, ensuring that they build on each other, to provide "ever deepening mastery of such core competencies." (Wieman, 2017).

The modern world manifests an increasing need for technical literacy and skills which makes science education important for all students, not just the ones pursuing careers in science or engineering. Unfortunately, large and growing body of evidence indicates that post-secondary science education is failing to meet these educational needs. Most students learn science as sets of facts or procedures that are irrelevant to the workings of the world, and learn without understandings, merely to solve problems that appear on their homework or by memorizing recipes that basically have no use other than passing university course exams. Such students are not learning science to see science the way an scientist would do, as a set of "interconnected, experimentally determined concepts that describe the world" (Wieman, 2017). They are also not learning critical problem-solving skills that will be applied to solve novel problems and novel contexts, as experts do (Wieman, 2017).

2.1.2 Looking back to the reality: What is missing?

The modern-day educational needs and goals are vastly different than what they were in past decades. The modern-day economy demands and rewards complex problem-solving, research, and communication skills, particularly in technical fields. These skills are far more important than simple information or knowledge. The truth is, however, in undergraduate STEM classrooms, the lecture format still predominates. This format began before the invention of the printing press, for that it is an efficient way to pass along basic information in the absence of written texts. The economics of scale has led to this antiquated model expanding to the current day lecture style of teaching, addressing a group of greatly passive students, often several hundred at a time in those research universities (Wieman, 2017, p. 7).

Wieman (2017) identified three major impediments to moving from the current model to an ideal STEM education program which accomplishes the educational goals discussed in the previous section, including structural and administrative limitations, the balance of research and learning, and failures in incentive systems.

Structural and administrative limitations include the fact that university governing boards and university presidents tend to be highly political and subject to vagaries of current events, which all act to distract academic administrative leadership. What's more, the size and complexity of modern research universities usually prevent faculty from being sufficiently aware of issues and pressures, but they remain a powerful entrenched body hindering reforms. On a departmental level, the actual ownership of courses and curricula are sometimes delegated not solely to departments, but to committees with little or no backgrounds on the subject matter.

The balance between research and teaching remains a matter of debate among STEM education at higher institutions. Both research and teaching are essential components of the modern research university and are vital contributions to the society and the scientific community, therefore abandoning either would be an unwise move. Optimizing the use of faculty time offers enormous potential for improvements in the educational efficiency. It is hard to imagine that faculty members teach expert competence without being actively engaged in the relevant field of research themselves. Complexity and rapidity in progress of STEM research fields dictate that faculty members can hardly remain sufficiently expert in their subject if their teaching is still largely based on what they learned back in school.

One of biggest barriers to improving STEM education in universities is that they are ineffective in measuring and rewarding effective teaching. Only when there are incentives for educational change built into the program, will it be possible for prospective students, governments, the public, and institutions themselves to recognize and reward teaching quality. The incentive in STEM education system in critical for the development of the undergraduate STEM programs.

2.2 Case Studies: Global STEM Reform Initiatives

Around the world, there exist many STEM educational reform initiatives that dedicate to improve STEM programs in higher institutions. In this sub-chapter, I will discuss a few STEM educational reform efforts, focusing on 1) the contexts/backgrounds of the programs; 2) the specific tenets that guide the initiatives; and 3) the research methodology employed to study these initiatives.

1. **The Summer Undergraduate Research Fellowship (SURF) at Xi'an Jiaotong-Liverpool University (XJTLU) (Wilson et al., 2017)**

The XJTLU is a joint venture between Xi'an Jiaotong University in China and the University of Liverpool in the UK, based in Suzhou, China. It merges two different higher education systems. The SURF program offers opportunities to develop practical research skills related to knowledge students' have acquired in classrooms, aiming to provide students with authentic research experiences. The reform to research-led teaching and learning is part of a wider agenda of education reform in China, which is concerned with moving away from teacher-centered and exam-focused approaches towards more active learning and student-centered approaches.

Mixed-methods of research and approach (surveys, interviews, and focus groups) was used with a primarily qualitative focus. The aim was to reflect upon a particular instance of educational practice, in this case SURF at XJTLU. The study also incorporated student voice. The STEM program at XJTLU can be described in terms of a total of six themes:

I. *Connecting with staff: learning about research and step-by-step guidance;*
II. *Interdisciplinary connections and collaborations;*
III. *Connecting academics with workplace skills;*
IV. *Producing output directed at an audience;*

V. *Student become part of a wider learning community.*

VI. *Skills.*

The lessons learned from the SURF program could be used to develop a more integrative approach to developing research skills as part of undergraduate programs. It is concluded that, from the case study of SURF at XJTLU, providing undergraduate students with opportunities to become involved in research-oriented projects at initial stage of their undergraduate careers can only enhance their skills and content knowledge, and generate a context in which inquiry, critical thinking, and reflection is at the heart of their undergraduate STEM education.

2. Institutional Engagements: 'Curriculum 2016^{+}' (Cleaver et al., 2017)

In 2013, University of Hull embarked on a strategic journey that stresses connecting research and teaching through curriculum and pedagogic design – the promotion of *whole institutional engagements* with curriculum design and pedagogy as an academic endeavor. At heart of the design was an underpinning vision and approach which was developed to encourage staff to make explicit the connections between the teaching and research within and across disciplinary communities and contexts, and to engage staff in developing disciplinary and practice-based pedagogies and assessment that reflected *real-world learning*. The following are the three tenets of this initiative:

1) Students and faculty (i.e., the teams) are asked to provide compelling pedagogic rationales as to why the chosen teaching, learning and assessments approaches were the most appropriate to use.

2) Teams were asked to identify ways in which their academic programs & pedagogies could be meaningfully linked with skills of the workplace; how any attributes/skills that had been absent in the past might now be meaningfully incorporated.

3) A cross-disciplinary effort. Multiple departments and initiatives are investigated and studied.

3. Biochemistry Program at University of Alberta, Canada (Milner, 2017)

Biochemists are defined by their research practices. Our existential angst as biochemists has a notable influence in determining the curriculum of an undergraduate program in biochemistry because it is entirely debatable which particular didactic courses would be necessary to qualify a student as a biochemist. A shift to research-oriented biochemistry curriculum is necessary: Research is a high-impact practice in undergraduate education.

Students in the biochemistry program of University of Alberta had extended research opportunities for students ever from the beginning of the program, throughout the course of the entire program, until their final capstone work. One of the core tenets is the integration of service teaching into the curriculum. The reform focuses on a new introductory courses structure: didactic content coupled with parallel research experiences. Course content are *limited, carefully selected*, to favor understanding of basic concept to provide appropriate time for *substantive engagements.* The new introductory course structure has been success and students have provided extremely positive feedback about their classroom experiences.

Another core initiative that the program has undertaken is the support of "teaching-intensive academic positions" throughout the department. This is an outcome out of their recognition that educators and education-focused leaders are necessary if an institution truly wishes to develop quality programming. This position is offered to staff for substantive engagement in educational development. The departmental leaders have rewarded educational development as important academic work.

4. **'Pedagogic Resonance': Learning Discipline, Design, and Experience (Edwards et al., 2017)**

Integration of research and teaching can provide valuable ways of enhancing the learning experience of students, yet it much be recognized that effective integration does not happen spontaneously and requires proactive steps on the part of instructors. Edwards et al. (2017) described the 'pedagogic resonance' between the perspectives that inform the course design (*learning design*), learning activities that students engage in (*learning experience*), and the practices/traditions of the specific disciplines into which the students are being inducted (*learning discipline*). They draw the notion of pedagogic resonance to elucidate the alignment between curriculum elements and how these are experienced by students within their chosen discipline. To put this in context, Edwards et al. (2017) provides several case studies in which these three core elements are evaluated. In the physics program, the *learning discipline* means Physics is not only considered to be a 'body of knowledge', to be learned, but a process of systematically testing theories against the evidence. Theoretical and mathematically-based and a more practical subject that connects math with the physical world via experimentation and application.

The aspect of *learning design* challenged the view that the foundations must be established before students can do research. Aspects of research can be introduced at a much earlier stage. Tutors can help students to develop conceptual understanding that prompts them in developing more coherent conceptual framework and "investigative habits of mind". *Learning experience* dictates that students engage in a process of research, interacting with simulations and do something about the material, such as: qualitative reasoning, group-based experimental problem, design and execute experiments by themselves.

2.3 Inclusion and Diversity in university STEM programs

Mounting research evidence suggests that incorporating diversity and inclusion initiatives in college courses and campus activities help students develop senses of belonging, confidence, engagement, and academic achievements (Nelson Laird, 2005; Zuniga et al., 2005). Specifically, undergraduate students who interacted with inclusive peers and took classes that emphasized diversity are more likely to demonstrate self-confidence and critical thinking skills (Nelson Laird, 2005). It was argued that underrepresented STEM students need to embrace their identities and that institutions and STEM culture must create ways to foster their embracement of personal and academic identities (Puritty et al., 2017).

Students' exposures to role models – educators, professionals, parents, etc. – that individuals can relate to are shown to increase the development of STEM identity (Hughes et al., 2013). Exposure to role models with the same race, gender, ethnicity as the individual can increase motivation and persistence in development of STEM fields (Ramsey et al., 2013).

Fostering a sense of belonging and inclusion in STEM community is significant to both developing STEM identities and retentions of students in the STEM field. Strayhorn (2012) defines senses of belonging as:

> *Students perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the … community (pg. 4).*

Research shows that underrepresented minorities and first-generation college students are particularly vulnerable to dropping out of higher education STEM programs; lack of sense of community contributes to this vulnerability (O'Keeffe, 2013).

On another level, inclusive teaching embraces authentic learning experiences. This requires careful planning of course materials to be covered, class activities, syllabus, and the instructional approaches. Learning can be better achieved when related with real-world environments. Such authentic learning experiences should be designed around characteristics that focus on real-world relevance and applications. These experiences focus on solving real-world problems through multiple forms of activities: role-playing, case studies, etc. They intentionally introduce multiple perspectives and interdisciplinarity). Forms of presentation, in this case, are also diverse (Lombardi, 2017.). Authentic learning experiences in undergraduate STEM classrooms bring students increased empathy, increased understanding of the theoretical underpinnings of a field (Lombardi, 2017; Smith et al., 2015).

Chapter Three
Research Settings and Methodology

3.1 The Research Setting

Vassar College is a small liberal-arts institute that is renowned for strong academic programs in STEM. The first professor hired at the College, Maria Mitchell, is a Professor of STEM (Astronomy) (Holmes, 2018). Also, Grace Hopper, the inventor of COBOL and a pioneer of Computer Science, obtained a bachelor's degree from Vassar and later became a Professor of Mathematics at Vassar. Vassar graduates who have earned STEM degrees are competitive and are usually admitted to top STEM graduate programs in the country. The strong science curriculum and research environment have enabled such accomplishments.

Recent collegial strategic planning has invested in improving STEM education at Vassar. The Integrated Science Commons, also known as the *Bridge for Laboratory Sciences*, was built in 2016, providing state-of-the-art research facilities for science students at Vassar. Taking advantage by the improved hardware facilities, the STEM programs at Vassar have strengthened their competence in both in-class and out-of-class independent scientific research qualities, manifested by increased research opportunities and options.

Recently, the Grand Challenges Program at Vassar has directed community attention to inclusive excellence of STEM at Vassar. The Grand Challenges Program is a five-year initiative of curricular innovation, faculty development, and community engagements founded with the help of grant from Howard Hughes Medical Institute (HHMI). The aim of this program is to improve Vassar STEM education by foster a STEM community that cherishes inclusive excellence. An institution that embodies inclusive excellence respects diversity background and perspectives of its members and makes space for all its members to participate meaningfully. There are several core components: *Student Initiatives*, *Community Engagement*, and *Faculty Development*, and *Courses & Pathways*.

The element most relevant to this research is *Courses & Pathways*. Every academic semester, a list of *Grand Challenges STEM courses* is available for students to sign up and take. These courses share the common characteristic of the integration of climate change into the courses, and they address environmental problems, and provide students with ways of creating their own programming. For instance, the course ENST/SOCI 266: *Racism, Waste, and Resistance* that was offered in the Spring 2021 semester explored the topics surrounding global climate change, pollution, resource depletion, contamination and extinction. It also examined the destructive global dynamics of environmental racism and resistance. In another course, ECON/INTL 273, *Development Economics*, students survey the central issues in the field of developmental economics, with focuses on economic growth, trade, poverty, inequality, education, and climate change. Students in this course examined such issues with examples from a global perspective, using case studies from Africa, Asia and Latin America to provide contexts for these topics. Besides, there are also a range of faculty-mentored research and community-engaged learning opportunities available for students to pursue their own academic interests along these topics.

Most importantly, the Grand Challenges Program has helped the college to accomplish a curricular innovation in which introductory-level STEM courses were reformed to integrate present-day issues, like climate change, as part of the work and teaching. It is essential that such efforts are made in intro-level classes since they are the 'gateway courses' that introduce students into the fields, especially for those without previous immersions in the natural sciences. Factors that prevent students from entering the STEM fields often stem from students' failure in these gateway classes. Lack of social capitals of students (unaware of what are expected at college-level STEM course, unprepared) and poor course design and teaching practices are the two major reasons that lead to students' failure or their disinterests in these intro-level classes. This calls for research projects focusing on inclusive pedagogy in intro-level STEM courses.

3.2 Method

The objective for this research project was to document and analyze the inclusive teaching practices that Vassar STEM professors employ in teaching introductory level classes in their respective departments, and to understand how COVID-19 pandemic has shaped their inclusive pedagogy and their perceptions on *inclusion*. The consensual qualitative research method that stresses words rather than numbers, seemed best suited for the purpose of this research. This inductive approach relies on interviews with open-ended questions, small sample-size, attention to context, and the integration of multiple perspectives on the issues being studied to explore the experiences, attitudes, philosophies, and convictions of a group of informants (Hill, 2011). I opted to closely examine the teaching practices of a small number of professors. Our objective was to develop a deep, and nuanced understanding of these selected individuals under specific contexts, rather than gaining brief testimonials from a large number of participants.

I adopted a standardized, open-ended interview approach in which the wording and sequence of interview questions are determined in advance. All interviewees are asked the same basic questions in the same order. Despite that this approach gives less flexibility in relating the interview to particular individuals and circumstances and may limit naturalness, by having the respondents answer the same set of questions, I hope to gather information taking advantage of the increased comparability of responses. In addition, data are complete for each person on the topics addressed in the interview, and it facilitates organization and analysis of the qualitative data.

Surprisingly, in some cases the conversation flowed in a manner that the respondents often have covered some of the subsequent topics and thus increased the natural flow of the interviews.

3.2.1 Participants

I have purposefully selected four professors from four STEM disciplines at Vassar College: Mathematics and Statistics, Chemistry, Biology, and Computer Science. These professors are selected because they have either taught, are teaching, or will teach introductory-level Grand Challenges courses at Vassar. Besides, these faculty members are known to have committed to inclusive teaching. As university professors, the majority of them are usually not specifically trained in teaching or education but obtained Ph.D. degree in their respective scientific fields. An advantage of not having formal trainings in teaching to this research is that I obtained authentic accounts, narratives, insights, and perceptions of the professors regarding inclusive teaching out of their own experiences. With such knowledge, I was able to capture the inclusive teaching practices used by the professors along with their philosophies, motivations, contexts, and impact factors behind their pedagogy. The limitation in the participant sampling would potentially hamper the conclusions in its representation of all STEM faculty at Vassar College. However, I believe it provided us with meaningful responses as these faculty members sincerely care about their teaching and actively take inclusion into consideration in their lecturing and course design.

3.2.2 Data Collection and Analysis

Interviews with four professors were conducted over the first two weeks in February 2021. Three professors taught remote courses in the past semester (Fall 2020) and one Math professor was on sabbatical but was currently teaching an introductory-level Mathematics class (MATH 144, *Foundations of Data Science*) in Spring 2021 semester. The Computer Science professor was teaching advanced level classes but is teaching introductory level Computer Science class (CMPU 101, *Problem-Solving and Abstraction*) in Spring 2021 semester. Therefore, I returned to these two Mathematics and Computer Science professors one month into the academic semester (March 2021) for a second interview to gain updated insights on their teaching practices in those two courses.

All informants were invited and encouraged to talk about their teaching introductory-level courses at their respective departments. However, before the interviews began, I confirmed with each of the professors that they were comfortable talking about their teachings in introductory-level classes and that they had taught these classes in ways that they could provide meaningful information pertaining their inclusive practices. The Biology professor informed the me that she had co-taught the introductory level Biology class (BIOL 107, *Energy Flow in Biological Systems*) with another faculty member in the department. More importantly, this particular Biology class is predominantly lecture-based with a class size of around 90 students per session, so she had minimal knowledge about her students and hence could not employ much inclusive pedagogy. She had instead volunteered to talk about her teaching in an advanced-level Biology class (BIOL 356, *Plants, Climate, and Society*) which is a Grand Challenges course with a climate-change theme that she designed and taught alone, so she had extensive experience and provided precious insights about her inclusive teaching in this course.

During the interviews, the interviewees were free to decline to respond to individual prompts, and to explore areas of interests in greater depth. The discussions that developed included "a mixture of conversation and embedded questions" (Fetterman, 1989, p. 49) designed to produce a balanced rapport (Birmingham & Wilkinson, 2003). Due to the pandemic, all interviews were conducted online via Zoom. The interviews were conducted in English and videotapes to cloud on Zoom. Participants signed consent forms to confirm their participation in the study and to give their consent for videotaping the interviews. They had the option of withdrawing their participation at any point.

I then transcribed the interviews and developed a coding system. Codings were done on the software Dedoose. Each interview was coded individually, and all interviews were brought together to analyze the words, phrases, or ideas that had emerged from independent reviews of transcripts. Then, a consolidated set of codes were developed which was brought to analysis. In addition, each transcript was given an identification code to ensure the interviewees remained anonymous during the coding process. An inductive analysis was used to identify patterns, themes, and categories of analysis that emerged from the data. All interviewees were given pseudonyms to protect their privacy.

Chapter Four
Results and Discussions

4.1 <u>Practices of Inclusive Education</u>

- Inclusion starts from getting to know the students
    - Perceptions of inclusivity: inclusion happens on two levels
    - Getting to know their students
    - Student Scientific Backgrounds
    - Flexibility of curricula
    - Assuming no prior knowledge
- Teaching is highly student-centered
    - Students are equal participants
    - Students build skills
    - Students explore their interests and think in broader contexts

4.2 <u>Inclusive teaching under the COVID-19 pandemic: lessons from in-person, remote, and hybrid teaching experiences</u>

- Technology enables remote learning, practical experiences, and communications
- Office hours and checking-in with students
- Creative ways of assessments: Oral examinations
- Using break-out rooms as substitutions for collaborative working experiences
- A major challenge of teaching and learning during COVID-19: personal connections and interactions are distanced

4.3 <u>At the heart of liberal arts education</u>

- Professors stand in the shoes of their students
- Professors genuinely care about their students and strive to create a sense of community
- Class activity are tailored to foster students' developments
- Constructivist classrooms

4.4 <u>Moving forward in STEM inclusive education</u>

- Keep encouraging students to form study groups for peer support networks
- Get to know students well and constantly check-in with them
- Maintain a flexible syllabus and teaching schedule to ensure mental wellness
- Keep incorporating the virtual learning style and online lecturing platforms
- College-level STEM inclusive education reforms: a delicate balance

4.1 Practices of Inclusive Education

4.1.1 Inclusion starts from getting to know the students

- **Perceptions of inclusivity: inclusion happens on two levels**

I began my interviews by asking the participants their own perceptions and definitions of inclusion, inclusivity, and inclusive pedagogy/teaching practices, because I believe the ways they perceive the idea of inclusion have direct impacts on their philosophies regarding teaching and learning which in turn affect the teaching practices they employ. Here are some of the answers I got:

> Prof. K: I think inclusive education is education designed to help every student reach their full potential rather than to sort the students into a hierarchy of ability or knowledge.

> Prof. H: Yeah, so I think for math stats and now I guess computer science and data science, we constantly are thinking about 'how to lower the entry bars for students?'.

> Prof. P: I mean, I think it's really just understanding that students are coming in from a lot of different backgrounds. and I don't mean just their scientific backgrounds, their educational background, but also cultural and socio-economic backgrounds. And because of that, there has to be sort of a cultural, an awareness of all of those different things in the way that we approach topics and approach conversations about topics, so that everyone sorts of feels invested in the information, and that they can be an equal participant in the discussion about it.

> Prof. M: To me, inclusion has helped me feel even more deeply um how much we all have in common with each other. Anytime you have a group of people, you can divide up that pie in so many different ways: these are, male and female students, or let's reject the gender binary, but we all are somewhere on that spectrum or whether whether we're gay or straight or where we are LGBT or when we have intersections.

The interviewed professors approached this concept from multiple perspectives, yet the recurring theme was identity. All of the professors are aware that Vassar, as a liberal arts institute, is a small but extremely diverse community. The issue of identity is often widely discussed in humanities and social science classrooms, but not so much in STEM classes. However, this is not an implication that STEM faculty does not take student identity into considerations. Rather, as shown above, student backgrounds are appreciated, and not only their scientific backgrounds, but students as human-beings. They acknowledge that a student's identity labels can be complex, and quite often overlap so that one can hardly describe a student using simple terms, like 'he is a first-generation student', or 'she is a student with financial difficulty'. In the classrooms of these professors, students are more than a group of young people to whom the knowledge should be imparted, but individuals with great potentials to become scientists and contribute to the scientific community and human knowledge.

At another level, the scientific or academic background should also be put at priority. The professor teaching the course *introduction to data science* emphasized that inclusion of students' backgrounds in subject knowledge should be stressed when designing course curricula. The question that this professor, Prof. S., thinks is about the entry bar of this course. For advanced courses at 300-level, the majority of students are major students, so these courses require extensive prior knowledge and experiences within the field; but this usually is not the case for introductory, 100-level courses. At colleges that advocate liberal arts education, students sitting in introductory STEM courses may not be STEM students. In fact, only a fraction of them will go into STEM fields. For instance, a student taking introduction to psychological science class may be an English major. Therefore, lowing course entry bars becomes critical when considering inclusion towards student with no prior exposure to the subject matter. Besides, equally important is to consider how to properly introduce students to the discipline when designing curricula of introductory level STEM courses. As this professor repeatedly emphasized, the key is to build fundamental skills and knowledge which are prerequisites to entry of higher-level courses, and beyond.

- **Getting to know their students**

I still remember vividly my sophomore Organic Chemistry class: my professor made the first homework assignment an individual meeting with her; as long as we visited her office hours to chat with her, we obtained 100% in the first homework. We were all surprised and thrilled for this "free point" given to us without having to do any problems sets. When I was at her office, I was shocked to see that extended Excel Spreadsheet she had prepared to record information of every student in her class: not just names, nationality, backgrounds, but also our interests, aspirations, career goals, and hobbies – as much as we were willing to share with her. I have never had a subject teacher or class professor who knew me this well. While chatting with her, I could really feel her dedication in getting to know her students, well beyond simply knowing our names.

From my interviews, I was glad to see that there are more professors at Vassar who make efforts to get to know their students and take students backgrounds into account when designing courses and incorporate this element into teaching.

- **Scientific Backgrounds**

Depending on their prior academic records, freshman students at Vassar have the option of transferring their credits from high school to College up to 3.0 course units if they performed well in their high school curricula (AP, IB, etc.). However, the inconsistency of these pre-college programs creates a barrier for the professors of introductory level STEM courses in evaluating the student's preparedness for these classes. The scientific backgrounds of students are thus normally what considered for professors first when preparing their classes. When asked about how different students' academic backgrounds are taken into account, this is what Prof. K responded:

> Prof. K: I gave a survey this year, where I asked them to rate their previous experience of chemistry and their comfort level in solving math-based problems and the main purpose of that and I was very clear about this, because I also have some other questions was I had assigned them to study groups or I signed them to study groups, and I use those answers to try and make those assignments, so that students who all identified that they were very uncomfortable with math-based problems weren't all-together. Then we kind of had a mix of levels of comfort levels of chemistry exposure in most of the groups. And I also ask them questions about how they like to work in a group do they feel like they're always carrying the weight for everybody else, do they feel like groups are really helpful they feel like they like to talk a lot and they don't like to talk and I also like to try and design those groups, with an eye towards those questions so that hopefully the students would all find some people who they could connect with and really work with well.

Through the survey, Prof. K can not only get a sense of how students are prepared in chemical knowledge, quantitative skills, but also their working style. Those students who are more willing to share and communicate would get grouped with students who are more silent problem-solvers. The groups also have a mix of level of exposure to chemistry and related STEM topics. In this way, students' ability and personality complements, so the group could reach maximum efficiency.

- **Flexibility of curricula**

Acknowledging students coming from different backgrounds, professors are quite intentional about the materials they cover in class. Prof. P emphasizes cultural awareness when designing the curricula and course materials:

> Prof. P: […] And because of that (individual difference), there has to be sort of a cultural awareness of all of those different things in the way that we approach topics and approach conversations about topics, so that everyone sorts of feels invested in the information, and that they can be equal participants in the discussion about it. I tried to be very intentional about how I do each of the introduction and the material, and also the papers that I choose, and the way that, sort of approaching the students leading the classes.

Due to the different lived experience, students may approach certain scientific topics, papers, or discussions from different perspectives, and are likely to present information in ways that they are familiar with. Prof. P thinks college classes are places where students should step out of their comfort zone and analyze and present issues in ways that are new to them. To achieve this goal, Prof. P designed a class activity in which students lead small-group discussions in the way they choose, after consulting it with the professor beforehand.

> Prof. P: For each group of students that is leading that discussion, there's a requirement that they meet with me in office hours to discuss what they got out of the paper, how they were going to discuss it, and then I tell them about things that I would do if I was going to teach it as well. So that they get an idea of other resources that they might not have known about. It is a 15-person class, but everyone gets that small mentoring, like smaller-group mentoring, about how to dig into supplementary material, how to look at references, how to find ways to introduce a topic, and how to look at popular media and how topics are being covered by the media and bring that into showing how it's important at the societal level.

Prof. K put all these aspects together and provided suggestions to incoming junior faculty members in inclusive teaching. Prof. K suggests that:

> Prof. K: I would, I think I would suggest that any new professors focus on a broad definition of inclusion focusing not just on demographic characteristics, but on social inclusion and learning styles and diversity and all of those things and be open to a wide range of possibilities of things that students might need. And I would suggest also that they write everything humanly possible in their syllabus.

- **Assuming no prior knowledge**

Another common practice that I found across the professors I interviewed is that they generally assume no prior subject knowledge from the students. As introduced earlier, a variable that is out of the control of the instructors is the academic background of incoming students. Given this premise, Prof. P treats her students with no previous knowledge on topics covered in class, so she stresses the first step of *building a common knowledge base*, before proceeding to advanced topics discussed in literature.

> Prof. P: Because they (students) are coming off from different backgrounds, what we're really approaching it, as is I treated as if people are coming in with no knowledge of any of the topics, so the assumption is you don't know anything about photosynthesis or you don't know anything about plant nutrition. And so, first, building a knowledge base that is common amongst all the students, and then giving them that sort of ownership over a specific topic so that they don't have to research all of them to a depth. They get that one that they get really comfortable with and lead the class on that discussion, and through all of that they're sort of building up these skills of how to read a paper and how to identify what's important, so that when they read the next paper they can contribute, interpret graphs that much better or look for those spots that much better.

Assuming students have no previous exposure to Chemistry, Prof. K really starts from the very basics of fundamental Chemistry for the first few lectures of her introductory Chemistry course. The purpose is to have the students get the flavor of the course: the contents, pace, difficulty – so they can decide whether this course is the right one for them. Prof. K considers assisting students self-select the right course an inclusive practice:

> Prof. K: So, for this course first of all, I start at the very beginning. I really assume no knowledge ahead of time. If they have some a couple of those initial lectures are probably a little boring. But and I will explicitly say to them, , that's the deal, if you think this course overall is going to be too small for you, you belong in 125 (CHEM 125, accelerated version of introductory Chemistry course) – that's fine, nothing wrong with that we can switch you out, but this is, this is what we're going to do so, I try and help students really self-select to the right course for them.

4.1.2 Teaching is highly student-centered

From my interviews, a common impression that the professors left me with is that their inclusive practices are strongly student-centered. The sole intention of class activities, assignments, and other course requirements is to assist student learning and personal growth, and to ensure that students get the most out of the class. Below are some of the aspects of students' engagement in class.

- **Students are equal participants**

As discussed previously, professors usually acknowledge the fact that students come from a wide range of different backgrounds, both personally and academically. Therefore, they give lectures and homework assignments assuming no students prior exposure to the subject matter and they require no special access to resources that may be unattainable to certain students. Like Prof. P mentioned:

> [….] everyone sorts of feels invested in the information, and that they can be equal participants in the discussion about it. [….] A lot of issues with privileges that students come in with, the fact that some students don't have access to certain resources.

In addition, Prof. P stresses the importance of checking-in with students and ensuring that nobody is left behind. Prof. P used the analogy of kindergarten kids holding the same rope when walking to describe an ideal class, in which all students learn and grow together:

> Like walking through campus and they [the kindergartener] are all holding onto a little rope and , nobody gets left behind in that situation because **e**veryone is together, and so I think that that idea of keeping everyone together and it can't just be the teacher or the professor, who is reaching down and grabbing everyone and pulling them up, I think if we build sort of a community in the classroom … if everyone is doing well in the classroom then that's the goal, there doesn't have to be someone who's winning and everyone else has lower grades, like the ideal class to me is that

> everyone gets an A that means I am doing my job everyone's learning, Fantastic. So having everyone invested in everyone else's ideas, and everyone else's success, I think, is the way to do that is basically , really, creating a learning community rather than sort of individual students focused on their own goals.

Lastly, Prof. K shared with me some critical insights from her own teaching experiences of treating students as equal participants of her classroom. Regarding in-class activities and discussions, Prof. K raised a point related to students as equal class participants. Prof. K reflects her pedagogy of trying to get every student engaged and ensure everyone has the opportunity to speak, ask questions, and answer questions to foster their learning:

> Prof. K: I do try to call on people who don't necessarily raise their hands and set up an atmosphere that says, like you can pass, you can say like I don't know I don't want to answer this one that's fine. But if you only call the people who raise their hands it's like the same five people, so I try and be really conscious of that.

The fact that students are different individuals determined their distinct tendency and willingness to participate in class activities. However, Prof. K tries to resolve this difference by being conscious of students’ participations in class and encouraging those who are more introverted to answer questions. This way, she would know whether every student has understood the material and reiterate some points whenever necessary. Besides, she mentioned another practice of her outside of class to make sure everyone contributes to out-of-class small-group assignments, too:

> Prof. K: I had them fill out a really quick Google form after each week which basically just said, this is what we did was everybody there? did everybody do okay? Did everybody were there any problems and how did your group function as a whole, I didn't ask them to greet each other, because that just felt really toxic. But just as a whole, did your group function well? Okay, and so I got some really good information in there. And then halfway through the Semester, I did shift the groups in large part, based on the feedback, there were some groups that were functioning really well, and they really wanted to stay together and that was, in particular, group of all remote students who were like these are people I am really getting to know I their first years,

> who are remote they don't know anybody. I don't really want to switch my group, I feel like we're really starting to connect… it's like okay fine, and then other groups where things weren't working so well, I was able to shift it around.

- **Students build skills**

Professors are usually quite intentional when designing their in-class activities with the goal of helping students develop skills. These skills are usually essential to be literate in science or critical skills to become an independent scientist; thus, it is of importance to start building these skills as undergraduate students. For instance:

> Prof. K: It's a 15-person class, but everyone gets that small mentoring, like smaller group mentoring, about how to under how to how to dig into supplementary material, how to look at references to find ways to introduce a topic and how to look at popular media and how topics are being covered by the media and bring that into show how it's more how it's important sort of at the societal level.

- **Students explore their interests and think in broader contexts**

The benefits of having a small class size reflect in multiple aspects of teaching and learning, but most notably in the input of students to the course. Many STEM classes at Vassar provide opportunities for students to take the lead and present on topics of their interests, usually in creative ways that they think can best present the information and convey ideas. Meanwhile, students themselves are prompted to consider why their topics of choice are significant and how that related to real-life situations and challenges, like climate change. The lessons learned from individual courses often transcend beyond courses themselves. Here is how Prof. P teaches her plant and society class, integrating students' presentations:

> Prof .P: There are also two individual projects throughout the semester. one is mid semester, and that one is that they get to choose any topic of their choice, involving Plants and Society, and Climate Change. And basically do a 15 minute presentation to the class about that topic and why it's important, just to kind of like sell the class on why they should be thinking about this topic and it's been kind of incredible so

> students have come up with a huge range really based on their interests from Agriculture to peat Moss farming to Vertical Farming, like those kinds of things, and, so each student – depending on the if there were more molecular biology focused, or if they're more ecology focused, etc. – they're able to sort of focus in on that thing that they really find interesting about plants and about what's going on and bring it into this space and sort of this umbrella topic of plants and climate change. It's not like a really specific things like it's not 'you have to do a 15-minute slideshow and that'. So, the students can really have creative freedom of how they want to present it, and so that's been really fun.

4.2 Inclusive teaching under the COVID-19 pandemic: lessons from in-person, remote, and hybrid teaching experiences

- **Technology enables remote learning, practical experiences, and communications**

As discussed in an earlier section, the foremost issue related to remote teaching and learning is accessibility and resources. Not only is the problem of connecting to virtual classrooms, which requires stable internet connection and computer resources, there is also some software requirements for certain computationally based STEM courses. The *Foundation of Data Science* course is one example. When Prof. H teaches it, she fully considers the potential barriers remote learning can pose for her data science students, and she tries to eliminate them to her fullest ability while retaining planned course contents, activities, and laboratory sessions. Additionally, as introductory level courses, students are often unfamiliar with the subject matter, let alone the computer programs associated with the field – this creates extra difficulty in introducing students to the course and subject with hands-on practical experiences of actually using computer programs. To achieve these goals, she takes initiatives and works together with CIS to coordinate the set-up of programs ready for student use in a remote fashion:

> Prof. H: We emphasize computational thinking and influential thinking, and we use the programming language. Python. and one thing I think we tried hard to make it accessible and as to use Jupiter hub, which is the online server that people can actually just log in as long as they have a browser, and they can do all of the computation. That like don't they don't need to install anything all of the like the packages on the programming a pre-loaded so students can just work on. There so because we know a lot of challenges or obstacles for introductory data science courses or statistics courses are the computing aspect and typically like say for my department, we do statistics courses intro stats, for example. So, they (CIS) hosted for us and we still need to contact them when everything anything comes up, but then for Jupiter hub I think my colleague Jason waterman from computer science.

To facilitate instructor-student communications in a virtual teaching and learning environment, professors have explored different options to ensure that important messages can be timely exchanged between students and the instructor. Prof. S used an online platform called Campuswire:

> Prof. S: I'm using a tool called campuswire. It's kind of a web-based online community, it gives me the ability to have channels to chat with my students, so I don't have to rely on the zoom chat. On Zoom, when I'm sharing my screen and that's what I'm doing, most of the time when I'm doing my lectures, it's hard for me to notice that there's a message on the chat. So, with campus wire I've got channels for in class and labs and assignments, and I've got a channel for talking to my coaches my TA. Just to initiate communication each class make sure that they're signed in also, but I think it's been going pretty well.

Zoom is the universal online platform that professors give lectures to students. Its functionality is diverse for users to exploit, such as break-out rooms and screen-sharing functions; however, there are certain limitations, including the fact that chats can hardly be seen during a lecture. Prof. S addressed this issue by using this new platform, Campuswire.

Communications between students and professors do not only take place in class, however. Students often run into issues with homework assignments or have trouble understanding certain concepts. This is when students reach out to professors. In pre-pandemic times, instructors set regular office hours, and there are always Teaching Assistants (TAs) help answer questions. Under the pandemic, accessibility of assistance outside of class becomes an issue. Prof. H tried out a similar online platform, Slack, to ensure that students can pose their questions and contact her whenever needed. Also, she finds that students can easily voice their concerns about class materials and the course in general:

> Prof. H: On slack, those weekly checking form can be a little bit personal, in a sense that it's about them, or like about this particular students, so I was able to catch those as well, due to the fact that we're using those weekly check in so for those kind of personal comments I will directly Slack message them directly, instead of doing on the channel that everybody else can see, and then I think for that it's…..Well, we do that in person, anyway, if that happens right but, but I think online is just hard so this kind of form that as long as people are willing to share, which I think they do because everybody, I think wants to do well in a course so there yeah so they're overall pretty willing to share their concerns and experiences so that I think is a good thing to do, maybe even in the future as well. After the pandemic ends.

- **Office Hours and Checking-in with students**

Holding online office hours is still the primary means that professors provide for students to come in and ask questions or raise their issues. This direct face-to-face communication style is the most favored. Even though online meeting has undoubtedly created difficulty, some professors pointed out positive aspects of holding office hours virtually:

> Prof. A: I think office hours actually worked really well! I would just have a zoom open and people would appear and that, I think was actually maybe better because I think there's like a little bit of a barrier for people like leaving wherever they are in coming physically to office hours, and it's much easier to like hop on the zoom link with a quick question for five minutes. , and sometimes somebody would hop on that asked the question I would answer it, they leave ,and then they come back, and be like Okay, 'I did the problem and it turned out like this do you think that looks', Okay, , and so that kind of easy in and out was really good.

Moreover, office hours and individual meetings with students outside classes can be great opportunities for checking-in with students, to see how they are doing, both personally and academically. Everything goes fully remote accompanies inevitable change to individual schedules for both students and faculty members. Taking advantage of their extra time slots available to meet with students, Prof. P. actively welcomes students to chat with her about anything they would like to talk about:

> Prof. P: I have tried to be really aware of the students and how the situation is affecting them because there are students who were remote, I really try to be inclusive of making sure that they were getting the most out of it that they could and checking in on them. And the other thing that I do is I at the beginning, I find out like what everyone's interested in like… This is the kind of class that you take it, because you're really interested sort of in either plants or climate change or both, and so everyone's kind of coming in with these different ideas like they want to work in Agriculture, or they they're interested in, I had a student that was interested in marine biology and climate change. Kind of keeping track of those interests and it allows me to, as I see summer internships pop up, or fellowships, or different opportunities, like that, then I can be like oh that student was interested in this I am going to send that to them. And so, thinking about all of the things that I normally would have done in person to get to know the students and make myself a resource for them, I try to do online.

Similarly, Prof. H finds it particularly helpful to have students submit a weekly feedback online to let the instructor know what troubles students have, and generally how they are dealing with what is being covered in class. This mode of feedback actually contributed a lot to her planning in her teaching, in terms of whether students have fully understood the materials and if the teaching pace is appropriate and acceptable. Prof. H hopes to continue doing this even after the pandemic:

> Prof. H: For foundations for data science or others courses I'm teaching right now, because it's fully online and doing like a weekly checking for that. Like it's like pretty standard questions, for example, like what is the most interesting topic of this week. What is the most challenging do you have any remaining questions or how, how are you working with your group things like that, and one practice I'm doing right now is that every Monday, because that I make it do like Sunday midnight. So, every Monday morning I spend like usually like about an hour going through all of the answer questions. Anybody like post it usually like 20-ish and I post a

> question, together with my response in the slack channel. Otherwise in the past, it will have to be somebody maybe after me term and crying my office saying that I wanted a higher grade, or something that I realized something might not be as great as I thought it would be… or after grading like a quiz or like an exam. But nowadays, I think I am able to a little bit catch those problems early on I'm not sure like how often those students going to read my responses. That I see repeating things about like certain chapters so to material or like just certain concerns about the course and stuff like that so trying to share that with everybody else, because anything that can maybe make them more or less.

Often times, she would receive responses that include both specific questions and general feedback such as 'I don't understand very well'. From some recurring responses, she gets a sense of the part of course material that needs reinforced lectures. However, for general concerns other than academic, she provides encouragements and tries to keep everyone in the class engaged and connected:

> Prof. H: And then, sometimes that can help generate more questions, I guess, or a lot of times also just like to offer encouragement, because sometimes you're going to see some common themes of confusion. I mean, sometimes it's very specific questions like how, how I can do this and that, but sometimes it's also like people's… I feel like I am understanding this only on the surface. And then I see that coming, like all the time, so I think it's also a good way, even though students cannot see the responses themselves, but others, but I think…from me summarizing this, and also maybe offer encouragement like what I was trying to say is a good way to keep them a little bit more engaged and connected, given that everything is very disconnected because of the pandemic and this kind of practice, I think.

Prof. K. employed what is called a 'pogo' method to keep track of student learning progress. In this method, each student in small groups has distinct roles, but they all work together and ensure that everybody is on track. The group leader reports to her on a weekly basis regarding the group work progress:

> Prof. K.: I use the 'pogo' method, which basically means each person in the group had a role, and the group was three people, which was a common group size, one person each week was the facilitator, which meant they were supposed to sort of lead the discussion; One person was the recorder, which meant they were supposed to write down the answers and then submit them to me; And one person was the equity monitor so if somebody wasn't participating, or if there was a problem they were supposed to sort of action and just get the group dynamics back on track. So that was one thing within the groups that I did.

In fact, Prof. K. spoke highly of this mode of group work that her introductory Chemistry class uses:

> Prof. K.: So overall I like the groups, I, like the structure of the Groups, I think it was really good to have the groups also had to do work together, and I think was really good to have the groups doing that graded work together – I think it really mattered. So, I feel really particularly good about that!

- **Creative ways of assessments: Oral examinations**

One part that presented outstanding challenges to almost all professors when teaching under the pandemic is assessments. Assessments are core parts of a course and is a critical way to evaluate students understanding of course materials; meanwhile, it also reflects how well the instructor has taught a particular course. Traditionally, in-person examinations are primarily how these assessments are performed for STEM classes. When students are on Zoom and are physically apart from each other and the instructor, it is particularly challenging to proctor them to take the exams. To resolve this problem, some professors invented novel ways to administer assessments in their classes, one being giving oral exams to students. For Prof. K's introductory Chemistry course, the emphasis lands on students' understanding of fundamental chemical principles, rationales, and graining basic chemical literacy. Without requiring heavy mathematics (as in *Quantum Chemistry*), or molecular drawings (as in *Organic Chemistry*), Prof. K deemed oral examination a feasible way to assess students learning. Throughout her semester of teaching the introductory Chemistry course, she gave out two oral exams to students:

> Prof. K.: Two of my three exams, I gave oral exams, where I met students for 10 minutes and asked them five questions and they just explained their answers to me and I had a rubric and I just went through it, as we went and there was making those assessments, the right level was challenging that was just a new thing for me… The exams couldn't be anything heavy math based because I had 10 minutes per student, I had about 25 students in the class so 10 minutes a student was about all I could do so I had them identify a mistake in a Lewis structure that was drawn mistakenly and explain why it wasn't a valid Lewis structure, like what to fix it. I had them rank elements in terms of electronegativity. One I had them assign Redox numbers, and on….both of the oral exams I had one question relating to the environmental climate material, we had covered where they just had to sort of talk through a concept that we had discussed. I had them determine if reactions were acid-base, redox, or solubility, precipitation, or no-reaction. you just categorize them so things like that things that would be on a regular test, but more on the qualitative side because that's what you can do in 10 minutes.

Reflecting on her experiences of administering these oral exams, she provided positive feedback and told me that it gave her a moment to connect with each student individually. Specifically at the moment when some of them were feeling nervous (for physical in-person exams), she was be able to assess their knowledge in that way. Also, she also thinks oral examination is a great side way in getting to know students, in terms of their learning styles and personality, to be able to best assist students in their learning specifically to each individual student:

> Prof K.: And I think that allowed me to get a better look at what the students did and didn't understand and also just sort of some patterns of certain students. One student who was completely sure that they had failed the last exam when they had gotten a 98.That kind of thing , but it was like Oh Okay, I have a little bit of a sense now of how you are as a student, like you're really nervous about your grades, even though you're doing really well. That’s actually useful information for me, so I can respond in some particular ways. And another student who was really struggling, when we did the oral exam, they actually did really well! They just needed a lot, a lot more time than anybody else had. And so, being able to identify that and say to them, you clearly know the material I am not sure what the issue is with time, but

> I think it's something worth pursuing because otherwise you're struggling in this class, but you actually clearly know what you're doing 100%.

- **Using Break-out Rooms as substitutions for collaborative working experiences**

Using the break-out room on Zoom was the common practice technique that was employed by all of the professor I interviewed. As expected, it is one of the primary methods that they use to substitute the in-person, face-to-face collaborative experiences normally students would have before the pandemic. Whenever students are asked to work in groups, break-out rooms are used.

To my surprise, each professor got something different out of this break-out room group work experience. Prof. K. helps students utilize the functionality provided with break-out rooms, such as the whiteboard, for demonstration purposes. It is clearly much more convenient that clear when it comes to drawing molecular diagrams or writing equations. Group work on a virtual piece of paper is made possible by the whiteboard function, where students can view other people's work and discuss, and also for instructor's inspections:

> Prof. K: I used breakout rooms for problem solving. Although one of the limitations that I found is that mostly the students didn't have the technology to be like screen sharing what they were writing, because , usually you would just write on a piece of paper or your notebook or something and really like those breakout rooms would have been a lot better if everybody had some sort of a tablet where they could be writing and looking at what the other people were writing, and it just wasn't something they could do, and that's I mean no fault of theirs, but I think that limited the usefulness.

Prof. P. encouraged her students to use the break-out room together with Google Document, to collaborate with each other in real time. The use of outside multi-media platforms allows the creation of multimedia products that could otherwise be impossible in in-person classrooms when all students have been pens and papers. Here, students can browse the internet and access digital resources to help them create illustrative media projects. Finally, Prof. P. added, that sometimes students can see the work progress of other groups and gain some insights (but no plagiarisms!).

> Prof. P: I made utilization of breakout rooms, a lot for working on what we would have normally done, by turning chairs around, and talking in small groups, instead used breakout rooms. And one of the ways that I did it was I would create Google slides and basically give them the link, and everyone would draw on and type on these Google slides and create the things that we were talking about, and so it was sort of the ‘virtual whiteboard method’. And, and it was really kind of funny because I created one document with several of the same slides and so each group basically group 1 one would have a slide that said group 1 etc. But with Google slides you can kind of see the people who are on it on a particular slide...
>
> Because I couldn't hear their discussions, because they were all in breakout rooms, but I could watch them and, like what they were doing, and that was kind of cute and it was it gave them…. So, one thing that was different than it would be on the whiteboard is that they would go into the Internet and, like grab a picture of something and put it on their slide, so it became more of like a multimedia collage than just drawings!

In his computer science course, Prof. S. takes advantage of the small break-out rooms to give out laboratory exercises and practical assignments and have the TAs to be ready to help at any time during the lab period. He sees break-out rooms as the place to help students develop practical skills and answer their questions in laboratory sessions, just like in-person class meetings:

> Prof. S.: We've set separate breakout rooms during the labs one for each coach, but the coaches and I can all monitor the channels, so we can invite students to come in and join us in the last couple weeks I’ve realized. The one-on-one thing in the in the breakout rooms isn't working as well, so we'll have multiple students come in and it's different because I’m helping one student and other students are watching, but often they have. Similar or related questions and more than once, when I get to another student has been waiting, they'll say Oh well, you actually answered my question when you were working with somebody else!

Last, but not least, Prof. H discovered that, the break-out rooms actually provide a novel avenue for students to work together, help each other, and even discuss something beyond the assigned work. Because she assigned pre-lecture videos for students to watch and take notes beforehand, all her class periods are dedicated to problem-solving and work sessions. What's more, when students are checking-in with each other and discussing the assignments, sometimes they discuss beyond their work, and reflect about the subject itself and their own experiences in exploring the field:

> Prof. H: I also found like peer learning from the peers when somebody with a very similar background like if it clicked for them and they're able to explain it to you, you might also get the click and then figure out that '*okay that's actually a really good way of thinking about this so*''. And in class exercises during the regular class and I still put students in groups to work on it, but I feel like now, students are like fully engaged in those live session exercises and they actually talk a lot more about like probability, in this case, or like math or statistics, instead of doing the exercise and then just trying to compare your answers with others, so I feel like now, given the chance of them to work. In a group for the entire 75 minutes because everything, the material content is shifted like outside of those sessions, and then I asked them to watch beforehand, I feel like, they get the more opportunity to discuss, and then a lot of times, I think, even though we think like STEM fields, maybe you don't need much discussion you just do like follow the formula and then do whatever, but the learning process [matters].

Interestingly, in the Biology seminar she teaches, Prof. P. also observes the same conversations going on among students working in small groups. After students became acquainted with each other, they are more willing to talk to each other beyond the current course material, and really check-in with each other and provide mutual support. Having this emotional companionship makes the class environment less tense:

> Prof. P.: With months of working together and getting to know each other and being able to have these conversations and by the end it was great… students were basically having arguments about like different topics, like in the chat box and then with each other, and it was just kind of funny that they had reached that point where like they were willing to sort of have these like debates about topics. And I think it's just important to sort of create that environment where everyone feels comfortable that they can talk about what we're all going through that we're all going through something yeah and it's the big virus-elephant in the room and we're all dealing with it and talking about its importance, and not making it the focus, but every now and then just saying hey how's everyone doing and it's good to sort of

> take the emotional temperature of the room sometimes and see how people are doing.

- **A Major Challenge of teaching and learning during COVID-19: Personal Connections and Interactions are Distanced**

Both Prof. P. and Prof. S. told me how they feel that remote teaching creates barriers for people to connect. For them, it was about being able to see students, read their facial expressions, and body languages. Simply knowing that students are there paying attention and being passionate about the class makes all the difference, and this remote experience has hampered that connection to some extent. Therefore, they sometimes would stop to ensure that everyone is on track, now that these subtle clues can hardly been seen and be helpful in informing them of students' learning.

> Prof. S: There is something about like your face really close up to the camera… I try to do my best to read facial expressions and body language and it's not always possible or it's not as effective, sometimes in the classes, that I teach and we're students are sitting behind a computer monitor in the computer lab. That every student is comfortable of turning their camera on or keeping a camera on, I tried to encourage that but, if a student is uncomfortable with that, I am not going to make them do that. But I will sometimes ask them if for a moment, can everyone, please turn your cameras on I just like to see your faces for a moment, it reminds me, we're all there and then and most students are willing to this turn it on briefly before they turn it off. It just it helps me so much to see their face even if it's just once, at the beginning of class or at a certain moment in class.

> Prof. P: As a teacher, we rely a lot on body language and so, if you're trying to teach something you can look around the room and see who's taking notes and who is looking confused about something, but when you're trying to focus on 15 boxes on the screen and also have your lecture up or something it's really tough. And so that the opportunities to feel the room and pause and really kind of understand when to take these breaks and when to have discussions it's a lot harder in the virtual environment, and so a lot of times I had to sort of build the opportunities in and just not let them happen organically like stick in a slide that had a question on it and make us stop and see where we stood on different things.

When talking to Prof. P, she also complained to me this issue of not getting enough feedback from students. She deeply feels this unequal investment and returns when she teaches classes online. When students turn off their cameras and, in the gallery, view all she sees are names, she feels all that energies she has put out there received no rewards. She emphasized that we are social animals, and not having that social interaction really changes the dynamics of the classroom:

> Prof. P.: It's one of those things when you're in a room with people you sort of feed off each other's energy. But, in , right now, like we're talking one on one and so we're interacting, but when it's a screen, and you're teaching and you're throwing all the energy at your computer monitor….there's not a lot coming back. And so, at the end of the day it was just like I am so tired, but I have to plan for the next day and. yeah, so I think the lack of interaction is it's really something that that I think is underestimated when people are talking about this just how mentally tiring it is to try to maintain interactions under these conditions.
>
> I think we don't realize how much we get back in energy from interacting with people like we think a lot about like '*Oh, how much effort I am putting into this discussion'* whatever, but I feel like other people's input into discussions feeds back into us and gives us energy back because it's something to, kind of, go back and forth with. And it just feels like you're just putting energy out there and nothing's coming back and so it's like recharging is so hard in these situations because we're all isolated like my all and I am seeing my partner every day and that's about it, like he's my only three-dimensional person.

4.3 At the heart of liberal arts education

- **Professors stand in the shoes of their students**

For many undergraduate students, these introductory level STEM classes are very likely their first immersions with STEM subjects. They would therefore enter these courses without ideas of what to expect, or even whether they are capable of doing well in these classes. This is the point where instructors step in and help with the students, step in their shoes, and really tell them 'you can do this.' Often times, it requires professors to stand in the shoes of students and consider what kind of obstacles or barriers that can be possibly challenging for their students, for a group of young people who are new to the field.

In her introductory Chemistry course, Prof. K tries to ensure that students previously built quantitative skills and their familiarity of mathematical tools wouldn't stand in the way of their initial explorations of Chemistry and tell them 'it's okay to struggle at the beginning, but you got this!':

> Prof. K.: I do really work with the students to say it's okay to find the problems hard, but what we're going to try and eliminate is that initial panic when you see like numbers and equations which I know many students have and just like okay we're going to work on just getting rid of that and getting the answers, but try and break it down and make it friendlier so that people can sort of push through some of those concerns.

Prof. S dedicates in encouraging students by modelling a fallible professor character. The message he tries to convey is that nobody is perfect and completely flawless, even as a college professor. By doing so, he hopes that students can at least stay assured that making mistakes in computer science and in programming cannot be more common. Even a trained programmer makes mistakes all the time. In class, when Prof. S. makes a mistake during live coding, he would turn to his class and ask for their help, so that students can get a first-hand experience of how to deal with coding errors and debugging; what is more, students practice the coding skills they have learned in a real coding setup:

> Prof. S.: And, and then I turned to the class and I asked him for help, so we're going go on, where's the problem, and get them to I'm trying to model that I'm fallible I'm trying to model that I'm not perfect and trying to model that writing programs and then I, in the first class I spend time making an analogy that writing code is a lot like writing prose in your composition classes. And so, so I tried to do everything I can to disavow my students of the assumption that I'm perfect or all knowing. I just I study the subject longer than my students and I had more experience and my

> students but I'm not I'm not perfect, so, so I think I do that well. I think that's part of what makes me approachable or helps to make me approachable.

Similarly, in the syllabus of Prof. K., she explicitly states that we embrace mistakes, and making them is totally fine as a learning experience:

> Prof. K.: So, I try to have syllabus language that is inclusive it and, specifically, says, making mistakes, is part of learning in this course, and so we're all going to embrace our mistakes and all of that.

- **Professors genuinely care about their students and strive to create a sense of community**

Of all these interviews I have had with four STEM professors, my favorite quote is actually from Prof. S., when he comments on his level of intimacy with his students:

> Prof. S. Well, I hear this feedback from students occasionally on the written parts of the CEQs or sometimes in class that students will say… *'you're such a dad!'*…which I take it as a compliment I do, I actually do feel paternal I told you that that my students now are they the same age as my children when I look at my class of students. I just see my *children*, right now, maybe this is a because of the stage of life that I'm in. And maybe at some point, that will all remind me of my grandchildren, but right now they're all my children I care about them, I tell them that…I tell them that I care about them by the end of the Semester I tell I tell them that I love them… sincerely, I care about them, I want them to do well, I believe in them that they can do well, and I think that. It helps students to hear that.
>
> Whether it's marks on the paper, or whether it's on words in an email, are fraught with peril that can be so easily misunderstood. there's no substitute for being able to talk to students in person, one on one on one to understand so. So, these are all the things I try to do to be approachable to let them know that they can come to me with anything.

Under COVID-19, remote teaching and learning has become the new "normal". This global wide, unprecedented pandemic has shifted everyone's life. It is also the first time for college professors to teaching online and for students to learn remotely. Prof. S. stresses to his students that this is new to everybody, and that ‘we are all in this together’:

> Prof. S.: this is a different time and I’m really stressing and trying to model that we are a community, and we do learn from each other and. And I need their feedback, not only to see how well they're learning what I’m talking about but also, they may have suggestions, why doesn't he just do this, it would be so much easier I’m open to that so I’m I’m listening to all of that, and I think. I think it's a way that students can pick up or believe that I really do care about them and how they're doing.

Prof. S. acknowledges that this pandemic reflects many aspects of personal differences and they may present challenges to equality, equity in education. He tells his students that, again, this is unexpected, and everyone is experiencing the pandemic for this first time, so not only students depend on him for guidance and support, but he also needs help and input from them, too. Whatever happens outside campus, no matter what happens around the world, we are always together:

> Prof. S: So, this um this pandemic, and the challenges that are presented for students to continue to be students and participate in classes. It magnified a lot of our differences. It magnified our privileges and then our disadvantages. But even when you take that magnifying glass away after COVID is over. Those feelings are still there, even if they're not magnified and if, and if left unaddressed or unacknowledged, they will fester and become a bigger problem, so I continue to believe that I need to tell my students that I care about them, eventually, that I love them… they're not ready to hear that, on the first class but, in the last class, they are and. And just acknowledging that I need their help, sometimes to connect with them and find ways to help them so. The challenge continues, and I become aware of more but that expression that that the more I learned the more I know that I don't know, right? The more I learned like this, this this whole area and that that's how it was for me when I learned about intersectionality and that if you've ever if you're in multiple. Underrepresented groups just how much that… multiplies!
>
> I really try to emphasize the sense of community that we have as a class together and whatever's going on out in the world around on campus that our class is a safe space to learn. And when there are incidents that are happening that are distracting in the world, or when they're incidents on campus. we've had we've had some hate

> crimes and stuff occasionally a graffiti in the library I don't know if you remember that.

In a similar fashion, Prof. P. constantly encourages students to voice their concerns if anyone needs help. She is more than willing to pause the class or her lecturing for a moment and address any questions or concerns if any of her students encounter difficulties:

> Prof. P.: This is going to be, hard class because , these things are happening and it's affecting me as much It is affecting you, and I want to say that out loud and acknowledge what we're feeling and we can take a couple minutes, just to talk about it for a while and I think that's another great thing about having us a small class like this is.

Lastly, Prof. H. acknowledged too that as a professor, this is also a learning curve for her. She points out the fact that being inclusive and care for students encompasses many aspects, and professors really need to get to know their students, what they need, in order to best support them. Then, they need to work out ways that the support can happen:

> Prof. H.: I guess it's going to b a learning experience for me for a long time to come…one or another, but I think COVID-19 definitely helped a little bit in that sense, I think I will….yeah… I guess they stay focused in terms of what could be possible issues and challenges and then try to be a little bit more helpful as much as I can, and I think accommodating like those difficult is definitely like the least that we can do at least, but "I think there are many other things that I need to learn and then trying to I guess digest and then trying to because at the other end is being fair to every student" right and we don't want to make exceptions for some students too much and stuff like that so on that matter, I think, by using slack or like just true to broadcast everything to everybody.

Prof. S. raised the same point: he is also actively learning what and how he might provide students with help:

> Prof. S.: I heard from students even who were in class and participating that it was so helpful have the recordings. If they didn't understand something that they could go back and watch a portion of the lecture and hear that explanation again or see what it was, we were doing. And, and one way or another, when we are past COVID , this is something else that I like to provide above and beyond my lecture

> notes and such. So, um so it's just another example of how I continue to learn what helps and I'm always looking for more ways that I can pre accommodate when I get accommodation letters from students. Students come to me with different accommodations like 'I need extra time on assignments' or 'staggered deadlines', or I need extra time on the exams and then all of those cases, I have gone along with already pre accommodating that that that I know through the grapevine that there are students who based on what don't even share their accommodation letter with me, because I have pre accommodated what they need.

- **Class activity are tailored to foster students' developments**

As courses offered at a small liberal arts institution, STEM courses are Vassar magnify the unique experiences and environments created for students that would otherwise be unattainable at large research-based universities. First and foremost, the small class size enables instructors help students develop transferable skills that are at the hearts of liberal art trainings. More importantly, these common skills are also being developed by students attending social sciences and humanities courses:

> Prof. P.: That's why it works really well as a seminar courses, because it's a small group and we can we can do that, we can focus on specific things, and …, I feel like it really fits in with the strengths of a liberal arts school, and the kinds of skills that the students have learned through their humanities courses and all of that, but bringing those skills in with looking at scientific topics and looking at data but being able to sort of think about them on the those next levels. Because really thinking about ….yeah…. we can look at what's happening at the molecular level, what's happening, , look at the data of how these things are changing, but it's the humanities, training and the liberal arts training that is really, I think, allowing these classroom discussions about '*what does this mean to society'*, '*how is this way* '*why do we* care', '*how is this important'*.

Even at introductory level STEM courses, professors are striving to help students develop professionally and help them foresee what their future careers may look like. In Prof. K's introductory Chemistry class, she intentionally takes some of the class time to play a series of "two-minute videos" created by a Professor of Biology and Chemistry at the Massachusetts

Institute of Technology (MIT) and the Howard Hughes Medical Institute (HHMI) who works on educational projects. In this series of videos, students (graduate students, postdoctoral fellows) and some faculty members at MIT are interviewed and invited to talk about their background and pathway to becoming a scientist at MIT. By doing so, students are also introduced to the lives of actual scientists. Some students may get inspired and also become part of this wonderful journey:

> Prof. K.: So there's a series of videos from MIT from Cathy Drennan who came to speak last year that are like so I showed all of those videos in my class they're like 12 videos so I did one a week there and they there are two videos per scientist one is sort of their personal story and one is their overview of their science work, and so we did those every week and I don't really know how that landed but it's a fairly diverse group of scientists and people talk a lot in there about overcoming various obstacles that they may have had towards getting to be a scientist at MIT. I did really want to really designate class time for that.

- **Constructivist classrooms**

As a constructivist, Prof. S. advocates for students and faculty as community learners who learn from each other. He therefore tells his students that feel free to report back to him on his pedagogy. Whenever there was something ambiguous or unclear, students could let him know and he would strive to provide an alternative explanation and improve his practices for teaching particular contents.

> Prof. S.: I spend time with students know who I am both personally and in terms of my research interests and in terms of being at Vassar and I tell them how much I love teaching this particular class. I acknowledge the problem of representation in the class and I, and I, and I come out to them and just say I want to be part of the change and… I hope I do a good job with that and I tell students that I consider our class a community of learners, that that we're all here to learn from each other, I learned things every time I teach a lecture, every lecture, a student question will cause me to understand a new way that students don't understand some concept that I'm talking about and it'll cause me to come up with new explanations for things. But I tell students, we all learn from each other it's not just you are learning from me it's me learning from you and you learning from each other and I also tell them,

> I sometimes use the analogy that my classroom in class isn't a waste this it's an oasis from everything else.

4.4 Moving forward in STEM inclusive education

- **Keep encouraging students to form peer support networks**

When asked the specific practices and pedagogy that were used during COVID that they would like to keep after the pandemic, Prof. K responded to me that she finds peer support networks important in assisting student learning. She also finds that Zoom or online meeting platforms provides a great avenue for students to meet and form study groups without having too physically be together:

> Prof. K: In terms of teaching, I think I will definitely keep the study groups. Last semester I let them choose whether they met in person outdoors or over zoom, I think I would continue to let people were able to meet indoors, I would encourage them to do so, but I think I would also say, you can always choose to meet over zoom if that's easier. So that's certainly one thing I would do um.

- **Get to know students well and constantly check-in with them**

Prof. P emphasized the importance of really getting to know the students early on in an academic semester, and constantly making sure that everyone in the class is on the same page and nobody is left behind. She uses the term "taking the temperature" to describe her approach:

> Prof. P: I think it's super important to get to know your students, which is harder with a large class, but I think , the majority of classes at Vassar are a size where it's you can absolutely get to know your students, and I think it's…We have to, we have to kind of go into it with a mindset of knowing that how a student is interacting in class, it means something. so if they are if they're quiet, , it doesn't mean that they're being unresponsive or that they're not interested that just might be like how they are, or they might be, not getting the information and so really being aware of all of the students and sort of like constantly take… I use the term take taking the temperature, but really that's kind of what it is, is always just sort of spot checking

> of how everyone is doing and where people are and because if you don't start that early, if you wait until like mid-term or something like that that at that point, they're so far behind that their ability to catch up is lessened.

- **Maintain a flexible syllabus and teaching schedule to ensure mental wellness**

Introductory STEM courses are often designed to introduce students to a certain science fields, so the science contents being taught are generally fundamental. The teaching task is supposedly low burden, but since students may be completely new to the subject, introductory STEM courses can still be a challenge for them. Prof. P. thinks that having a flexible teaching and learning schedule can help relieve this tension:

> Prof. P: I think having a sort of change of pace in the middle of the semester, where we stopped having the papers and stopped having the lectures, and just everyone got to talk about what they loved and what they found really interesting was a really like breath of fresh air okay let's relax for a minute and just listen to someone else talk about something, rather than trying to make sense of some kind of graph. And I think that was having peak and valleys of activity, I think are important, because if it's just constantly *go-go-go*, everyone gets burned out. Not making everything, at the same pace, I think it's really important to take sometimes when you take the speed down a little bit and let everyone relax. Yes, it's because it's a lot when you're mean for classes and most of them online is just got to be mentally exhausting because teaching two classes online was mentally exhausting, so I can't like taking for them seems like it would just….I would be wrecked…. I would be wrecked at the end of every day because it's …. as a professor, it *was so tiring!*

- **Keep incorporating the virtual learning style and online lecturing platforms**

I totally agree with Prof. H. when she was talking about her prospects of future STEM teaching and the ways of being inclusive in teaching. None of us are sure about when the pandemic will end nor what the future teaching mode will be like, but she hopes at least instructors and students will be open and flexible:

> Prof. H.: So, I think that's the challenge, I mean regardless of what the learning or teaching mode is, but I think the pandemic start to make all of us, like the professors, as well as the students to see the other possibilities of learning. maybe not ideal, because of the circumstances but moving forward to going back to normal, I think I hope everybody will be a little bit more open. To all of the learning practices teaching practices and then that I think will probably make it easier to deal with.

After having taught courses online for almost a year now, Prof. P. suggests that sometimes meeting online is a great substitution for in-person meetings, especially at times when conditions prevent meeting in-person, such as inclement weather conditions:

> Prof. P: This might be a snow day but right now, we could just be like 'hey class, we're just going to pop on zoom today and have lecture and you can just sit in your room or whatever and we'll go from there', so I think that there are it's created sort of these avenues of interaction that could be tools in the future, not the stately and not everyday type of things, but things that we can keep in our tool belt and implement when needed.

- **College-level STEM inclusive education reforms: a delicate balance**

Finally, Prof. H. ended our interview with a fair point about the future of inclusive STEM education, and that is how we should restructure Vassar's STEM curricula to contain more inclusive elements. The reform can lead to changes as small as adding new classroom activities, and as large as restructuring courses offered in the academic department. Whatever the reforms end up being, Prof. H. mentioned, we must consider how to balance the rigorousness of the courses and the inclusive elements. Focusing too much on teaching and pay minimal attention in inclusive pedagogy would hamper students' learning efficiency but having too many inclusive teaching elements in a course compromises the time spent in actually lecturing the course materials, which is needed to get to advanced courses or future careers (jobs or graduate programs). This is therefore a delicate balance and needs further research:

Prof. H.: I will definitely like keep doing part of them and then see how that can incorporate into your hybrid learning style once we once we return to normal, for I guess general for stem education, I think. I think many things like I said I think a lot of the changes my needs to take place, not on a course level. On a maybe on a program or like a like a major curriculum level and that, I think. I think at least my department is definitely having those conversations like here and there, like maybe not very explicitly, but then we gather and talk about those challenges, and then try to see if we can reshape ratio or restructure the curriculum a little bit to make it happen, so I personally think that's a better way to do it.

Chapter Five
Conclusions

5.1 Practices to be inclusive in STEM education

This work focused on the inclusive STEM practices that are employed by Vassar STEM professors in their introductory level courses. I have conducted 45-minute interviews and had them talk about their inclusive pedagogy, both in and out of classrooms, and their own evaluation and reflections of their teaching practices. In addition, a section of the interviews was dedicated to discussions related to teaching and learning under COVID-19.

The overall impression that I got from my interviews with these STEM professors is that they truly *care about teaching*, and wholeheartedly *care about their students*, without any reservations. Their teaching styles are all student-centered: from in-class activities to out-of-class assignments and office hours, the sole purpose is to have students best learn and grow in a way that they enjoy the most, hence they can get the most out of the courses. For instance, a couple of them opted to hold completely student-oriented class sessions where students explore topics of their interests and lead discussions. In this way, students build their skills of communications and collaborations while having fun doing it. Out of classes, they actively encourage students to come and talk with them. All professors interviewed are dedicated in getting to know their students, and they view student's diversity (both personal and academic) a plus to the class. Meanwhile, they acknowledge individual difference due to diversity and strive to take advantage of diversity into class activities.

Stepping in the shoes of students is another major impression these interviews had left me with. Knowing that introductory level classes are often the initial exposures of the vast majority of students to the field, Prof. S intentionally makes a fallible character in front of his students, attempting to make the case that it is more than common to make mistakes in computer science – and even professors make them, too! In introductory Chemistry class, Prof. K knows that her students may find lost and are curious about future career as scientists. She therefore dedicates a section of her class time into displaying videos with interviews of scientists at MIT.

There are way more scenarios and stories of my interviewed professors signifying their care to their students, but I will not revisit them all here. Instead, I wish to use the last sub-section of this dissertation to look into the future of inclusive STEM teaching and reflect upon what else could be done in promoting inclusive STEM education at Vassar. I will do so by discussing practices used in other universities and possible insights we could gain from their initiatives.

5.2 Looking into the future

Diversity and Inclusion in STEM will always be a hot topic of discussion in the global scientific community. Historical and political reasons have put underrepresented and marginalized groups in a disadvantaged position in science. The question that this work has been attempting to answer is: what are some of the teaching practices that Vassar STEM professors employ to promote STEM inclusion, and why? The focus of the project is put on specific pedagogy used in and out of the classrooms, from insights provided by lecturers of intro-level STEM classes at Vassar. While these are invaluable lessons that will for sure contribute to building inclusive STEM community at Vassar, and certainly important lessons have been concluded, it is nevertheless equally crucial that we consider changes that can be made on departmental/institutional levels.

What can be done at an organizational level to better assist STEM professors employ their inclusive pedagogy and promote STEM inclusion across the department, or across college campus? This is another interesting yet important question to ask followed by this work. Here, I would like to revisit a quote from my interview with Prof. H:

> I think a lot of the changes my needs to take place, not on a course level. On a maybe on a program or like a like a major curriculum level and that. I think at least my department … gather and talk about those challenges, and then try to see if we can reshape ratio or restructure the curriculum a little bit to make it happen.

From the perspective of a lecturer, Prof. H certainly embraces inclusive teaching, but meanwhile, she worries about her task of having ample time to cover certain materials and prepare students to be professionally competent. This calls for a change and reorganization at a higher level, beyond individual courses. At a departmental level, what can be done collectively? Perhaps it would be feasible to start the reform by restructuring the curriculum, as Prof. H suggested. We could start by lowering the bar of academic requirements for students without compromising the rigidity of the entire departmental curriculum. For instance, as long as students have completed the core requirements towards their STEM major, they could opt to take one unit of electives instead of two. At individual course level, intro-courses could be reconsidered to *a*) eliminate unnecessary elements: if certain topics are not essential for students enter higher-level course in the department, instructors can choose not to focus on such topics and have students learn on their own. and *b*) incorporate real-life scenarios into teaching so students get a direct sense of how the scientific concepts they learn relates to real life. The goal here is to really stand in the shoes of students and think for ways that make their STEM learning experiences more enjoyable without losing the rigorousness of the curricula. In other words, upon exiting the STEM program, Vassar students are as professionally competent as any other undergraduate student from other universities. However, we must admit that academic rigorousness and inclusivity is always a delicate balance, as suggested in the previous chapter.

What else could be done at a departmental or institutional level? It is a good idea to examine some efforts by other higher education institutions in promoting inclusivity and diversity in their communities. Here, I will take the Department of Chemistry at MIT as an example to make the case of how they have worked as a community to foster STEM inclusive excellence at MIT Chemistry.

First, the department has its own Diversity, Equity, and Inclusion Committee (DEIC) that is composed of graduate students, post-doctoral fellows, faculty, as well as staff members. The DEIC embraces diversity, including race, gender, sexual orientation, gender identities, and disabilities, a strength to the department (*The Diversity, Equity, and Inclusion Committee – MIT Department of Chemistry*, n.d.). The DEIC is committed to promoting the values of inclusion and equity. Working together with other departmental and interdepartmental/institutional efforts towards inclusion, such as CADI (*MIT CADI – Chemistry Alliance for Diversity and Inclusion*, n.d.) or Women+In Chemistry (*MIT Women+ in Chemistry*, n.d.), DEIC aims to put forth action plans to create and sustain an actively anti-discrimination community and culture that provides a welcoming and enriching environment for all members. Here are some examples of the initiatives (extracted from https://chemistry.mit.edu/about/the-equity-and-inclusion-committee/)

- Working with CADI and QoL to implement the in-person, department-wide implicit bias training.
- Re-evaluating the Graduate Admissions process and our PhD program.
- Creating a job description for a full- or part-time departmental equity officer.
- Designing new strategies and mechanisms for MIT Chemistry to expand ability to recruit and empower underrepresented groups. One approach might be the "Bridge to PhD" program for post-Bac students with weaker academic backgrounds to prepare them for successful PhD application. See, for example, programs at Columbia and Fisk-Vanderbilt.
- Developing a 10-year plan to increase the number of underrepresented minority graduate students with special emphasis on Black Students.

Figure 1. Some Initiatives of Diversity and Inclusion at the Department of Chemistry, MIT

Figure 2. Examples of Joint Community Initiatives between MIT Chemistry and Committee on Quality of Life (QoL)

The figure above shows some of the initiatives that the DEIC collaborates with the quality-of-life committee. These initiatives focus on improving students' lives in four core aspects: community, education & development, mentorship & advising, and equity & inclusion. Even beyond thinking about STEM inclusion, the committee strives to improve students' life quality in every aspect. For example, all second-year graduate students must pass a qualifying exam (also known as the second-year oral) to officially become a Ph.D. candidate in the program. This qualifying exam is known to be extremely stressful and high-stake, as failure to pass the oral exam would result in unsuccessful progression in the program and students may get kicked out of the program. However, the purpose of this exam was never to give students a hard time; rather, the faculty members at the department would like to see every student to succeed, so one critical initiative of DEIC is to revamp the qualifying exams to ensure its educational value and take away burdens on students. The goal is to help students become qualified candidates and provide them with constructive feedback (*The Diversity, Equity, and Inclusion Committee – MIT Department of Chemistry*, n.d.).

The members of the DEIC committee are diverse: members of graduate students, post-docs, faculty, and staff actively engage in this collective effort. In this way, voices from multiple parties can be heard and issues can be analyzed from different perspectives. In addition, they also have an external advisory board that oversees the entire program: these are faculty from other institutions who are also STEM professors that care about inclusion.

Can STEM programs at Vassar adopt a similar strategy? Admittedly, we are an undergraduate-only institution; it would not limit the perspectives and voices being raised for this reason. The Grand Challenges Program is a great start and provides a platform to initiate such efforts. We already have student catalysts that act for the betterment of STEM inclusive excellence at Vassar. Some of them collaborate with other Vassar initiatives such as the Engaged Pluralism Initiative (EPI) and organize events together. Moving forward, the Grand Challenges program could think about collaborate with more departments or groups at Vassar and really expand the notion of inclusion to every aspect of student's life on campus: not only reforming curriculum and pedagogy, but also improving mentorship programs, renovating assessment schemes, working to enhance student's senses of community, etc. Furthermore, to invite more community members into this effort. Vassar staff members that work in STEM departments, such as the administrative assistants, could be part of the Grand Challenges Program and bring novel perspectives into the program. They could also use their resources as administrative assistants to organize events. Lastly, we could also get together an external advisory board and take advantage of expertise of STEM inclusion from other universities and institutions in improving our own STEM inclusion agenda. These are all possible avenues to go.

Lastly, studies have shown that engaging STEM faculty in culturally responsive teaching workshops brings extensive benefits toward faculty awareness of inclusion and diversity in their classroom teaching (O'Leary et al., 2020). After trainings in the workshops, faculty increase their knowledge of barriers of learning, improve attitudes about their students, and get inspired to adopt teaching strategies to support equity and inclusion in their classrooms (Hughes, Hurtado & Eagan, 2014). Instructors could become more aware of various strategies to remove possible barriers of inclusion in their classrooms, such as to combatting stereotype threat and microaggressions. In addition, they could recognize how those conventional teaching practices – such as the norm referenced grading systems, and lecture-dominated teaching modes – are often associated with disparities in students' success (O'Leary et al. 2020). The Vassar Grand Challenges Program could certainly act to organize professional development workshops for faculty with at least partial focus on trainings of inclusive and diversity in STEM teaching.

Nonetheless, I would like to commend everyone who are working hard in the Grand Challenges Program and trying their best in making Vassar STEM community a more inclusive and more diverse place. I have absolutely no doubt that the Grand Challenges Program will grow larger, stronger, and tighter than ever. I also strongly believe that the STEM community at Vassar will be a welcoming community to everyone – students, faculty, and staff – and a place for all its members to teach, learn, grow, explore, share, and care for each other as a family.

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Appendices

Appendix A: Interview Questions

<u>Introduction</u>

Thank you for participating the interview. As part of the research project I am conducting, this interview will focus on the inclusive teaching practices you employ in your teaching in the [introductory level class] at [department]. This interview will be studied for use in this project , which is sponsored by…. the faculty research advisors are… This zoom interview is being recorded. In any use of the videotape, you will not be identified by name.

1. Let's start by talking about your career at Vassar. How long have you been at Vassar, and what courses have you taught at Vassar?

<u>About the course</u>

Thank you. Now I would like to start my questions by asking about this course.

2. Please tell me about this course. When did you (will you) teach this intro-level class, for how many times, and what are the topics covered, and target group of students??

3. To what extent to do about the students in this class, and how do you take student diversity into consideration in your teaching?
    - How do you accommodate those students without fundamental understanding of the subject or discipline/sufficient background knowledge? This happens frequently with students taking 100-level courses.

<u>Current Inclusive Pedagogy</u>

Now let's talk about how you have employed inclusive pedagogy in your teaching.

4. How do you define "inclusive education" and "inclusive teaching practices"?

5. Please describe some of the teaching practices you employ in this course that fit your definition.
    - In-class activities?
    - Out of class: What are the ways that you support your students, so they succeed in your class? How and how often do you provide feedback to your students?

6. In general, what aspects of these inclusive teaching do you think you are doing well, and what aspects are not so well, or challenging for you? Why?

Teaching Under the Pandemic

Thank you, now we will shift our talk to something that concerns all of us, the COVID-19 pandemic.

7. First, please describe the way you taught this course under the pandemic. Was it hybrid/remote only? How was your overall experience? Please comment.

8. What did you do differently than before the pandemic (in terms of engaging students, providing supports, etc.) when trying to be inclusive? How was it?
    - Were they effective? What worked well, what did not work, and what was difficult?

A Reflection: Looking at the future of inclusive teaching

In this last section, we will reflect on your inclusive teaching experiences before and during this pandemic and see how that will inform teaching in the future.

9. What did you learn from your experiences of teaching under COVID that will inform your inclusive pedagogy and STEM education in the future?
    - For example, you may have discovered that students enjoy computer-based experiments for certain topics, and you will keep offering that in the future.
    - For another example, lab exercise will not be always available as part of the training in this class, so alternatives must be considered.

10. How have your definitions on **inclusion** evolved, and why? How did the COVID-19 teaching experiences shift your thoughts on inclusive teaching?

Back-up questions (if time permits):

If you are asked to give advice for an incoming assistant professor in your department who is about to teach the intro-level class on inclusive teaching practices, what advice would you give, and why?

Final Comments: If this interview has not captured an important aspect of your inclusive teaching practices, or you feel like you need to explain any of your above answers, please describe it.

Appendix B: Consent Form

Research Title: Inclusive teaching practices in introductory level STEM courses at Vassar - past, present, and future

Primary Investigators: Naike Ye[1,2,*], Christopher Bjork[1,†], Jodi Schwarz[3,†]

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Dear Professor ____________,

Thank you for your participation in this research project. This project is conducted by the student researcher Naike Ye as part of his senior thesis work at the Department of Education. In order for you to understand the purposes and the contents of the research, please kindly refer to the information below. Please sign your name at the bottom of second page to indicate that you have understood elements that are involved in this project, and to give your consent of participation.

Purposes

- To study the inclusive teaching practices employed by instructors of the introductory level STEM courses at Vassar and the approaches to engage students from various backgrounds, before and during the current COVID-19 pandemic;
- To understand how the faculty perceptions of *inclusion* have evolved over time;
- To understand the extent to which the pandemic has reshaped the faculty perception of *inclusion* and has informed the future of STEM inclusive education at Vassar.

Procedure

Vassar professors teaching introductory level STEM courses at various departments (Mathematics, Biology, Chemistry, and Computer Science) will be invited to participate in the project by being interviewed by the student researcher. They will be asked to reflect on their inclusive pedagogy in their classes, experiences of teaching during the pandemic, and their perceptions of *inclusion*. The interviews will be conducted via *Zoom* and will be videotaped and transcribed later for analyses.

Harm, discomfort, and risk

No harms, discomforts, or risks should be expected during your participation. You may answer the questions to the best of your ability and your willingness. You are free to discontinue participation at any time without penalty or prejudice.

Benefits to the participants

You will have the opportunity to reflect on your teaching practices: successes, failures, the joys, the challenges. We hope that the outcome of the research will contribute to STEM education at Vassar and will in turn benefit your teaching.

Confidentiality

In any use of the interview recordings, you will NOT be identified by name. A copy of transcribed texts of the interview will be sent to you afterwards and you may choose to adjust and/or qualify your responses to be included in any form in the dissertation of the student researcher.

Contact Information

For any questions or concerns, please do not hesitate and contact the student researcher or the faculty advisors. Contact information can be found at the top of the first page.

Consent – Please Sign

I have read the above descriptions and am fully aware of the details of the research project. I give my consent to the researchers for my participation.

Printed Name ____

Signature ____ **Date** ____________________

Appendix C: Video Recording Release Form

Research Title: Inclusive teaching practices in introductory level STEM courses at Vassar - past, present, and future
Primary Investigators: Naike Ye, Christopher Bjork, Jodi Schwarz
Student Researcher: Naike Ye

As part of this project, I will be making video recordings of you during your participation in the interview via Zoom. Please indicate what uses of these recordings you are willing to permit by putting your initials next to the uses you agree to and signing the form at the end. This choice is completely up to you. I will only use the videotapes in ways that you agree to. In any use of the tapes, you will NOT be identified by name.

1. **_______** The video recordings can be studied by the research team for use in the research project.
2. **_______** The recorded interview can be transcribed, quoted, or presented in other forms in the dissertation of the above student researcher at the Department of Education.
3. **_______** The contents of the recorded interview can be anonymously shared with members in the Vassar community.

I have read the above descriptions and give my consent for the use of the video recordings of me as indicated by my initials above.

Printed Name _______________________________________

Signature ____ Date ____________________