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Diversity and Inclusion in Science Teaching Learning (DISTL): Focusing On the Perspectives of Undergraduate Students and Graduate Teaching Assistants in the Chemistry Classroom

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DIVERSITY AND INCLUSION IN SCIENCE TEACHING LEARNING (DISTL): FOCUSING ON THE PERSPECTIVES OF UNDERGRADUATE STUDENTS AND GRADUATE TEACHING ASSISTANTS IN THE CHEMISTRY CLASSROOM

BY

ALBERT AIDOO

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DISSERTATION ACCEPTANCE PAGE
Albert Aidoo

This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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This dissertation is dedicated to the Aidoo family and my Sweet Darlin Dear, Dr. Abigail Bemah Donkor Aidoo. I would like to say thank you!

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ABBREVIATIONS

i.	STEM	Science, Technology, Engineering and Mathematics
ii.	DISTL	Diversity and Inclusion in Science Teaching and Learning
iii.	DIEA	Diversity, Inclusion, Equity and Access
iv.	CAST	California Standard Test
v.	MOSART	Misconception Oriented Standard Based Assessment Resources for Teachers
vi.	GTA	Graduate Teaching Assistants
vii.	URMs	Underrepresented Minorities

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ABSTRACT

DIVERSITY AND INCLUSION IN SCIENCE TEACHING LEARNING (DISTL): FOCUSING ON THE PERSPECTIVES OF UNDERGRADUATE STUDENTS AND GRADUATE TEACHING ASSISTANTS IN THE CHEMISTRY CLASSROOM

ALBERT AIDOO

2022

Students in Science, Technology, Engineering and Mathematics (STEM) come with a wide range of experiences and educational backgrounds. There is high attrition rate and low academic achievement among students in STEM areas, specifically in college chemistry courses that are prerequisites for many STEM majors. Hence it is important to look at diversity and inclusion specifically in first- and second-year college chemistry courses to address the challenge of student attrition in STEM. Diversity can be understood as the differences each student brings along the dimensions of prior knowledge, skills, race, ethnicity, sexual orientation, gender, socio-economic status, age, ability, religious or political beliefs, or other different ideologies that makes students individually unique. The purpose of the DISTL project was to: 1) to understand the current role of student-diversity in various chemistry courses; 2) Gauge instructors understanding of diversity and related teaching practices at the college level; 3) develop DISTL curriculum modules for meeting the needs of diverse students in chemistry courses; 5) piloting and implementing DISTL curriculum in chemistry classrooms and 6) conducting studies to test the impact of DISTL curriculum on student diversity and inclusion practices, instructor and student attitudes, student academic achievement and student retention in the STEM related majors. This study was conducted using a mixed methods approach where surveys, and standardized assessments were used to gather data on student diversity, academic performance, and student retention of knowledge

CHAPTER 1- INTRODUCTION

1.1. Motivation of the Study

Across the nation, many institutions of higher learning are grappling with high attrition rates and low academic achievement in science, technology, engineering, and mathematics (STEM) academic programs. From literature, less than half of students who enter STEM curricula at the freshmen level can complete their degrees. This startling statistic is even more alarming for minority groups especially Africans, African Americans, Latinos, and Native Americans, students from low-income backgrounds, and first-generation college students, all of whom graduate at nearly half the overall rate (Jones et al., 2018). These groups have historically been and continue to be underrepresented in STEM fields. This trend continues even at the graduate level in STEM programs, particularly among students from the afore mentioned underrepresented groups. These alarming issues in STEM education necessitated this research to find out why and how diversity and inclusion impacts student attrition rates and academic achievement in the diverse population of undergraduate chemistry classes.

1.2. Problem Statement

Students in STEM fields come with a wide range of experiences and educational backgrounds. There is high attrition rate and low academic achievement among students in STEM areas, specifically in college chemistry courses that are prerequisites for many STEM majors. From various literatures, it has been identified that students’ background (gender, gender identity, race, ethnicity, disability status, sexual orientation, socioeconomic status, culture, life experiences, pedigree and any other thing that makes one different from the other) plays an intrinsic role in students' academic achievement (Jones et al., 2018; Nelson & Lovitts, 2001). Suggestions have been made as to how to solve this challenge. For example, a work was done by Sharkawy where he used stories and reflective activities to enrich student images of diverse scientists and scientific work. At the end of the study, student perceptions of scientists with respect to gender, disability and socio-cultural background changed positively (Sharkawy, 2012). Also, Finson et al in their study discovered that 78% of the images in science books portray white mainly males as scientists. (Finson et al., 1995). To the best of our knowledge, there is no published article on how student perceptions about diversity affects their self-efficacy and academic achievement. There is also prior research exploring how instructor perceptions affect their deliveries as teachers. Finally, there are no curriculum modules for meeting the needs of diverse students in chemistry courses. These three specific challenges are the gaps this research seeks to address.

1.3. Purpose of Study

The purpose of the DISTL (Diversity & Inclusion in Science Teaching and Learning) project was multifaceted and included the following goals:

1. To understand the current role of student-diversity in various chemistry courses.
2. Gauge faculty understanding of diversity and related teaching practices at the college level.
3. To develop DISTL curriculum modules for meeting the needs of diverse students in chemistry courses.

4. To pilot and implement DISTL curriculum in chemistry classrooms
5. To conduct studies to test the impact of DISTL curriculum on student diversity and inclusion practices, instructor and student attitudes, students' academic achievement, and student self-efficacy in chemistry courses.

1.4. Research Question

The research questions included are:

1. What is students' perception or understanding of diversity and inclusion?
2. What is GTA's perception or understanding of diversity and inclusion?
3. What is the impact of DISTL interviews and diversity and inclusion modules on
    - Students' knowledge of Chemistry
    - Students attitude towards Chemistry
    - GTA's knowledge of Chemistry

CHAPTER 2- REVIEW OF LITERATURE

2.1. Diversity, Inclusion, Equity and Access

The issue of diversity and inclusion has become one of the most talked about topics in the field of science as the demographics of the nation continue to change. Achievement gaps between well-represented and underrepresented students have been called “one of the most urgent and intractable problems in higher education” (Bensimon, 2005), and are increasingly recognized as an international issue (Spitzer & Aronson, 2015). In an article published by Alexander et al and Matz, women and underrepresented minorities (URM) in these disciplines actually underperform, compared to well-represented peers with the same academic preparation (Alexander et al., 2009; Matz et al., 2017). For example, the percentage of URM and non- URM students who enter U.S. colleges intending to complete a STEM major is about the same (National Academies of Sciences & Medicine, 2016), but 6-year STEM-completion rates vary from 52% for Asian-Americans and 43% for Caucasians to 22% for African-Americans, 29% for Latinos/Latinas, and 25% for Native Americans (National Academies of Sciences & Medicine, 2016). According to Carnevale et al, STEM jobs are the fastest growing occupational category and, by 2020, 65% of all jobs in the U.S. will require a post-secondary degree with STEM literacy skills(Carnevale et al., 2013). However, less than 25 percent of college students pursuing bachelor’s degrees will be specializing in STEM fields as stated by the U.S. Department of Education, (Jones et al., 2018). In addition, the current STEM workforce is predominantly male and White or Asian, even as women and racial and ethnic minority groups are projected to comprise greater percentages of the U.S. population in the coming decades (Cohn & Caumont, 2016). Several prior research studies have also indicated that women and underrepresented minorities (URMs) feel unwelcome or excluded in conducting academic work (Ibarra, 1996; Nelson & Lovitts, 2001; Padilla, 1997). This has become a great concern in education. In an article published by National Center for education, there are four alarming achievement gaps in STEM higher education. These are between white and other racial/ethnic groups, between men and women (Jones et al., 2018), among socio-economic classes (Levant et al., 2017) and with first generation college students (Stephens et al., 2014). Due to these challenges, institutional programs like multicultural student centers, ethnic studies, advocacy programs, identity workshops, and curriculum changes in colleges and universities have been instituted to promote assimilation and integration of women and URM students (Braxton, 2019). Though efforts are being made to address these issues, research has yet to link achievement gaps in a specific introductory course with the disproportionately high attrition from STEM majors observed for female, URM, and low-socioeconomic status students. Diversity according to the Open Chemistry Collaborative in Diversity Equity (OXIDE) is understood to mean the inclusion of the other, where another is anyone unlike oneself. This may include gender, culture life experiences, gender identity, sexual orientation, race, ethnicity, university pedigree, disability status, socioeconomic status , ideas, political ideology, country of origin and other characteristics. (Hernandez & Watt, 2014). From this definition, it can be understood that diversity is any attribute of a person that makes one different from the other. The impact of diversity is not felt when inclusion is omitted from the equation. Inclusion involves systems and dispositions that seek to engage individuals from diverse backgrounds and create a welcoming and supportive environment in which these individuals can successfully operate. Studies have shown that increasing diversity in educational environments provides a boost in productivity and success (Ellison & Mullin, 2014). Bollinger in his paper stated that, university officials and others have argued for affirmative action because such policies allows students “to live and study with classmates from a diverse range of backgrounds, [which] is essential to students’ training for this new world, nurturing in them an instinct to reach out instead of clinging to the comforts of what seems natural or familiar” (Bollinger, 2007).

2.2. Theoretical Framework

2.2.1. Constructivism

The concept of constructivism is a theory founded on the observation and scientific study of how people learn (Brandon & All, 2010). The major theme is that learning should be an active process in which learners construct new ideas and concepts based upon their current and/or past knowledge (Applefield et al., 2000; Brandon & All, 2010). Learning is a process that involves active construction and not passive acquisition (Duffy & Cunningham, 1996). Thus, in constructivism, the familiar and inaccurate metaphor of the mind as a container waiting to be filled is replaced by the metaphor of the mind as an agent actively seeking to satisfy its curious and resolving issues. According to Bodner, teaching and learning are not synonymous; we can teach, and teach well, without having the students learn (Bodner, 1986). Until recently, the accepted model for instruction was based on the hidden assumption that knowledge can be transferred intact from the mind of the teacher to the mind of the learner. Educators therefore focused on getting knowledge into the heads of their students, and educational researchers tried to find better ways of doing this (Bodner, 1986). Constructivism as theory of learning has its origin from the cognitive sciences (Bodner, 2007). As a theory of learning, constructivism provides a basis for understanding how people incorporate new knowledge into existing knowledge and then make sense of that knowledge (Nussbaum, 1989; Tobin, 1990; Von Glasersfeld, 2013). It provides a theoretical framework for thinking about how people engage with objects in the world around them and make sense of these objects (Bodner et al., 2001; Bodner, 1986). Bodner (2006) argued that constructivism assumes that people don't "discover" existing knowledge, they actively construct it. He went on to argue that they "invent concepts and models to make sense of their experiences and then continually test and modify these constructions in light of new experiences". According to Fosnot and Perry (2005), the aim of constructivism is "*cognitive development and deep understanding*" (Fosnot & Perry, 2005). Bodner tried to capture the spirit of the constructivist theory by arguing that "knowledge is constructed in the mind of the learner" (Bodner, 1986). The term constructivism has been applied to a wide range of concepts and ideas with each "form" (Good, 1993) or "brand" (Staver, 1998) having its own tenets, assumptions, and implications. These forms are Personal constructivism (Kelly, 1955), Radical constructivism (Von Glasersfeld, 2013), Social constructivism (Solomon, 1987), Critical constructivism and Contextual constructivism (Tobin, 1993). For this study, personal constructivism of Piaget or Kelly and radical constructivism by von Glasersfeld were used as framework to design the diversity and inclusion modules for the respective topics. Both models of constructivism focus on the sense-making or meaning-making that occurs as individuals try to understand their experiences with the world in which they live (Von Glasersfeld, 2013). This theoretical framework was used design the DISTL modules for the study.

2.2.2 Phenomenography

Phenomenography, according to Bowden, is the empirical study of the different ways in which people think of the world. The aim of phenomenography is to discover the qualitatively different ways in which people experience, conceptualize, realize and understand various aspects of phenomena or essence in the world around them (Bowden et al., 1992). In phenomenographic research, the researcher chooses to study how people experience a given phenomenon, not to study a given phenomenon. Phenomenography is related to a field of knowledge, which is defined by having experience as the subject of the study (Gandhi-Lee et al., 2015). Phenomenography assumes that knowledge results from thinking about experiences with people and objects in the world in which we live. Phenomenography approaches studying from a different perspective, based not in the researchers' understanding but rather on the peoples' understanding. This means that phenomenographical researchers focus on understanding and describing the experience of studying from the peoples' point of view (Lowrey, 2002). It was originally developed by a research group in the Department of Education, University of Gothenburg, Sweden. The word 'phenomenography' was coined in 1979 and appeared in print for the first time two years later (Marton, 1981). It has been used in information research since the early 1990s, with the first investigation revolving around doctoral students' experiences of literature reviews (Bruce, 1994). This was followed shortly after by two studies, conducted in Sweden (Limberg, 1998) and Australia (Bruce, 1997) examining the experience of information seeking amongst school students, and the experience of effective information use amongst higher educators, respectively. These two studies were each complemented by articles on the phenomenographic research approach and its potential impact for information research (Bruce, 2000; Fisher et al., 2005; Limberg, 2000). For example, in educational psychology, questions are frequently asked about, why some children succeed better than others in school. Any answer to this question is a statement about reality. An alternative is a question of this kind “what do you think about why some children succeed better than others in school?” (Säljö, 1981). Any answer to this second question is a statement about people's perception of reality. These two ways of formulating questions represent two different perspectives. In the first perspective, we orient ourselves towards the world and make statements about it. This is what Marton refers to as first order perspectives (Marton, 1981). In the second perspective we orient ourselves towards people’s ideas about the world or experience of it and make statements about people’s ideas about the world or about their experience of it. Marton named such perspectives second order (Marton, 1981). The second perspective is what we refer to as phenomenography. For this study, this theoretical framework was used to help us understand the impact of diversity, inclusion, access, and equity from the perspectives of the students and instructors.

2.3.3. Critical Theory

Historically, researchers in education interested in explaining why education is liberating for some and oppressive for others, have relied on theories that emanate from outside the range of existing paradigms for educational research and theory (Lynn, 2002). Critical theory, which is one of these philosophies, is primarily concerned with issues of power and justice. It has been used to deal with matters of race, economy, class and gender; and it concerns itself with the way education, religion, and other social institutions interact to construct a social system (Lincoln & Denzin, 2000). Within the realm of education, critical theory provides the tools to explore, determine, understand, and eventually address the issues important to each diverse group within the complex social, historical, political and institutional practices used to create the classroom environment in which students and their instructors interact (McLaren, 1994). Critical theory can be traced back to a group of philosophers at the Institute of Social Research in Frankfurt, Germany, who initiated a conversation in the German tradition of philosophical and social thought. Frustrated by forms of domination emerging from capitalism, critical theorists such as Horkenimer, Adorno and Marcuse, saw in critical theory a method for temporarily freeing academic work from these forms of power. They came to view their academic disciplines as manifestations of the discourses on power relations in the social and historical contexts that produced them. Other critical theorists such as Poster and Hooks have argued that critical theory originates in the assumption that we live in a world of pain and that critical theory has a pivotal role in the alleviation of that pain (Hooks, 1994; Poster, 1989). Critical theory is concerned with generating knowledge that can be provided to individuals to help them understand their situation, with the goal of facilitating their freedom from one or more oppressive aspects of the classroom environment in which the study is being carried out. Critical theories seek to generate knowledge that will result in action that leads to a change in the society being analyzed. If change is not part of the process of generating knowledge, critical theorists believe that the process is not complete. Critical theory is transformative; its main goal is to produce social change, enlightenment and emancipation (Brookfield, 2005). Critical theory is grounded in the current instructional environment, while, at the same time, envisioning a less alienated, more just, and more democratic world. The main goal of critical theory is to help people create an environment in which they are free to make their own choices regarding the way they decide to think, learn and live (Mayo, 2007). Since this research seeks to raise awareness on the impact of diversity and inclusion in underrepresented groups in STEM to bring about transformation, it became appropriate to use this theory. This theory also aided in the development of the DISTL survey questions to probe the understanding of students and instructors about diversity and inclusion.

2.4. Self-Efficacy

Self-Efficacy as defined by Zimmerman et al, as the belief in one's ability to perform a specific task. Self-efficacy is defined as a judgment about one's ability to organize and execute the courses of action necessary to attain a specific goal in a given domain (Pajares, 2005; Zimmerman, 2000). It is goal-directed and self-efficacy assessments that direct respondents to rate their level of confidence for attaining a specific goal. The goals that an individual sets for themselves, the effort expended to reach those goals, and persistence when difficulties arise is influenced by their self-efficacy (Bandura & Locke, 2003; Pajares, 2005; Salim).

A study conducted by American Association of University Women in 1991, revealed that girls' confidence in their academic abilities falls drastically from elementary to high school. The decline is particularly significant in girls' and young women's belief in their math and science abilities. At every age, from elementary to high school, boys are more confident in their math abilities than are girls (Rittmayer & Beier, 2008). A study from 2010 on persistence in STEM degrees, using data from the National Student

Clearinghouse showed that only 24.5% of white students and 32.4% of Asian American students who declared a STEM major as freshmen completed a STEM degree in four years (Chang et al., 2010). For underrepresented groups, the situation is even worse, as the same study found that “Latino, Black, and Native American students had four-year STEM degree completion rates of 15.9%, 13.2%, and 14.0%, respectively” (Chang et al., 2010). This is startling, considering the demand for STEM positions is expected to increase. To ensure a strong workforce of scientists and engineers in the future, one must understand why the levels have fallen so low. Persistence through undergraduate education may be explained by self-efficacy (Painter, 2012). Self-efficacy is a significant predictor of both the level of motivation for a task and ultimately task performance (Bandura & Locke, 2003); on average, individuals with high STEM self-efficacy perform better and persist longer in STEM disciplines relative to those lower in STEM self-efficacy. Therefore, in this study, a survey tool designed by Christopher Bauer was used to ascertain how the DISTL modules impacted students’ attitude and self-efficacy towards general chemistry.

CHAPTER 3- METHODOLOGY AND MODULE DEVELOPMENT

3.0. Mixed Method

Thorough research method designs are needed to guide the researcher for an effective research study. This is important because they set the logic by which the researcher makes interpretations at the end of the study.(Creswell et al., 2004). Mixed methods, according to Creswell, involve the integration of both quantitative and qualitative data collection and analysis in a single study or a program of inquiry. This form of research transcends just simply collecting both quantitative and qualitative data; it indicates that data will be integrated, related, or mixed at some stage of the research process. The underlying idea of mixing is that neither quantitative nor qualitative methods are sufficient in themselves to capture the trends and details of the phenomenon. When used in combination, both quantitative and qualitative data yield a more complete analysis, and they complement each other (Creswell et al., 2004). There are four major types of mixed methods designs which include the Triangulation Design, the Embedded Design, the Explanatory Design, and the Exploratory Design. To decide which methodologies will best fit the research questions, the four key decisions proposed by Creswell in the field of mixed method study were followed (Creswell & Clark, 2017). These include (1) the approaches to data collection to answer the proposed research questions, (2) the research approach among the qualitative and quantitative methods that has the dominant priority, (3) ways data collection and analysis will be integrated for both approaches and (4) a consideration of the theoretical framework to guide the study and how they serve to inform the study purpose and methods (Creswell & Clark, 2017). For the purpose of this research, convergence mixed method was used to qualitatively and quantitatively conduct the study and analyze the results from the data collected.

3.1. Convergence Mixed Method

In the convergence mixed model, quantitative and qualitative data are collected and analyzed separately by the researcher on the same phenomenon and then the different results gathered are converged by comparing the different results during the interpretation. Researchers use this model when they want to compare results or to validate, confirm, or corroborate quantitative results with qualitative findings. The purpose of this model is to end up with valid and well-substantiated conclusions about a single phenomenon (Creswell et al., 2004). Figure 3.1 is a schematic representation of how convergence mix-method is conducted. Figure 3.2 is a schematic representation of how the convergence mixed method was used to design the DISTL study.

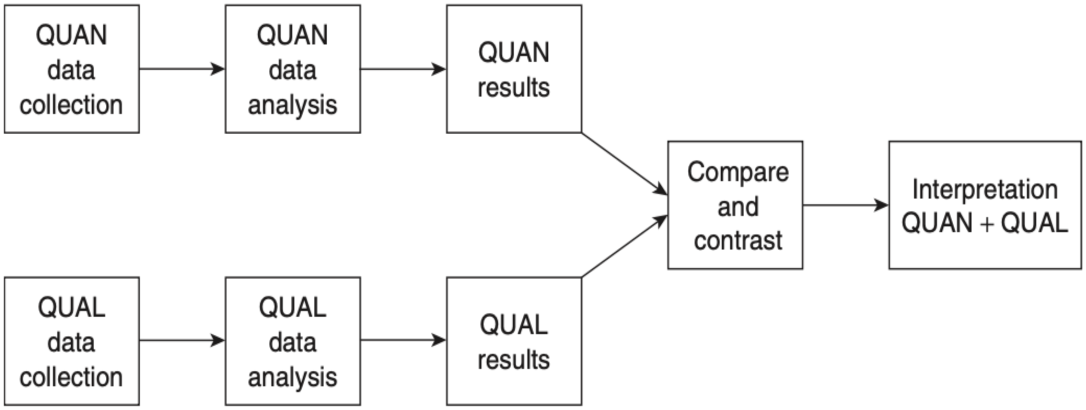
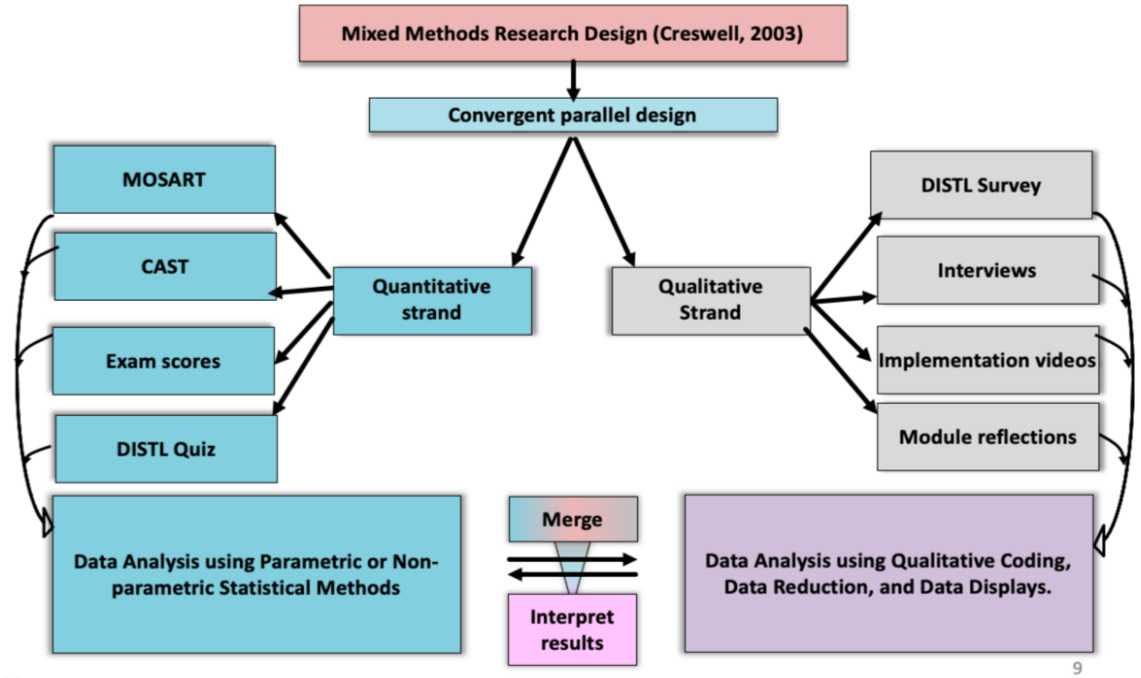


Figure 3.1. A schematic representation of convergence mixed method as proposed by Creswell et al., 2004



Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and Conducting Mixed Methods Research.* California: SAGE.

Fig 3.2. Schematic representation of Method Development for DISTL Project using Convergence Mixed Method

3.1. Qualitative Strand

3.1.1. Selection of Students for DISTL project

A summary of the research including the number of students envisioned to participate in the study was sent to the institution review board (IRB) of South Dakota State University for approval to conduct the study on the students. An email was then sent to the students in Chem 106 and Chem 452, requesting their participation in the study voluntarily. A consent form was then sent to all students who volunteered to partake in the study. Students were randomly selected to participate in this study from Summer 2020 to Spring 2021. Find the consent form in Appendix M.

3.1.2. Development of DISTL Survey and Interviews

During this research, various literatures were used to develop tools to measure the perceptions of students and instructors regarding diversity, inclusion, equity and access. These tools included the DISTL survey and semi-structured interview protocols which were used for both students and instructors.

3.1.2.1 DISTL Survey for Students

The survey questions for the students were designed to probe their:

- Background and demography
- Classroom experience with their science teachers and curriculum in high school
- Classroom experience with their science teachers and curriculum in college
- Understanding of diversity, inclusion, equity, and access
- View of scientist in the STEM field

The survey was mounted on QuestionPro and sent to the students by sharing the survey URL link in an email. Find details of the DISTL Survey for students in Appendix O.

3.1.2.2. DISTL Survey for Instructors

The survey questions for the instructors were designed to probe their:

- Background and demography
- Classroom experience with their science teachers and curriculum in high school
- Classroom experience with their science teachers and curriculum in college
- Understanding of diversity, inclusion, equity, and access

- Classroom experience with students as a science instructor
- Training as instructors to teach diverse students
- View of scientists in the STEM field

The survey was mounted on QuestionPro and sent to the instructors by sharing the survey URL link in an email. Find details of DISTL Survey for Instructors in Appendix N.

3.1.3. QuestionPro

QuestionPro is web-based software for creating and distributing surveys. This software is used for creating survey questions, distributing your survey through email to a list of potential respondents, and contain tools for analyzing and viewing the results. You simply build your survey and email it to a list of potential respondents or post the survey URL link wherever you want. QuestionPro will take care collecting and recording the responses. Results are available in real time.

3.1.4. Interview Protocols

A semi-structured interview was designed based on the research questions and the what the students and instructors learned from the modules that were developed. 21 open-ended questions and 36 open-ended questions for the pre- and post-interview respectively were drafted for the instructors and students. The interview protocols for Pre and Post interviews for the students and instructors is found in Appendix J.

3.1.5. Module Reflections (Summary)

At the end of each module, a set of questions was given to the students to probe their understanding of the module. This also included questions about how diversity with respect to the scientific work from both past and modern scientists were related to the scientific topic studied in class.

3.1.6. Attitude towards Subject of Chemistry Inventory (ASCI)

To be able to ascertain how the DISTL modules impacted students' attitude towards general chemistry, the ASCI survey was given to the students. It was given to them during their first week of class (pre) and last week of class (post). In this survey, students position themselves on a seven-point scale between two polar adjectives, in reference to how they feel about chemistry and student's tendency to approach or avoid the topic of chemistry (Bauer, 2008). The inventory is often referred to as the Bauer survey and can be found in Appendix E.

3.2. Quantitative Strand

3.2.1. California Standard Test (CAST)

Standardized tests serve as a tool to determine how well students understand specific academic subjects and skills. These tests can help identify gaps in knowledge or skills early on so children can get the support needed to be successful in school. CAST is designed to assess a student's ability to think critically and to solve problems. The criteria for selecting the CAST instrument is that the questions adequately cover a selection of academic content standards assessed on the chemistry content and presents a variety of ways standards can be assessed. All questions have been validated (Russell, 1994). The

75 multiple-choice questions from CAST are categorized under investigation and experimentation, atomic and molecular structure, chemical bonds, chemical reactions, kinetics, and conservation of matter (Russell, 1994). The test was given to the students at the first (pre) and last (post) week of their general chemistry class. The questions were in line with the four modules that had been selected for the DISTL project. A selection of questions from the CAST is found in Appendix F.

3.2.2. Misconception Oriented Standard Based Assessment Resource for Teachers (MOSART)

The MOSART test is a tool used to measure changes in understanding of scientific concepts by teachers or students when administered before and after lessons. The questions in this test are based upon documented misconceptions concerning science concepts (Sadler et al., 2007; Sadler et al., 2006). The tests used for the DISTL project included 22 multiple-choice items which were based on the four modules. This instrument was used to probe for any conceptual shift among students pre- and post-implementation of the DISTL modules. A sample of questions from this test can be found can be found in Appendix G.

3.3. Development of Modules Focused on DISTL

Thorough work was done to develop modules that were chemistry-based yet focused on diversity and inclusion. Prior to the development of the modules, the literature was researched to ascertain whether there were any modules or materials in undergraduate general chemistry, developed to address diversity and inclusion. From our findings, there were no such materials. Four chemistry topics that are taught in first year undergraduate general chemistry class were selected for module development and included:

- State of matter- Module 1
- Intermolecular forces- Module 2
- Solution chemistry- Module 3
- Acid/base chemistry- Module 4

The choice of topics for the modules were informed by literatures that identified those topics as essential to the success of every first-year general chemistry student. After the topics were identified, many chemistry books including the ones used for teaching undergraduate general chemistry students in SDSU were consulted. Science books and literature which discuss the history of the concepts in the topics were also consulted. With respect to the history about the various scientists who contributed to the establishment of the concepts in the topics, several factors were considered which included:

- The year they made those contribution: Ancient and Modern Scientist
- Their country of origin
- Their gender
- Their Socio-Economic status
- Their field of study and specialty
- Any other thing that made them different from their peers (eg. Disability).

When all these resources were identified, what was left was how to tell the story so that the modules contained all the essential information the student need to understand the concept taking into account diversity and inclusion. Therefore, every module begins with an introduction to the concept, outline of key points, a table which talks about the various scientists who contributed to the module including their backgrounds and finally some questions to probe the students' understanding on what was learned. Below is a brief description of the four modules that were developed.

3.3.1. Module 1- State of Matter

In this module, students were introduced to state of matter (i.e. solids, liquids, gases and plasma) and discussions on the contributions of diverse individuals that led to the discovery of state of matter. The module began with a brief overview the general concept of state of matter and the background of some prominent philosophers and scientists both from ancient times and modern era who are current researchers in the area. Our goal was to unravel the scientific diversity involved in the study of state of matter. Module 1 can be found in Appendix A.

3.3.2. Module 2- Intermolecular Forces

In this module, students were introduced to the intermolecular forces and discussion on the contributions of diverse individuals to the discovery of intermolecular forces. The module also included a brief overview of the background of some prominent (or less than) philosophers and scientists both from ancient times and modern era (current science). Our goal was to unravel the scientific diversity involved in the study of the forces between molecules. We also sought to discuss the challenges that may have hindered or marginalized some groups, leaving their contributions unrecognized while other groups grew exponentially. Module 2 can be found in Appendix B

3.3.3. Module 3- Solution Chemistry

This module introduced students to the solution chemistry and the contributions of diverse individuals to the study of the solution chemistry. The module also included a brief overview of the background of some philosophers and scientists both from ancient times and modern era with the goal of unraveling the scientific diversity involved in the study of solution chemistry. Module 3 can be found in Appendix C

3.3.4. Module 4- Acid and Base Chemistry

Module 4, which was the last module, introduced students to Acids and Bases and the contributions made by diverse individuals in the discovery of acids and bases. It also included a brief overview of the background of these prominent philosophers and scientists both from ancient times and modern era. The goal was to unravel the scientific diversity involved in the study of acids and bases and other factors that may have hindered or marginalized some groups, leaving their contributions unrecognized. Module 4 can be found in Appendix D

Chapter 4- Pilot Module

4.0. Introduction

A good research study with relevant experimental design and accurate performance is required to obtain high-quality outcomes. For the purpose of such study, it is very beneficial to analyze its feasibility before performing the main. The feasibility study done prior to performing the main study is known as a pilot study. A pilot study is the first step of the entire research protocol and is often a smaller-sized study assisting in planning and modification of the main study. A pilot study asks whether something about the research could be done, should the researchers proceed with it, and if so, how should it be conducted. It is performed reflecting all the procedures of the main study and validates the feasibility of the study by assessing the inclusion and exclusion criteria of the participants, preparation of instruments and testing of the instruments used for measurements in the study, as well as training of researchers and research assistants (Benger et al., 2016). However, a pilot study also has a specific design feature; it is conducted on a smaller scale than the main or full-scale study. A pilot study is important for improvement of the quality and efficiency of the main study and results in an increase researcher's experience with the study method (Arnold et al., 2009; Thabane et al., 2010).

4.1. Piloting of DISTL Project

The piloting of DISTL modules was conducted to identify potential problem areas in the modules prior to implementation and integration in the general chemistry course. The piloting stage of DISTL study provided the conceptual premises from which the assumptions of the implementation of modules were drawn; modules developed during the piloting stage assisted in developing additional modules on all the topics considered for the scope of this study. The DISTL framework also guided the selection of the diversity and inclusion concepts to be included in the modules. For the pilot study, four modules were developed and included states of matter, intermolecular forces, solution chemistry and acid/base chemistry. The piloting study involved the use of research protocols that involved data collection instruments, sample recruitment strategies, and other study techniques for the preparation of implementation and integration stages. Piloting of DISTL modules provided the groundwork in DISTL study and focused on determining the impact of developed modules on students' academic performance, students' conceptual understanding, students' perception of diversity and inclusion, and students' attitudes in the subject of chemistry.

4.2. Research Questions for Piloting DISTL Project

The research questions included are:

1. What is students' perception or understanding of diversity and inclusion?
2. What is the impact of DISTL interviews and diversity and inclusion modules on?

- Student knowledge of Chemistry
- Student attitudes towards Chemistry
- GTA's knowledge of Chemistry

4.3. Piloting Study Setting and Participants

The research study was conducted in one of the largest universities in mid-west known as South Dakota State University (SDSU). The study was piloted in Chem-106 (Chemistry Survey) and Chem-452 (Inorganic Chemistry) classes during the Fall semester in 2020.

4.3.1. Piloting Study Setting and Participants for Chem-106 students

Chem 106 is one of the undergraduate general chemistry classes in SDSU, which offers a survey of general chemistry concepts for students intending to pursue non-chemistry degrees in areas such as allied health, agriculture, and dairy/animal science. Enrollment in the Fall 2020 class was 172 students. This class was offered in hybrid format which resulted in some students attending class in person and others attending online via synchronous Zoom. Course assignments, quizzes and research instruments (such as MOSART and CAST) were delivered and collected through Desire to Learn (D2L) platform. Emails were sent to all the students in the class, informing them about the DISTL study and how it involved voluntary participation. A consent form was attached the email sent to the students. Out of 172 students who enrolled in the course, 54 students consented to participate in the study. For the 54 students who consented, 38 (70.4%) of them were females whiles 16 (29.6%) of them were males. Details of the students are found in Tables 4.1 to 4.3.

4.3.2. Piloting Study Setting and Participants for Chem 452 students

Chem-452 is an inorganic chemistry class offered for students in their 3rd or 4th year of college. Students in this class are chemistry majors. Emails were sent to all the students in the class, informing them about the DISTL study and how it involved voluntary participation. A consent form was attached the email sent to the students. There were 17 students enrolled and all consented to participate. Out of the 17 students who consented, 9 (52.9%) of them were females while 8 (47.1%) of them were males. Details of the students are found in Tables 4.4 to 4.

Table 4.1. Social Backgrounds of Chem 106 students for Fall 2020

Age		**Gender**		**Country of Origin**		**English as first Language**	
18yrs	31	Male	16	Black/ African American	2	Yes	10
19yrs	16	Female	38	Caucasian/White	45	No	30
20yrs	3	Trans-gender	0	Hispanic/Latinx	1		
21yrs	3	Gender Variant	0	Native American	2		
Other	0	Other	0	Native Hawaiian	1		
				Prefer not to answer	3		
				Other	1		

Table 4.2. Academic Backgrounds of Chem 106 students for Fall 2020

High School GPA		**ACT**		**High School Completion**		**Chemistry in High School**	
1.5-1.9	0	15-19	10	2020	37	Yes	53
2.0-2.4	1	20-25	30	2019	1	No	1
2.5-2.9	3	26-30	10	2018	2		
3.0-3.5	15	31-32	1	2017	2		
3.6-4.0	35	Unsure	1	Other	10		

Table 4.3. Undergraduate Majors of Chem 106 Students for Fall 2020

Majors		**Majors**	
Nursing	35	Natural Resource Law Enforcement	1
Wildlife and Fishery science	3	Early Childhood Education	1
Ecology and Environmental Science	2	Business Economics	1
Dairy Manufacturing	1	Athletic Training	1
Fashion Studies	1	Agricultural Science	4
Agricultural System Tech	1	Exercise Science	2

Table 4.4. Social Backgrounds of Chem 452 students for Fall 2020

Age		**Gender**		**Country of Origin**		**English as first Language**	
18yrs	0	Male	9	Black/ African American	0	Yes	17
19yrs	0	Female	8	Caucasian/ White	17	No	0
20yrs	3	Trans-gender	0	Hispanic/ Latinx	0	**Year in College**	
21yrs	7	Gender Variant	0	Native American	0	Freshman	0
22yrs	2	Other	0	Native Hawaiian	0	Sophomore	0
23				Prefer not to answer	0	Junior	4
				Other	0	Senior	13

Table 4.5. Academic Backgrounds of Chem 452 students for Fall 2020

High School GPA		**ACT**		**High School Completion**		**Chemistry in High School**	
2.5-2.9	0	15-19	0	2016	2	Yes	53
3.0-3.5	2	20-25	2	2017	10	No	1
3.6- 4.0	9	26-30	12	2018	3		
4.01- 4.5	6	31-34	3	2019	0		
Unsure	0	Unsure	1	Prefer not to answer	3		

Table 4.6. Undergraduate Majors of Chem 452 Students for Fall 2020 in college

Majors		**Majors**	
Chemistry	7	Chemistry Education	3
Chemistry and Biochemistry	4	Biochemistry	3

4.4. Data Collection

4.4.1. Data Collection for Chem-106 Fall students

During the first and last week of the Fall 2020 semester class, pre and post assessment were assigned to students. These assessments were MOSART and CAST standard tests and the Bauer survey. The MOSART and CAST standard tests were used to assess any shift in students' academic performance and any change in alternate conceptions formed in the minds of the learners during study. All instruments were previously validated. A semi- structured interview was also used to gather students' responses after they read the module. This was used to analyze the impact of the DISTL modules on students' conceptual understanding of chemistry and DIEA. The Bauer survey was also used to measure students' attitude before and after they took the modules. DISTL survey was used to gather data on students' backgrounds and perceptions on diversity and inclusion and chemistry as a course before taking the class. This survey was mounted on Questionpro.

4.4.1. Data Collection for Chem-452 Fall students

The DISTL study in Chem-452 students was focused on perception of DIEA in students pursuing higher-level chemistry education in college and how the DISTL modules could impact their understanding. DISTL survey was used to gather data on students' backgrounds and perceptions on diversity and inclusion in chemistry. This survey was mounted on Questionpro. A semi- structured interview was also used to gather students' responses after they read the modules. This was used to analyze the impact of the DISTL modules on students' conceptual understanding of chemistry and DIEA.

4.5. Data Analysis

4.5.1. Assessment of Student Academic Performance

Academic performance was measured using student scores in both pre- and post-CAST and MOSART tests. Both CAST and MOSART were administered to the students during the first week and last week of their Chem 106 class. Out of the 54 students who participated, 22 students completed both pre and post CAST and MOSART assessments for which the mean, and standard deviation were calculated. During significance testing, statistical significance was set at 0.05 and p values were reported for both tests. The assessment of students' academic achievement was based only on Chem-106 students.

4.5.2. Assessment of Students Perception of Diversity and Inclusion before Module for Chem-106 and Chem-452 students

Students' perception of diversity and inclusion was assessed using the DISTL Survey. This survey could be found in Appendix N. The DISTL survey contained Likert scale questions and open-ended questions. The Likert scale ranged from strongly disagree to strongly agree where strongly agree is 1 and strongly disagree is 5. The quantitative data from the Likert scale was gathered with their means and standard deviations using Questionpro. A semi-structured interview was conducted for Chem 106 students. The responses from the DISTL survey open-ended questions and the interviews were then transferred and analyzed using AtlasTi. Codes were deductively and inductively generated from the research questions and the responses. The questions from the survey and interview sought to probe students understanding of diversity and inclusion, their perception of who scientists are, their experiences in their chemistry classrooms both in high school and college and finally, their experiences with their chemistry instructors in the area of diversity and inclusion. In all, 54 students participated in this survey from Chem 106 and 17 students from Chem 452. Their demographic background is found in Tables 4.1 and 4.2. At the end of the analysis, the following codes were developed and placed into themes with definitions for each code. These were then broken down into positive and negative views in Table 4.7.

Theme 1: Experience regarding classroom environment, instructor, teaching and academic expectations from students

- HCP - Helpful Chemistry Professor. This is when the interventions of the instructor led the student to develop a positive attitude towards science/chemistry
- HRMC - Helpful Resource material and curriculum. This is when the resource material helps the student develop a positive attitude towards chemistry/science and positively impacts their academic success
- RPS - Respect from instructor to students. This is when the instructor respects all the students irrespective of their backgrounds
- VC - Valued in Class. This is when the student feels their contributions matter in class
- UHRMC - Unhelpful resource material and curriculum. This is when the materials do not help, students understand chemistry/science
- UVC - Unvalued in Class. This is when the student does not feel valued in class
- UCP/UHS - Unhelpful Chemistry Professor. This is when the instructor’s interventions cause the student to lose interest in Chemistry. This includes situations where the instructor uses only the textbook and no other resources for teaching.

- MS - Motivation from self. This is when the student's motivation is not from curriculum, material, or instructor but from themselves.

Theme 2: Experience regarding students general view of chemistry as a subject

- PAC/PAS - Positive attitude/Experience to Chemistry. This is when the student already has a positive attitude to chemistry/science. This may be due to factors such as instructor, material/resources, and curriculum.
- NAC/NAS - Negative Attitude/Experience Towards Chemistry. This is when the student does not have excitement for doing chemistry

Theme 3: Experience of the student in terms of fair treatment of all students and time spent on diversity

- UFAEL – Unfair assessment of assignment and evaluation of learning
- FAEL – Fair assessment of assignment and evaluation of learning

Theme 4: Student understanding of diversity, inclusion, equity and access and its impact on students

- NGW - No group work activities in class or science courses
- PIWDS - Positive impact of working with diverse students.
- PIDC - Positive Impact of Diversity in class. This is when students exposed to a diverse community of students improve their academic success and relationship with other students.
- SIKDI - Student In-depth Knowledge in Diversity and inclusion. Diversity recognizes a range of identities and the value in the varied perspectives that each identity brings to a collective. Here we seek to highlight those efforts that target

groups underrepresented in our disciplines, particularly those having a range of racial/ethnic, socioeconomic, and academic backgrounds

- SPDA - Student perception of Disability Able. This is when students see scientists with disability being as able as those without disability.
- SPDU - Student perception Disability unable. This is when students see scientists with disability as not as capable as those without disability
- SPEE - Student perception ethnic equal. This is when the student sees every scientist as equal irrespective of their cultural differences
- SPEW - Student Perception White Scientist. This is when the student perception is that a scientist is a white person.
- SPGES - Student perception gender equal as scientist. This is when students see scientists to be equal irrespective of their gender
- SPGMs - Student perception as Male Scientist. This is when student sees scientists as Male dominant. This also applies when the examples the students give about scientists consist of only males.
- SPGFs - Student perception as Female Scientist. This is when student sees scientists as Female dominant. This also applies when the examples the students give about scientists consist of only females.
- SPKDI - Student Partial knowledge in Diversity and inclusion. This is when the student’s definition of Diversity and Inclusion does not fully address the concept of diversity. That is, it is either only discussing one of the factors of diversity or defining diversity without examples.

- SPnSE - Student’s perception that not all scientists are equal with respect to their background.
- SPOs - Student’s perception of old people as scientists

Theme 5: Student perception that it is the responsibility of the instructor to use the content of math and science courses to help students understand diversity

- DITL - Diversity incorporated in teaching and learning. This is when the instructor makes attempts to incorporate diversity in teaching
- WDS - Worked with diverse students. This is when the student works with students from different backgrounds as a group.
- NDITL - No Diversity incorporated in teaching and learning. This is when the instructor does not make any attempt to incorporate diversity in teaching
- IIDC - Indifferent when it comes to the impact of diversity in classroom
- WnDS - Worked not with diverse students. This is when the students think they did not work with diverse students or think they only worked with students from the same cultural background as them.

Table 4.7. Summary of Chem 106 Students perception on DISTL in STEM

Students Perception	**Code**	**Positive**	**Negative**
Experience: Classroom environment, instructor, teaching, academic expectation from students	ECIAE	HCP, HRMC, RPS, VC	UHRMC, UVC, UCP
Experience/General view of Chemistry as subject	EGCS	PAC	NAS/NAC
Experience: Fair treatment of all students and time on diversity	EFTS	ECS, FAEL,	UFAEL, UECS
Students understanding of Diversity, Inclusion, Equity and Access and its impact on students	SUDIEA	SIKDI, PIDC, PIWDS, SPDA, SPEE	SPDU, IIDC, IDWDS, SPEW, SPGMs, SPGFs, SPOs
Students' perception that it is instructors' responsibility to use the content of math and science courses should help students understand diversity	IMSCD	DITL, WDS,	NDITL, WnDS, IIDC

4.5.3. Analysis of module on Chem 106 Students Conceptual Understanding of Chemistry

An interview was conducted with the students after they went through the DISTL module to evaluate the impact of the modules on their conceptual understanding of chemistry. 16 students participated in this interview. The coding of students' responses followed a both deductive and inductive approach. At the beginning of coding, every individual post was read multiple times before the coding process. An initial round of open codes, deductive codes, were focused on codes generated from the research questions. The inductive codes were then generated from student submissions on the topics and the explanation associated with each topic. The interviews were coded using AtlasTi software. Each student submission with explanation of concepts and the example provided by students was analyzed for correctness and its connection to the content presented via the materials. At the end of the analysis, the following codes were developed with their definitions: Table 4.8 sorts the codes into positive and negative responses

- IUM- In-depth Understanding of Module. This is when the definitions and explanations of the module reflect an in-depth understanding of the module. Here the student gives examples and analogies related to the module.
- PUM - Partial Understanding of Module. This is when the definition and explanation of participant covers only a small portion of the definition without any examples
- ERM - Example related to module. This is when the example given is relevant to the module
- PIMDI - Positive impact of module in relation to diversity and inclusion. This refers to when the participants definition and explanation of terms reflects an understanding of diversity and inclusion from the module.
- NIMDI- No impact of module on students understanding of diversity and inclusion. This is when the student’s response does not reflect the impact on the module of their understanding of diversity and inclusion.

- HM - Helpful Module (HM). This is when the module adds to the knowledge of the participant on a particular topic.
- UHM – Unhelpful Module. This is when the module does not impact the understanding of the student, or the student finds it difficult to understand the module.
- MM - Misconception about modules. This is when the definition/explanation of terms is inconsistent with the module

Table 4.8. Analysis DISTL module on Students Conceptual Understanding

Positive Codes	Negative Codes
PIMDI, HM, CUM, ERM	NIMDI, UHM, PUM, MM

4.5.4. Analysis of Module on Chem 106 Students understanding of DIEA in STEM

Interview 2, which was used to assess students conceptual understanding of chemistry from the DISTL module, was also used to evaluate the impact of the module on students understanding of DIEA. 16 students participated in this interview. The coding of students' responses followed a both deductive and inductive approach. An initial round of open codes, deductive codes, were focused on codes generated from the research questions. The inductive codes were then generated from student submissions on the topics and the explanation associated with each topic. Students' responses were coded using AtlasTi software. Each student response with explanation of concepts and the example provided by students was analyzed in relation to its connection to the modules presented. At the end of the analysis, the following codes were developed with their definitions: Table 4.9 sorts the codes into positive and negative responses

Students understanding of Diversity, Inclusion, Equity and Access after module

- SIKDI - Student In-depth Knowledge of Diversity and Inclusion. This is when the definition of diversity and inclusion include the following: Diversity recognizes a range of identities and the value in the varied perspectives that each identity brings to a collective. Here we seek to highlight those efforts that target groups underrepresented in our disciplines, particularly those having a range of racial/ethnic, socioeconomic, and academic backgrounds. Equity seeks to meet the needs of individuals to ensure their access to opportunities and resources. Inclusion involves systems and dispositions that seek to engage individuals from diverse backgrounds and create a welcoming and supportive environment in which these individuals can successfully operate
- SPKD – Student Partial Knowledge in Diversity and Inclusion

Students Perception of the Scientist in STEM Field after DISTL module

- SES – Socio-Economic Status as a contributing Factor of the success of a scientist. This is when social status or class is seen as a contributing factor in determining the success of a scientist
- DF - Diverse Field. This is when the student sees scientists from different scientific fields coming together to contribute to a concept
- DG – Diverse Gender. This is when the student sees different genders coming together to contribute to a concept.

- DC - Diverse Country. This is when the student sees scientists from different countries coming together to contribute to a concept
- GSS -Gender being a reason why scientist was recognized or successful.
- MGD - Male Gender Dominate. This is when the participant sees the scientific community to be male biased or mainly made up of males.
- NDC - No diversity in Country. This is where the participant reports that the scientists are from a single place
- NDF - Not Diverse Field. This is when the fields of the scientists are the same with no diversity
- NDG - Not Diverse Gender. This is where the students see little to no diversity in the gender representation of the scientists.
- USC – Unrecognized Scientific Contribution. This is when the student thinks some scientists were not recognized for their work despite their impacts.

Table 4.9. Analysis of DISTL Module on Students understanding of DIEA in STEM- Interview 2

	Codes	Positive	Negative
Students understanding of Diversity, Inclusion, Equity and Access after module	SUDIEA - AM	SIKDI	SPKDI
Students Perception of the Scientist after in STEM Field after DISTL module	SPSSF - AM	DC, DF, DG	USC, NDF, NDG, NDC, MDG, GSS, SES

4.5.6. Assessment of Student Attitude Using Bauer Survey

The attitude of students toward chemistry before and after the module was analyzed using the Bauer survey. This survey categorizes students' attitude into five constructs. These are Anxiety, Emotional Satisfaction, Intellectual Accessibility, Interest or Utility and Fear. This survey has a scale ranging from 1 to 7. The seven choices help strengthen the reliability of the instrument and are appropriate for the target population. The adjectives are placed at the ends of each line. The responses from the students are then analyzed with Microsoft Excel with specific functions generated by Christopher Bauer and his group. The Bauer survey can be found in Appendix E

4.5.7. Assessment of GTAs Perception of Diversity and Inclusion

GTAs' perception of diversity and inclusion was assessed during the piloting stage using the DISTL Survey. The DISTL survey for GTAs contained Likert scale questions and open-ended questions. The Likert scales ranged from strongly disagree to strongly agree just as the DISTL survey for the students. The quantitative data from the Likert scale was gathered with their means and standard deviations using Questionpro. The open-ended questions from the survey were further transferred and analyzed using AtlasTi. Codes were deductively and inductively generated from the research questions and the response from the survey. The questions from the survey sought to probe GTAs understanding of diversity and inclusion, their perception of who scientists is, their experiences in their chemistry classrooms both in high school and college and finally, their experiences chemistry classroom as instructors taking into account diversity and inclusion. In all, 12 GTAs participated in this survey. Their demographic background is found in Table 5.3

and 5.4. At the end of the analysis, the following codes were developed and placed into themes with definitions for each code.

Theme 1: Experience: Classroom environment, instructor, teaching, academic expectation from instructors as students

- HCP - Helpful Chemistry Professor. This is when the interventions of the instructor led the student to develop a positive attitude towards science/chemistry.
- HRMC/TCREE - Helpful Resource material and curriculum. This is when the resource material helps the student develop a positive attitude towards chemistry/science and positively impacts their academic success.
- RPS - Respect from instructor to students. This is when the instructor respects all the students irrespective of their backgrounds
- UCP/UHS - Unhelpful Chemistry Professor. This is when the instructor's interventions cause the student to lose interest in Chemistry.
- UHRMC - Unhelpful resource material and curriculum. This is when the materials do not help students understand chemistry/science
- UVC - Unvalued in Class. This is when the student feels their contribution does not really matter and feels undervalued in class
- VC - Valued in Class. This is when the student feels their contributions matter and feel valued in class

Theme 2: Experience/General view of Chemistry as subject

- NAC/NAS - Negative Attitude/Experience Towards Chemistry. This is when the instructor as a student did not have the excitement in doing chemistry.
- PAC/PAS - Positive attitude/Experience to Chemistry. This is when the instructor as a student had a positive attitude to chemistry/science. This may be due to factors such as instructor, material/resources, and curriculum.
- IdWDS - Indifferent about working with diverse students. This is when the student was not impacted in any way, working with diverse students

Theme 3: Experience: Fair treatment of all students and time on diversity

- FAEL – Fair assessment of assignment and evaluation of learning
- UFAEL – Unfair assessment of assignment and evaluation of learning
- UECS - Unequal contribution from students
- EOC/IPEC - This is when every student has equal opportunity to contribute in the classroom
- IPFC- This is instructor’s perception that females contribute more in the classroom than males
- IPMC- This is instructor’s perception that males contribute more in the classroom than females

Theme 4: Instructors’ understanding of Diversity, Inclusion, Equity and Access and its impact on students

- EISS - This is where the instructor thinks ethnicity has an impact on student success
- EnISS - This is where the instructor thinks ethnicity does not have an impact on students success
- FDC - This is where the majority of the students in class are females

- IIDC - Indifferent when it comes to the impact of diversity in classroom
- IIKDI - Instructors In-depth Knowledge in Diversity and inclusion. Diversity recognizes a range of identities and the value in the varied perspectives that each identity brings to a collective. Here we seek to highlight those efforts that target groups underrepresented in our disciplines, particularly those having a range of racial/ethnic, socioeconomic, and academic backgrounds.
- IPDA – Instructor’s perception of Disability Able. This is when instructor see scientists with disability being as able as those without disability.
- IPDU – Instructor’s perception Disability unable. This is when instructor sees scientists with disability as not as capable as those without disability
- IPEE – Instructor’s perception ethic equal. This is when the instructor sees every scientist as equal irrespective of their cultural differences
- IPEW/IPEMa – Instructors Perception White Scientist. This is when the perception of instructors is that scientists are white people
- IPGES - Instructor’s perception gender equal as scientist. This is when instructors see scientists to be equal irrespective of their gender.
- IPGMs – Instructor’s perception as Male Scientist. This is when instructors see scientists as Male dominant. This also applies when the examples the instructors give about scientists consist of only males.
- IPGFs - Instructors perception as Female Scientist. This is when the instructor sees scientists as Female dominant. This also applies when the examples the instructors give about scientists consist of only females.

- IPGEs - Instructor’s perception gender equal as scientist. This is when instructors see scientists to be equal irrespective of their gender
- IPKDI – Instructor’s Partial knowledge in Diversity and inclusion. This is when the instructor’s definition of Diversity and Inclusion does not fully address the concept of diversity. That is, addressing only one of the factors of diversity.
- IPOs - Instructor’s perception that old people are scientists
- IPnSE - Instructor’s perception that not all scientists are equal with respect to their background
- PIWDS - Positive impact of working with diverse students.
- PIDC - Positive Impact of Diversity in class. This is when students exposed to a diverse community of students improve their academic success and relationship with colleagues.

Theme 5: GTAs teaching Experience as Chemistry instructors

- ThDS- This is instructors perception that the training given to him/her as an instructor adequately prepares him/her to teach diverse students.
- ThDS- This is instructors perception that the training given to him/her as an instructor does not adequately prepare him/her to teach diverse students
- Thndis- Instructors perception that the training given to him/her as an instructor does not adequately prepares him/her to teach students with disability
- ThnMC- Instructors perception that the training given to him/her as an instructor does not adequately prepares him/her to manage crises in the classroom
- ThES- Instructors perception that teaching method used is helpful for the students
- ThnES- Instructors perception that teaching method used is not helpful for the students

Theme 6: GTAs perception on Students Preparedness in chemistry class

- SPBC- This is when instructors perceive students to be prepared before coming to class
- SnPBC- This is when instructors perceive students as not prepared before coming to class

4.5.9. Analysis of DISTL Module on GTAs Conceptual Understanding of Chemistry

An interview was conducted for the instructors after they went through the DISTL modules to evaluate the impact of the modules on their conceptual understanding of chemistry. Their responses also helped to revise the modules. 12 instructors participated in this interview. Instructor responses were coded using both an inductive and deductive approach. The interviews were coded using AtlasTi software. Each student submission with explanation of concepts and the example provided by students was analyzed for correctness and its connection to the content presented via the materials. At the end of the analysis, the following codes were developed and placed into themes with definitions for each code. These were then broken down into positive and negative views in Table 4.10

- IUM- Comprehensive Understanding of Module. This is when the definitions and explanations of the module reflect an in-depth understanding of the module as evidenced by providing examples and/or analogies related to the module.
- PUM - Partial Understanding of Module. This is when the definition and explanation of participant covers only a small portion of the definition without any examples
- ERM - Example related to module. This is when the example given is relevant to the module

- nAEPS- No Addition, Examples, Pictures needed. This is where the instructor sees the module to be good without any addition needed.
- AEPS- Addition, Examples, Pictures needed. This is where the instructor sees the need for additional examples, pictures or schemes to modules

Table 4.10. Analysis DISTL module on Instructors Conceptual Understanding

Positive Codes	Negative Codes
nAEPS, IUM, PAM	AEPS, NAM, nIUM,

4.5.10. Analysis of DISTL Module on GTAs understanding of DIEA in STEM- Interview 2

The interview 2 was also used evaluate instructors conceptual understanding of DIEA. 12 instructors participated in this interview. The coding of instructor’s responses followed a both deductive and inductive approach. An initial round of open codes, deductive codes, were focused on codes generated from the research questions. The inductive codes were generated from the instructors’ responses on the topics and the explanation associated with each topic. Students’ responses were coded using AtlasTi software. At the end of the analysis, the following codes were developed and placed into themes with definitions for each code. These were then broken down into positive and negative views in Table 4.11

Instructors understanding of Diversity, Inclusion, Equity and Access after module

- SIKDI - Student In-depth Knowledge of Diversity and Inclusion. This is when the definition of diversity and inclusion include the following: Diversity recognizes a range of identities and the value in the varied perspectives that each identity brings to a collective. Here we seek to highlight those efforts that target groups underrepresented in our disciplines, particularly those having a range of racial/ethnic, socioeconomic, and academic backgrounds. Equity seeks to meet the needs of individuals to ensure their access to opportunities and resources. Inclusion involves systems and dispositions that seek to engage individuals from diverse backgrounds and create a welcoming and supportive environment in which these individuals can successfully operate
- SPKD – Student Partial Knowledge in Diversity and Inclusion

Instructors Perception of the Scientist in STEM Field after DISTL module

- SES – Socio-Economic Status as a contributing Factor of the success of a scientist. This is when social status or class is seen as a contributing factor in determining the success of a scientist
- EACD- Europe/America/Caucasian dominating as a Country in the field of science
- IPSRO- Instructors perception that some scientists are more recognized than others
- nEORW- Not Everyone recognized for the work they do
- nASS- instructors perception that all scientists did well (some were not more successful than others)
- ASS- instructors perception that some scientists were more successful than others
- DF - Diverse Field. This is when the subject areas of the scientists are different

- DG – Diverse Gender. This is the perception that different gender scientists come together to contribute to a concept
- DC - Diverse Country. This is when the countries of the scientist are different
- GSS -Gender being a reason why scientist was recognized or successful.
- MGD - Male Gender Dominate. This is when the participant sees the scientific community to be male biased or mainly comprised of males.
- NDC - No diversity in Country. This is where the participant reports that the contributing scientists are from the same locale with no diversity
- NDF - Not Diverse Field. This is when the fields of the scientist are the same with no diversity
- NDG - Not Diverse Gender. This is where the perception is little to no diversity in the gender of contributing scientists
- USC – Unrecognized Scientific Contribution. This is the perception that some scientists were not recognized for their work despite their impacts.
- PIMDI - Positive impact of module in relation to diversity and inclusion. This refers to when the participants definition and explanation of terms reflects an understanding of diversity and inclusion from the module.
- NIMDI- No impact of module on understanding of diversity and inclusion. This is when the response does not reflect an impact of the module on the understanding of diversity and inclusion.

Table 4.11. Analysis of DISTL Module on GTAs understanding of DIEA in STEM- Interview 2

Themes	Codes	Positive	Negative
Instructors understanding of Diversity, Inclusion, Equity and Access after module	IUDIEA - AM	IIKDI, PIMD	IPKDI, NIMDI
Instructors Perception of the Scientist after in STEM Field after DISTL module	IPSSF - AM	DC, DF, DG, EORW, ASS, IPCE, IMT	USC, NDF, NDG, NDC, MDG, GSR, SES, CSS, IPSRO, nEORW, nASS

4.6. Results and Discussion for the Pilot DISTL Project

4.6.1. Academic Performance Analysis

The academic performance of students was based on student scores in MOSART and CAST pre and post module piloting. These tests were given to the students during the first week and last week of their Chem 106 class. Details of these two standard tests are described in chapter 3. The scores of the students were transferred to an excel spreadsheet for analysis. Scores were calculated as percent values. A change in student mean ± standard deviation from pre to post were calculated. Pre and Post mean ± standard deviation for MOSART test scores were 40.61± 0.13 and 56.4± 0.15, respectively. For CAST standard test, the scores for their pre and post were 52.0± 0.12 and 72.0±0.17, respectively. To test for the significance, statistical significance was set at 0.05 and p values for both tests were reported (**Table 4.12)**. The results indicated a significant difference between pre and post MOSART at a *p value* = 0.007. The same was seen for CAST with *p value* of 0.002. Analysis on both standard tests show an increase in students average scores and a statistical difference between the pre and post mean scores of both MOSART and CAST.

Table 4.12. Analysis of DISTL impact on students' academic performance

	MOSART (N=22)		CAST (N= 22)	
	Pre	Post	Pre	Post
Mean	40.61	56.4	52.0	72.0
SD	0.13	0.15	0.12	0.17
P-value	0.007		0.002	

4.6.2. Analysis of student's perceptions on DIEA in STEM- DISTL Survey

Results from Chem 106 and 452 students' perception on DIEA before module piloting were gathered using DISTL survey mounted on QuestionPro. Most of the students in Chem-106 perceived their understanding to be positive for classroom environment, instructor, teaching, academic expectation of instructors from teachers and chemistry as a subject. The Chem-106 student's perception as being treated fairly in the classroom irrespective of their race, gender, religion, culture, and disability was positive. Also, Chem-106 students' perception of helpful instructor related to doing well and positive attitude for Chemistry was also positive as indicated in **Tables 4.13 to 4.14**. From the data, students perceive that it is instructor's responsibility to be mindful of diversity and how it has influenced science as indicated in **Tables 4.13 and 4.18**. Also, students want instructors to include diversity in science and mathematics content and problem solving. From the analysis using AtlasTi, in **Table 4.17**, some Chem-106 students showed an in-depth understanding of diversity and inclusion (SIKDI) but also, there were a fair number of instance where students viewed science to be male dominated and saw men to better scientists than women. A similar result was realized in Chem 452 students though this class represents students who are chemistry majors as indicated in **Table 4.20**. **Figure 4.3** show the comparison between Chem 106 and 452 students before the module piloting

Table 4.13. Results from DISTL Survey for Chem 106 Fall 2020

	Item Summary	**Strongly disagree (%)**	**Disagree (%)**	**Neither nor (%)**	**Agree (%)**	**Strongly agree (%)**
Experience: Classroom environment, instructor, teaching, academic expectation from students	Welcoming classroom	0.0	1.9	12.9	72.2	12.9
	Welcoming instructor	0.0	5.6	3.7	64.8	25.9
	Variety of teaching strategies	3.7	18.5	33.3	40.7	3.7
	Trained to teach diverse students	0.0	18.5	31.5	44.4	5.6
	Low students' participation	0.0	0.0	12.9	57.4	29.6
	High expectation	0.0	1.9	7.4	68.5	22.2
Experience: Chemistry as subject	Connects with everyday life	0.0	18.5	35.2	38.9	7.4
	Integrates multicultural perspectives	0.0	12.9	31.5	48.2	7.4
Experience: Fair treatment of all students and time on diversity	Disability	0.0	5.7	5.7	62.3	20.7
	Gender	0.0	1.9	5.7	58.5	33.9
	Religion	0.0	0.0	7.4	61.1	31.5
	Socio-Economic Status	0.0	5.6	5.6	57.4	31.5
	Culture	0.0	5.6	9.3	42.6	42.6
	Time-Diversity	1.9	7.4	33.3	42.6	14.8
Instructor expectation: From students and how expectations help students	Academic Skills	0.0	0.0	14.8	75.9	9.3
	Develop positive attitude and self-efficacy	0.0	5.6	29.6	57.4	7.4

	Item Summary	**Strongly disagree (%)**	**Disagree (%)**	**Neither nor (%)**	**Agree (%)**	**Strongly agree (%)**
Students' effort and general view of learning chemistry	All can learn	0.0	14.8	16.7	61.1	7.4
	Fail- effort is less	0.0	9.26	18.5	55.6	16.7
	Succeed- effort and hard work	0.0	9.3	9.3	53.7	27.8
	Some can never succeed	5.6	27.8	38.9	24.1	3.7
Instructor responsibility to use information, teaching approaches and know students to support diversity	Student background and experiences	0.0	5.6	18.5	64.8	11.1
	Support diversity	0.0	0.0	11.1	59.3	29.6
	Meeting the needs of students is important	0.0	3.7	33.3	50.0	12.9
Content of math and science courses should help students understand Diversity	Diversity	0.0	5.56	25.9	61.1	7.4
	Problems in the field influenced by diversity	0.0	1.9	27.8	64.8	5.6

Table 4.14. Experience: Classroom environment, instructor, teaching, academic expectation from students- Chem 106 Fall

Code	Freq	Comment 1	Comment 2
HCP	82	I did have a wonderful teacher who worked hard to make the concepts relevant.	My teachers in high school treated students’ great.
HRMC	32	I liked chemistry and biology the most. I liked the teachers and environment.	The curriculum is what made me love the classes. There was also a lot of hands-on learning with dissections and models to touch and practice on!
MS	5	The course did not motivate me at all, but I motivated myself to get it done by telling myself I have to get into nursing School.	I enjoyed animal science the most because it was targeted more towards my interests.
RPS	12	They treated us with respect and took our education seriously and made it fun in the process.	They treated us all equally
UCP	33	I did not like chemistry because of my teacher and how she taught. My high school science teacher was awful, and I didn't learn very much.	My least favorite was biology. This was due to my teacher. The way he taught didn’t help me learn anything and he was a lazy teacher overall.

Code	Freq	Comment 1	Comment 2
UHRM	30	I do not think the courses necessarily motivated me or pushed me to do my best	No quite the opposite. This class was quite boring for me.
UVC	12	They often would like to ignore our questions and tell us to keep trying to find the answer online which often led to false information being retained by students.	I felt like just another body in my chemistry courses
VC	22	I did feel valued for sure. my opinions and thoughts matter	I feel valued in my class. My contributions to discussions were important and valued in my class.

Table 4.15. Experience/General view of Chemistry as subject- Chem 106 Fall

Code	Freq	Comment 1	Comment 2
PAC	26	I enjoy science, so I did quite well in those courses.	I received A's in all classes. They were a great base for science knowledge.
NAC	35	Challenging and very, very stressful. First time taking chemistry	I struggled with chemistry so bad when I took it my freshman year, which is why I am retaking it as a senior to increase my GPA. It was hard to adjust to college in general let alone a subject I had never clicked with to begin.

Table 4.16 Experience: Fair treatment of all students and time on diversity- Chem 106 Fall

Code	Freq	Comment 1	Comment 2
FAEL	3	They treated us fairly most of the time	My teachers in high school treated everyone fairly and had many different styles of teaching to adapt to every student

Table 4.17. Students understanding of Diversity, Inclusion, Equity and Access and its impact on students- Chem 106 Fall

Code	**Freq**	**Comment 1**	**Comment 2**
SIKDI	31	Yes, I am a white, female. This puts me in to a gender group and a race group. I think that a lot of people associate diversity with only races other than white people, but we are also a group diverse from other races.	I think each group has some degree of diversity because our life experiences are different and many of the people I know are from different geographical locations, which can impact our opinions, values, and more. I think living in South Dakota where there is not as much diversity as other locations in the Unites States affects the answer for me to these questions. I have made many friends from diverse cultures and differing religious affiliations than me because I love being around anyone and have always been an accepting person. I know many people gravitate towards people that are exactly like them, but I feel I do not do this.
SPDA	15	Yes, they can be good as every scientist	Yes, I don’t think a physical disability affects intellectual ability

Code	Freq	Comment 1	Comment 2
SPDU	5	I feel that people with disabilities have a big disadvantage when it comes to science. They may not be taken as serious and may not be taken in by the scientist community. With this, I do believe that individuals with disabilities most likely have ideas that able-bodied people have not thought about yet.	I believe they are capable of great things, but I do think able-bodied people would be a better option.
SPEE	22	No. Your success as a scientist is not based on your culture but based on the science you are learning about	In my opinion, people of all different backgrounds make up the body of scientists. If there are not different cultures and life experiences being brought to the table in the world of scientists, many questions in the scientific community would be left out. All ideas are necessary to be beneficial to science.
SPEC	4	Yes, I would say that the discussion posts were group work because we had to respond to others. Yes, everyone contributed.	Yes, and we all helped each other when someone needed it

Code	**Freq**	**Comment 1**	**Comment 2**
SPnEC	3	I did engage in-group work mainly for labs and I feel like I pulled much more weight compared to others when answering questions from the lab.	Everyone acted like they were contributing in front of the professor or TA but some students definitely were not contributing.
SPEW	4	I anticipate them being an older white man. I feel as if that is the stereotypical view of scientists sadly. I feel as if this should change.	Scientists appear in my mind as old, white, male. I think this is because of old movies with scientist in them
SPGEs	44	Their work is very important A scientist could be anybody, does not matter race, gender, age	I think a scientist can be male or female and a person of any color. It does not matter
SPGMs	19	I think scientist are very smart and most of the time I think of them as male	I think that scientist is very smart and most of the time I think of them as male. Most videos showed in my science classes have male scientists
SPGFs	4	I think of scientist as female, females are smart and intelligent	An example of scientist is Jane Gooddall and that is it, sorry.

Code	Freq	Comment 1	Comment 2
SPKDI	16	Within this country or area, I do not believe that I am part of a diverse group because I have similar characteristics and a similar lifestyle to most people around the area.	Diversity, in my opinion, means the difference between two things

Table 4.18. Students' perception that it is instructors' responsibility to use the content of math and science courses should help students understand Diversity- Chem 106 fall 2020

Code	Freq	Comment 1	Comment 2
WDS	7	I worked with many different types of students during group work and we each had to adapt to each other's differences and overcome them to work together effectively.	Teams it was almost always a team so it was nice because you had others that would help. Yes, it would be a diverse group of different races
WnDS	8	There were hardly any students in my high school from a different ethnicity than me	My class was all the same ethnicities.
DILT	6	Sometimes like when it was Martin Luther king jr day they would always thank the African American students.	I feel like my teachers at the college had several teaching methods to help every student learn and they would answer questions if the students had them.

Code	Freq	Comment 1	Comment 2
IIDC	7	It honestly didn't make a difference. We all wanted to pass the class and worked together despite being different	I didn’t really have diversity in my high school
NDITL	12	Never had any experiences where teachers addressed diversity within the classroom.	Not really, I feel like they could teach more about it especially when foreign exchange students come, I feel as the teacher should let them explain what they do in their country

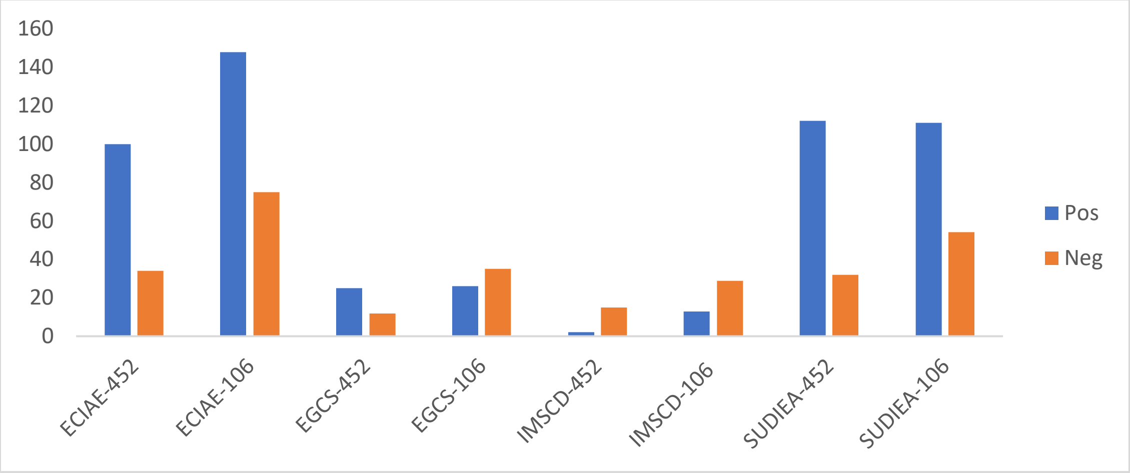
Table 4.19. Summary of Students Perception of DIEA in STEM from Interview 1- Chem106

Students Perception	Code	Positive	Negative
Experience: Classroom environment, instructor, teaching, academic expectation from students	ECIAE	HCP, HRMC, RPS, VC 148	UHRMC, UVC, UCP 75
Experience/General view of Chemistry as subject	EGCS	PAC 26	NAS/NAC 35
Students’ perception that it is instructors’ responsibility to use the content of math and science courses should help students understand diversity	IMSCD	DITL, WDS, 13	NDITL, WnDS, IIDC 29

Students Perception	**Code**	**Positive**	**Negative**
Students understanding of Diversity, Inclusion, Equity and Access and its impact on students	SUDIEA	SIKDI, PIDC, PIWDS, SPDA, SPEE 111	SPDU, IIDC, IDWDS, SPEW, SPGMs, SPGFs, SPOs 54

Table 4.20. Summary of Students Perception of DIEA in STEM from Interview 1- Chem 452

Students Perception	**Code**	**Positive**	**Negative**
Experience: Classroom environment, instructor, teaching, academic expectation from students	ECIAE	HCP, HRMC, RPS, VC 100	UHRMC, UVC, UCP 34
Experience/General view of Chemistry as subject	EGCS	PAC 25	NAS/NAC 12
Students' perception that it is instructors' responsibility to use the content of math and science courses should help students understand diversity	IMSCD	DITL, WDS, 2	NDITL, WnDS, IIDC 15
Students understanding of Diversity, Inclusion, Equity and Access and its impact on students	SUDIEA	SIKDI, PIDC, PIWDS, SPDA, SPEE 112	SPDU, IIDC, IDWDS, SPEW, SPGMs, SPGFs, SPOs 32



ECIAE: *Student classroom experience* **EGCS**: *Student view of chemistry*
IMSCD: *Students view that instructors responsible for bringing DIEA into classroom*
SUDIEA; *Student understanding of DIEA*

Figure 4.3. Comparison of Students Perception of DIEA in STEM from Interview 1 between Chem 452 and Chem 106 Students during the Fall 2020 semester

4.6.3. Analysis of GTAs perceptions on DISTL in STEM- DISTL Survey

The responses from GTAs perception before the module indicated that they had a negative experience in their classroom environment, instructor teaching and academic expectation (ECIAE) as students through high school to college as shown in Table 4.21. This is confirmed by the dominance of the negative response in their experience or general view of chemistry as a subject. Their experience as with respect to being treated fairly in class was also negative. With respect to GTAs understanding of DIEA, it was positive yet the negative response indicating a partial understanding of the DIEA is also high as seen in Table 4.21. The responses for the GTAs also indicate that they feel they were not adequately trained to teach diverse students.

Table 4.21. Summary of GTAs Perception of DIEA in STEM from Interview 1

Students Perception	**Code**	**Positive**	**Negative**
Experience: Classroom environment, instructor, teaching, academic expectation from GTAs as students	ECIAE	HCP, HRMC, RPS, VC **38**	UHRMC, UVC, UCP, IdRPS **44**
Experience/General view of Chemistry as subject	EGCS	PAC **1**	NAS/NAC **5**
Experience: Fair treatment of all students and time on diversity	EFTA	FAEL, EOC, IPEC **22**	UFAEL, UOC, UPS, IPFC, IPMC **29**
GTAs' understanding/ Experience of Diversity, Inclusion, Equity and Access and its impact on GTAs	SUDIEA	EISS, IIKDI, IPDE, IPEE, IPGES, IPSD **51**	IIDC, EnISS, FDC, IPDA, IPEW, IPGMS, IPFS, IPKDI, IPnSD **34**
GTAs teaching Experience as Chemistry instructors	ITECA	ThDS, ThES, **8**	THndis, ThnDS, ThES, ThnMC **28**

4.6.4. Results and Discussion of the DISTL Modules on Conceptual Understanding of Chemistry and DIEA for Chem 106

From the analysis on the interview conducted to examine the students' conceptual understanding, the frequency of the code related to the conceptual understanding of students from the four modules were analyzed as described in (**Table 4.6)**. From the analysis, students' responses indicated a comprehensive understanding of the module (CUM) at a frequency of 50 and a partial understanding of the module (PUM) at 17. This indicates that the module had a positive impact of students conceptual understanding of chemistry. A frequency of 25 was recorded for students who attested to the fact that gender (GSS), country (CSS) and socio-cultural status (SES) might be some of the main possible reasons why some scientists were not recognized. This raised the awareness of the need to recognize people's effort in the field of science irrespective of their background and make it inclusive. Students understanding of DIEA was positively impacted by the module as a frequency of 48 was recorded for the code (PIMDI). There was also a drastic reduction of the student's misconception of DIEA as only a frequency of 3 was recorded for SPKI but 24 recorded for SIKDI as indicated in Table 4.24. An awareness was also raised from their comments, the necessity for women and minorities to get more involved with STEM.

Table 4.22. Impact of Module on Chem 106 Students Understanding of Chemistry

Code	Frequency	Comment 1	Comment 2
ERM	21	You have gas, liquid, solid. Dipole- Dipole bond. Hydrogen bonds and London Dispersion.	By simple everyday things I know one of the examples was like breathing when it's cold outside. And the condensation like that
HM	65	Honestly, I just sometimes cannot understand chemistry, but I feel like the way you put it, you explained each part of it very well.	So, you did a very good like the job of expanding upon the background of the scientists and their contributions. There are so many discoveries and you included all of them with each of the scientists.
PIMDI	48	Like when I think of like science think of like people in the US. Like, I forget about the other scientists in the world have contributed to things. This module has helped to see this.	So, you gave a history of how the Egyptians or the Greek people-- Greek philosophers-- were talking about not like earth, fire, wind, and water but like strife love. And I found that very interesting because I didn't know about that. But otherwise, like the general information about intermolecular forces, I didn't know very well before reading the module. So I guess I learned a lot from the module about the intermolecular forces

Code	Frequency	Comment 1	Comment 2
PUM	17	The molecules interacting with each other. I know that. Yeah, I don't really know. I feel like since I don't understand how to do it. It was kind of just like kind of blur. (***This is resulting from misconception carried from the regular class***)	To be like the forces that are inside things that like hold them together. That makes sense. Maybe not
UHM	3	Okay, so this module had a lot of information, and I was trying to understand it, but what I got was that the module explains the results of how well each state of matter reacts with another state of matter which I didn’t understand very well	Not so complicated explanation too because when I read it, I just read a bunch of like Scientific words, and I don't understand what any of actually means like, I know the definitions of them. But when I tried to think of what it actually is. I don't understand.
CUM	50	Um, anything that takes up space that has volume or a mass. With it's the solid, liquid and gas. Plasma	Yeah, like open water if you'd melt ice. And so, the solid was ice melted to a liquid. And then boiled would be from a liquid to gas.

Table 4.23. Code summary of Module impact on Chem 106 Students Understanding of Chemistry

SCUM	
Positive Codes	Negative Codes
PIMDI, HM, CUM, ERM 181	NIMDI, UHM, PUM, MM 22

Table 4.24. Impact of Module on Chem 106 Students Understanding of DIEA

Code	**Frequency**	**Comment 1**	**Comment 2**
DF	11	And then the most recent ones are females, and there were a lot. I saw that there were a lot of females	There's, scientists, chemists, philosophers, so it's not all just one thing. So, it's like a ton of different ideas coming in to make a big idea, which is the chemistry.
DC	29	Like they said in the module there are a couple people from Greece and Ireland, and different places throughout Europe, plus India, which is kind of close to Europe.	There's a British scientist, French chemist Greek philosopher and so it's like all coming from different things in different people's ideas coming together

Code	**Frequency**	**Comment 1**	**Comment 2**
GSS	10	I think the gender could just because a long time ago. Females didn't have the same abilities or rights to do what males could do	Probably yeah. looking at these charts, males got more credit than females did for a lot of stuff.
HM	65	Honestly, I just sometimes cannot understand chemistry, but I feel like the way you put it, you explained each part of it very well.	So, you did a very good like the job of expanding upon the background of the scientists and their contributions. There are so many discoveries and you included all of them with each of the scientists.
MGD	21	So, there's a lot more males. I feel like that contributed to it.	They're all males except two of them were females
NDC	5	Um, it seemed to me that most of the people were originated in like mostly countries where white people are from	Still, it seemed to be like countries that I would see dominating in like people that are white in race
NDF	8	I see similar field work	But again, they're all working for the same thing.
NDG	4	So still are the males only one female.	Um, so for that one was also all males.
SIKDI	24	Being supportive of people who are coming from different backgrounds and making sure they feel heard and that they feel like they it	Scientist should properly be known for what they did. I would make it, so no one had to take credit for their work. Also, what they did will be

		like it's safe for them to contribute.	given credit for. So would be my main big focused is equality.
SPKD	3	Inclusions to me is probably just like. Not very good definition, but just like including people.	I feel like it would be hard to include everyone I don't know. I honestly think if I was like the head person probably just like pick the people that have, like, never mind. I'm. It doesn't make sense. Um, I don't honestly know how I would include everyone
SES	9	Oh yeah, I definitely think that. I think probably more in the earlier days they could have the people who are more well off, or had better access to research or any experiment, since they can afford due to their background	Yeah, definitely. Some people have grown up differently from their family could raise them differently. They could have lived in different conditions they might not, they might not have the same
USC	12	I'm sure that there's plenty of scientific discoveries that have been covered up. And I'm sure that that's at times been because of the person's background	I'm sure that there were lots of people who had, large scientific discoveries over the years that were lost to history or were had their work ripped off or just otherwise we're not recognized and may never be recognized.

CSS	6	I don't know if it's like Finland somewhere like that they have very smart people, so they easily succeed	Again, that that can be based on the location of where they had their education, it can have an effect on their success.

Table 4.25. Code summary of Module impact on Chem 106 Students Understanding of DIEA

N= 16	Codes	Positive	Negative
Students understanding of Diversity, Inclusion, Equity and Access after module	SUDIEA - AM	SIKDI **24**	SPKDI **3**
Students Perception of the Scientist after in STEM Field after DISTL module	SPSSF - AM	DC, DF, DG **57**	USC, NDF, NDG, NDC, MDG, GSS, SES, CSS **75**

4.6.5. Summary of GTAs responses from DISTL module on Chemistry Concepts and DIEA

The data gathered from GTAs responses after they went through the module showed positive for the impact of the module on their conceptual understanding of chemistry. The major code contributing to the high positive responses for SIRCC (130) was the in-depth knowledge in the module with a frequency of 103. The high frequency code for AEPS, which was 38, indicated that more pictures and examples were needed to make the module more impactful to the students. This was the major contributing factor for the negative code frequency (51) in SIRCC. No partial or misconception about DIEA was recorded for the GTA responses after the module. This indicates a positive impact of the module of their understanding of DIEA. The high negative code for GTAs perception of scientist in STEM shows how the STEM work field is perceived not to be diverse. There is therefore the need to put in a lot of effort to make the STEM field more diverse and inclusive.

Table 4.26. GTAs Response on Chemistry Concepts from DISTL Module

SIRCC	
Positive Codes	Negative Codes
nAEPS, IUM, PAM, **130**	AEPS, NAM, nIUM, **51**

Table 4.27. GTAs Response on DIEA from DISTL Module

N= 12	Codes	Positive	Negative
Students understanding of Diversity, Inclusion, Equity and Access after module	SUDIEA - AM	SIKDI, PIMD **26**	SPKDI, **0**
Students Perception of the Scientist after in STEM Field after DISTL module	SPSSF - AM	DC, DF, DG, EORW, ASS, IPCE, IMT **75**	USC, NDF, NDG, NDC, MDG, GSR, SES, CSS, EACD, IPSRO, nEORW, nASS **102**

4.6.4. Impact of DISTL modules on students Attitude

From the pilot study, students attitude from the Bauer Scale showed positive gains on emotional satisfaction (36 % - 43 %) and lower anxiety for the post DISTL survey (65 % - 61 %). This shows a positive impact on the attitude of students. There was a lowering of intellectual accessibility and interest or utility for the post modules. How the constructs were analyzed could be found in Chapter 3. The modules were therefore revised for the spring semester to address these constructs. The results could be found in Table 4.6.

Table 4.28. Analysis of the Impact of DISTL modules on students Attitude for Fall 2020

Attitude Score, N= 15	**Pre**	**Post**	**P-value**
Emotional Satisfaction	41.5	42	0.97
Anxiety	61	59	0.43
Intellectual Accessibility	35.5	34	0.43
Interest or Utility	66.5	61	0.42
Fear	45	42	0.43

CHAPTER 5- MODULE IMPLEMENTATION

5.0. Introduction

Students in STEM come with a wide range of experiences and educational backgrounds. There is high attrition rate and low academic achievement among students in STEM areas, specifically in college chemistry courses that are prerequisites for many STEM majors. Hence it is important to look at diversity and inclusion specifically in first- and second-year college chemistry courses to address the challenge of student attrition in STEM. Curriculum implementation entails putting into practice the officially prescribed courses of study, syllabuses, and subjects. The process involves helping the learner acquire knowledge or experience. It is important to note that curriculum implementation cannot take place without the learner. The learner is therefore the central figure in the curriculum implementation process. Implementation takes place as the learner acquires the planned or intended experiences, knowledge, skills, ideas and attitudes that are aimed at enabling the same learner to function effectively in a society. Viewed from this perspective, curriculum implementation also refers to the stage when the curriculum itself, as an educational program, is put into effect.

5.1. Implementation of DISTL Project

The four modules which were used during the piloting stage were maintained with some few revisions in them based on the responses from the Chem-452 students, Chem-106 Students and the responses from the GTAs during the fall semester. These revised modules were implemented in the chem 106 survey course during the spring 2021 semester. The implementation of DISTL modules and the study on the effectiveness of the implementation of DISTL were based on the data collected in the form of pre-and post- MOSART and CAST, 4 exams for the course and a final exam, pre- and post quizzes on module content, students' reflections on each module after its implementation, DISTL survey and semi-structured qualitative interviews. The schematic for data collection during implementation stage of the DISTL modules is presented in **Figure 5.1**

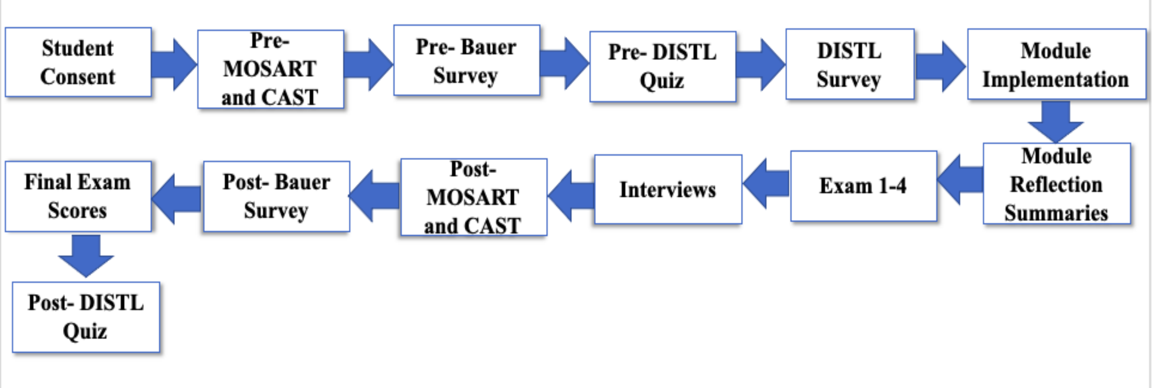


Figure 5.1. Chart showing how DISTL modules were implemented in spring 2021

Student consent forms were gathered from Chem-106 students during the 2021 spring semester. The pre assessment tools including MOSART, CAST, DISTL quiz, Bauer survey and DISTL survey were used at the 1st and 2nd week of the semester. The modules were delivered one at a time, followed by the discussion board reflection/summaries and the corresponding summative unit exam. The semi-structured interview was then conducted to assess the impact of the modules on the conceptual understanding of the students. The post assessment tools were then used during the last week of the spring semester. Assessing the impact of DISTL module implementation on academic performance was done through CAST, MOSART, the 4 exams covering chemistry content taught in the course, and the DISTL quiz on the modules. To understand the impact of the DISTL modules implementation on student conceptual understanding, data from student's module reflection summaries on each module after its implementation, were collected. Data on student conceptual understanding were also collected through the semi-structured interview conducted after the students took the module. Attitude toward the Subject of Chemistry Inventory (ASCI) also known as the Bauer survey was used to study the impact of the implementation of DISTL on student attitudes towards chemistry. DISTL survey was used to assess student's perception, understanding and experience of DIEA in their chemistry classroom and STEM was a whole. DISTL survey was also implemented at the beginning of the semester using Questionpro. Based on student responses to the module reflection summaries on D2L, students were invited for the semi-structured qualitative interviews. This semi- structured interview was conducted with 5 students, and each interview took approximately 45 minutes. The criteria for selection of students for the semi-structured interview were based on students who took part in the DISTL survey, DISTL quiz, read through and summarized each module throughout the study.

5.2. Research Questions

The following research questions were used to guide the research, investigating effectiveness of DISTL modules:

1. What is students' perception or understanding of diversity and inclusion?
2. What is GTA's perception or understanding on diversity and inclusion?
3. What is the impact of DISTL modules on
    - Student knowledge of Chemistry
    - Student attitudes towards Chemistry

Prior to implementation of the modules, data on student perception or understanding was collected and analyzed to answer the first and the second research questions. The third research question is focused on the effectiveness of modules and this question based on data collected pre- and post-module implementation using various instruments described above (MOSART, CAST, Exam scores, etc).

5.3. Implementation Study Setting and Participants

The implementation phase of this research study was conducted at South Dakota State University (SDSU) during the Spring 2021 semester. Chem 106 is one of the undergraduate general chemistry classes in SDSU, which offers a survey of general chemistry concepts for students intending to pursue non-chemistry degrees in areas such as allied health, agriculture, and dairy/animal science. A detail of the students including their background and majors is presented in Tables 5.1 and 5.2. The enrollment in the Spring 2021 Chem 106 class was 132 students. This class was offered in hybrid format which resulted in some students attending class in person and others attending online via synchronous Zoom. Course assignments, quizzes and research instruments (such as MOSART and CAST) were delivered and collected through Desire to Learn (D2L) platform. Emails were sent to all the students in the class, informing them about the DISTL study and seeking voluntary participation from students. A consent form was attached the email sent to the students. Out of 132 students who enrolled in the course, 55 students consented to participate in the study. Out of the 55 students who consented, only 31 of them participated in the DISTL survey. 17 (54.8%) of them were females while 14

(45.2%) of them were males. Demographic summary of the students is presented in Table 5.1

Table 5.1. Social Backgrounds of students for Spring 2021

Age		**Gender**		**Country of Origin**		**English as first Language**	
18yrs	6	Male	14	Black/ African American	1	Yes	10
19yrs	19	Female	17	Caucasian/ White	28	No	30
20yrs	3	Trans-gender	0	Hispanic/ Latinx	1		
21yrs	0	Gender Variant	0	Native American	0		
22yrs	1	Other	0	Native Hawaiian	0		
Others	1			other	1		

Table 5.2. Academic Backgrounds of students for Spring 2021

High School GPA		**SAT/ ACT**		**High School Completion**		**Chemistry in High School**	
1.5-1.9	0	15-19	9	2020	15	Yes	28
2.0-2.4	1	20-25	13	2019	6	No	2
2.5-2.9	3	26-30	4	2018	2	Others	1
3.0-3.5	8	31-32	0	2017	2		
3.6-4.0	18	Unsure	1	Other	6		

Table 5.3. Undergraduate Majors of Chem-106 Students for Spring 2021

Horticulture	2	Nursing	3
Agricultural Communication	6	Psychology	1
Animal Science	5	Medical Laboratory Science	1
Exercise Science	1	Chemistry	1
Natural Resource Law Enforcement	1	Respiratory Therapy	1
Construction Management	4	Conservation Planning & Park Management	1
Radiological Technology	1	Rangeland Ecology	2

5.4. Data Analysis

5.4.1. Assessment of Student Academic Performance

Students' academic performance was measured using scores in both pre- and post-CAST, MOSART, DISTL quiz and student exam scores from exams 1-4 plus the final exam. The pre and post- tests were administered to the students during the first 2 weeks and last 2 weeks of their Chem 106 class. Parametric and non-parametric statistics were used to deduce the significance between the groups. The p-value was set at 0.05 confidence level.

5.4.2. Assessment of Students Perception of Diversity and Inclusion

During the implementation stage, the perceptions of Chem 106 students regarding diversity and inclusion were assessed using the DISTL survey. 31 students completed this survey; demographic data for the students is found in Tables 5.1-5.3. The DISTL survey contained Likert scale question and open-ended questions. The Likert scales ranged from strongly disagree (1) to strongly agree (5). The quantitative data from the Likert scale was gathered with their means and standard deviations using Questionpro. The open-ended questions from the survey were further analyzed using AtlasTi. Codes for the open-ended questions were deductively and inductively generated based on the research questions and the student responses to the survey. The questions from the survey sought to probe students understanding of diversity and inclusion, their perception of who scientists are, their experiences in their chemistry classrooms both in high school and college and finally, their experiences with their chemistry instructors regarding diversity and inclusion of diversity and inclusion. The codes were placed into five main themes, related to student experience in the classroom, student views about chemistry, student views about treatment of students in the classroom, student perceptions about diversity and inclusion, and student perceptions about who is responsible for the education about diversity and inclusion. The themes, corresponding codes and definitions are provided below and then separated into positive, negative, and neutral views in Figure 5.1 and Table 5.4

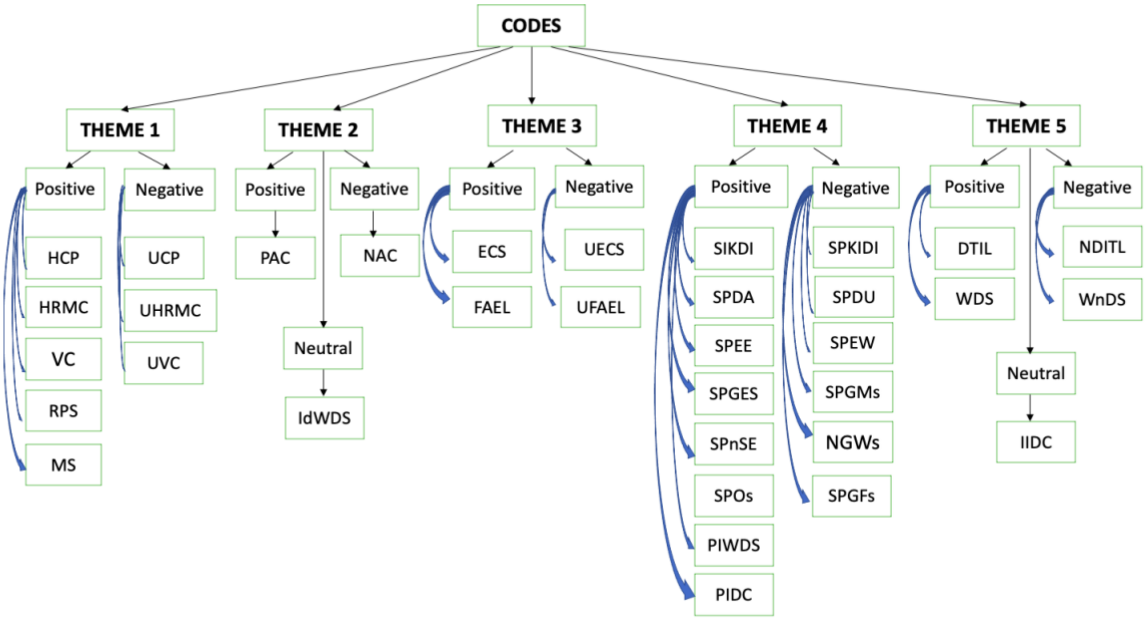


Figure 5.1. Schematic diagram for code development

Theme 1: *Experience regarding classroom environment, instructor, teaching and academic expectations from students*

- HCP - Helpful Chemistry Professor. This is when the interventions of the instructor led the student to develop a positive attitude towards science/chemistry
- HRMC - Helpful Resource material and curriculum. This is when the resource material helps the student develop a positive attitude towards chemistry/science and positively impacts their academic success
- RPS - Respect from instructor to students. This is when the instructor respects all the students irrespective of their backgrounds
- VC - Valued in Class. This is when the student feels their contributions matter in class

- UHRMC - Unhelpful resource material and curriculum. This is when the materials do not help, students understand chemistry/science
- UVC - Unvalued in Class. This is when the student does not feel valued in class
- UCP/UHS - Unhelpful Chemistry Professor. This is when the instructor's interventions cause the student to lose interest in Chemistry. This includes situations where the instructor uses only the textbook and no other resources for teaching.
- MS - Motivation from self. This is when the student's motivation is not from curriculum, material, or instructor but from themselves.

Theme 2: *Experience regarding students general view of chemistry as a subject*

- PAC/PAS - Positive attitude/Experience to Chemistry. This is when the student already has a positive attitude to chemistry/science. This may be due to factors such as instructor, material/resources, and curriculum.
- NAC/NAS - Negative Attitude/Experience Towards Chemistry. This is when the student does not have excitement for doing chemistry

Theme 3: *Experience of the student in terms of fair treatment of all students and time spent on diversity*

- UFAEL – Unfair assessment of assignment and evaluation of learning
- FAEL – Fair assessment of assignment and evaluation of learning

Theme 4: *Student understanding of diversity, inclusion, equity and access and its impact on students*

- NGW - No group work activities in class or science courses
- PIWDS - Positive impact of working with diverse students.

- PIDC - Positive Impact of Diversity in class. This is when students exposed to a diverse community of students improve their academic success and relationship with other students.
- SIKDI - Student In-depth Knowledge in Diversity and inclusion. Diversity recognizes a range of identities and the value in the varied perspectives that each identity brings to a collective. Here we seek to highlight those efforts that target groups underrepresented in our disciplines, particularly those having a range of racial/ethnic, socioeconomic, and academic backgrounds
- SPDA - Student perception of Disability Able. This is when students see scientists with disability being as able as those without disability.
- SPDU - Student perception Disability unable. This is when students see scientists with disability as not as capable as those without disability
- SPEE - Student perception ethnic equal. This is when the student sees every scientist as equal irrespective of their cultural differences
- SPEW - Student Perception White Scientist. This is when the student perception is that a scientist is a white person.
- SPGES - Student perception gender equal as scientist. This is when students see scientists to be equal irrespective of their gender
- SPGMs - Student perception as Male Scientist. This is when student sees scientists as Male dominant. This also applies when the examples the students give about scientists consist of only males.

- SPGFs - Student perception as Female Scientist. This is when student sees scientists as Female dominant. This also applies when the examples the students give about scientists consist of only females.
- SPKDI - Student Partial knowledge in Diversity and inclusion. This is when the student's definition of Diversity and Inclusion does not fully address the concept of diversity. That is, it is either only discussing one of the factors of diversity or defining diversity without examples.
- SPnSE - Student's perception that not all scientists are equal with respect to their background.
- SPOs - Student's perception of old people as scientists

Theme 5: *Student perception that it is the responsibility of the instructor to use the content of math and science courses to help students understand diversity*

- DITL - Diversity incorporated in teaching and learning. This is when the instructor makes attempts to incorporate diversity in teaching
- WDS - Worked with diverse students. This is when the student works with students from different backgrounds as a group.
- NDITL - No Diversity incorporated in teaching and learning. This is when the instructor does not make any attempt to incorporate diversity in teaching
- IIDC - Indifferent when it comes to the impact of diversity in classroom
- WnDS - Worked not with diverse students. This is when the students think they did not work with diverse students or think they only worked with students from the same cultural background as them.

Table 5.4. Summary of Students perception on DISTL in STEM- Spring 2021

Students Perception	**Theme**	**Positive**	**Negative**
Experience: Classroom environment, instructor, teaching, academic expectation from students	ECIAE	HCP, HRMC, RPS, VC	UHRMC, UVC, UCP
Experience/General view of Chemistry as subject	EGCS	PAC	NAS/NAC
Experience: Fair treatment of all students and time on diversity	EFTS	ECS, FAEL,	UFAEL, UECS
Students understanding of Diversity, Inclusion, Equity and Access and its impact on students	SUDIEA	SIKDI, PIDC, PIWDS, SPDA, SPEE	SPDU, IIDC, IDWDS, SPEW, SPGMs, SPGFs, SPOs
Students' perception that it is instructors' responsibility to use the content of math and science courses should help students understand diversity	IMSCD	DITL, WDS,	NDITL, WnDS, IIDC

5.4.3. Quantitative Analysis of the Impact of Module on Students Conceptual Understanding of Chemistry and DIEA

Students' conceptual understanding of chemistry from the module was assessed through their pre and post DISTL quiz, pre and post- MOSART and CAST. The DISTL quiz contained 50 questions with each question carrying 0.30 points. These tools were given to the students during the 2nd week and last week of the spring 2021 semester. At the end of the semester, the pre- and post- results were analyzed to look for any changes

5.4.4. Qualitative Analysis of Student Conceptual Understanding Chemistry after Module

To qualitatively analyze conceptual understanding, students were tasked to write their reflections on each module, from module 1 to 4. There were 10 students who successfully completed the 4 modules. The reflection questions were taken from the module. Each module contained two questions for students to reflect upon and were focused on the following areas:

- Students general understanding of the chemistry concept in the module
- What do students think about diversity with respect to the scientific work and the contributions of people represented in the module.

Also, a semi- structured interview was conducted to analyze the impact of the module on students' conceptual understanding after they went through the DISTL module. Responses from both the students' reflections on the modules and the interviews were collected and coded using AtlasTi. The coding of students' responses followed a both deductive and inductive approach. An initial round of open codes, deductive codes, were focused on codes generated from the modules. The inductive codes were then generated from student submissions on the topics and the explanation associated with each topic. Each student submission with explanation of concepts and the example provided by students was analyzed for correctness and its connection to the content presented via the materials. At the end of the analysis, the following codes were developed with definitions; they are grouped into positive and negative views in Table 5.5.

- IUM- In-depth Understanding of Module. This is when the definitions and explanations of the module reflect an in-depth understanding of the module. Here the student gives examples and analogies related to the module.
- PUM - Partial Understanding of Module. This is when the definition and explanation of participant covers only a small portion of the definition without any examples
- ERM - Example related to module. This is when the example given is relevant to the module
- PIMDI - Positive impact of module in relation to diversity and inclusion. This refers to when the participants definition and explanation of terms reflects an understanding of diversity and inclusion from the module.
- NIMDI- No impact of module on students understanding of diversity and inclusion. This is when the student’s response does not reflect the impact on the module of their understanding of diversity and inclusion.
- HM - Helpful Module (HM). This is when the module adds to the knowledge of the participant on a particular topic.
- UHM – Unhelpful Module. This is when the module does not impact the understanding of the student, or the student finds it difficult to understand the module.
- MM - Misconception about modules. This is when the definition/explanation of terms is inconsistent with the module

Table 5.5. Analysis DISTL module on Students Conceptual Understanding

Positive Codes	Negative Codes
PIMDI, HM, IUM, ERM	NIMDI, UHM, PUM, MM

5.4.5. Analysis of Student Conceptual Understanding of DIEA

Responses from both the students' reflections on the modules and the interviews were collected and coded using AtlasTi to evaluate the impact of the module on their understanding of DIEA. At the end of the analysis, the following codes were developed with definitions; they are grouped into positive and negative views in Table 5.6:

Students understanding of Diversity, Inclusion, Equity and Access after module

- SIKDI - Student In-depth Knowledge of Diversity and Inclusion. This is when the definition of diversity and inclusion include the following: Diversity recognizes a range of identities and the value in the varied perspectives that each identity brings to a collective. Here we seek to highlight those efforts that target groups underrepresented in our disciplines, particularly those having a range of racial/ethnic, socioeconomic, and academic backgrounds. Equity seeks to meet the needs of individuals to ensure their access to opportunities and resources. Inclusion involves systems and dispositions that seek to engage individuals from diverse backgrounds and create a welcoming and supportive environment in which these individuals can successfully operate

- SPKD – Student Partial Knowledge in Diversity and Inclusion

Students Perception of the Scientist in STEM Field after DISTL module

- SES – Socio-Economic Status as a contributing Factor of the success of a scientist. This is when social status or class is seen as a contributing factor in determining the success of a scientist
- DF - Diverse Field. This is when the student sees scientists from different scientific fields coming together to contribute to a concept
- DG – Diverse Gender. This is when the student sees different genders coming together to contribute to a concept.
- DC - Diverse Country. This is when the student sees scientists from different countries coming together to contribute to a concept
- GSS -Gender being a reason why scientist was recognized or successful.
- MGD - Male Gender Dominate. This is when the participant sees the scientific community to be male biased or mainly made up of males.
- NDC - No diversity in Country. This is where the participant reports that the scientists are from a single place
- NDF - Not Diverse Field. This is when the fields of the scientists are the same with no diversity
- NDG - Not Diverse Gender. This is where the students see little to no diversity in the gender representation of the scientists.
- USC – Unrecognized Scientific Contribution. This is when the student thinks some scientists were not recognized for their work despite their impacts.

Table 5.6. Analysis of DISTL Module on Students understanding of DIEA in STEM- Interview2

	Codes	Positive	Negative
Students understanding of Diversity, Inclusion, Equity and Access after module	SUDIEA - AM	SIKDI	SPKDI
Students Perception of the Scientist after in STEM Field after DISTL module	SPSSF - AM	DC, DF, DG	USC, NDF, NDG, NDC, MDG, GSS, SES

5.4.6. Assessment of Student Attitude Using Bauer Survey

The attitude of students toward chemistry before and after the module was analyzed using the Bauer survey. This survey categorizes students’ attitude into five constructs including Anxiety, Emotional Satisfaction, Intellectual Accessibility, Interest or Utility, and Fear. This survey has a scale ranging from 1 to 7. The seven choices help strengthen the reliability of the instrument and are appropriate for the target population. The adjectives are placed at the ends of each line. The responses from the students are then analyzed in Microsoft Excel with specific functions generated by Bauer et al (Bauer, 2008). The Bauer survey is found in Appendix E.

5.5. Results and Discussion on Implementation of DISTL Module

5.5.1. Academic Performance Analysis

The academic performance of students was based on student pre and post MOSART and CAST scores and exams 1 to exams 4 and the final exams. The MOSART and CAST were given to the students during the first week and last week of their Chem 106 class. The exams were given to the students throughout the semester. Details of the MOSART and CAST tests are described in chapter 3. The scores of the students were transferred to an excel spreadsheet for analysis. At the end of the study, two categories of students were realized. Those who took part in the DISTL (D) study and those who did not take part in the DISTL (ND) study. Students who went through at least 2 of the DISTL modules were considered part of the DISTL group (D). Therefore, the score from these two groups were calculated as percent values and compared for MOSART, CAST and EXAMS. A change in student mean ± standard deviation from pre to post were calculated for the MOSART and CAST and to test for significance between the groups. The same was done to find the significance difference between the two groups for the exams 1 to 4 and their final exams. To test for the significance, statistical significance was set at 0.05. Pre and Post mean ± standard deviation for MOSART test scores can be found in **Table 5.7**. The results showed no significant difference between the pre and post MOSART of students who did the DISTL project (MO-D) at *p-value = 0.11* though the results indicate an increase in their mean scores from 48.22 to 54.17. The results showed a significant difference between the pre and post score for students who did not take part in the DISTL (MO-ND) study at *a p-value= 0.003*. It is important to note that, the students in the DISTL group had a lower average score in the beginning as compared to the students in the non-DISTL group. To an extent this could be the reason students in ND group had higher post average scores and the significant performance as compared to the DISTL group. For CAST standard test, which was reported in **Table 5.8**, the pre and post scores indicated a significant difference between students who took part in the study (CO-D) with *p-value= 0.006*. A similar trend was also recorded for students who did not take part in the study (CO-ND) with *p-value= 0.003*.

To further probe the impact of the module on students' academic performance, the 4 exams scores and the final exams for students who participated in the study (Ex-DIS) in the module and those who did not participate (Ex-NDIS) were compared as shown in **Table 5.9**. Except for exam 1, where the results indicated a significant difference between the scores of two groups with a p-value= 0.03, exams 2 to the final exam showed no significant difference between the two groups. Though the results from exams 2 to 4 and the final exams did not show a significant difference between the groups, their mean scores indicate an increased performance in the students who took part in the DISTL study (Ex-DIS) compared to those who did not take part in the DISTL study as indicated in **Table 5.9**. Though, the mean scores indicate a positive shift in the conceptual understanding of the students who took part in the DISTL project, the impact seems to be very minimal. This may be because more modules on different chemistry concepts are needed to adequately ascertain the impact of the module on the students.

Table 5.7. Analysis of DISTL impact on students' academic performance

MOSART				
	DISTL		N- DISTL	
No of Students ***(N)***	N= 46		N= 110	
	Pre	Post	Pre	Post
Mean	48.22	54.17	50.24	59.09
SD	14.49	14.55	14.01	16.93
P-value	0.11		0.003	

Table 5.8. Analysis of Students Academic Achievement from MOSART and CAST

CAST				
	DISTL		N- DISTL	
No of Students ***(N)***	N= 42		N= 84	
	Pre	Post	Pre	Post
Mean	44.33	60.77	49.54	63.77
SD	20.8	19.95	18.23	24.86
P-value	0.006		0.003	

Table 5.9. Analysis of Students Academic Achievement from Exams

Exams	Exams 1		Exams 2		Exams 3		Exams 4		Final	
DIS=53 N-DIS=135	DIS	N - DIS	DIS	N - DIS	DIS	N - DIS	DIS	N - DIS	DIS	N - DIS
Mean	84.5	88.5	85.3	85.1	82.4	81.5	80.9	75.5	80.7	79.6
SD	10.8	7.2	8.3	16.1	16.0	24.0	21.6	26.5	13.9	20.7
P-value	0.03		0.157		0.35		0.32		0.44	

5.5.2. Analysis Of the Impact of The Module on Students Conceptual Understanding from DISTL Quiz

To qualitatively analyze the impact of the DISTL module on students conceptual understanding, the pre and post DISTL quiz gathered from the students were statistically analyzed using a t-test with an alpha value of 0.05. Comparing the mean ± standard deviation of their pre and post scores showed an increase in their mean scores from 61.2 to 63.4 as shown in **Table 5.10**. From the DISTL Quiz results, there was an indication of a positive impact on conceptual understanding as shown with the increased mean scores (and the lower standard deviation), however this impact was not at a statistically significant level. This shows that more work is to be done on the module to effectively connect their chemistry concepts to the concept of diversity and inclusion.

Table 5.10. Impact of Module on Students' Understanding of Chemistry from DISTL Quiz

DISTL Quiz (N=24)	**Pre**	**Post**
Mean	61.2	63.4
Standard Deviation (SD)	12.9	9.6
P-Value	0.53	

5.5.3. Analysis of student's perceptions on DISTL in STEM- DISTL Survey

Results from students' perception on diversity, inclusion, equity, and access before the module implementation were gathered using DISTL survey and after module completion using the semi-structured interview. The survey was mounted on QuestionPro and interview coded was analyzed and using AtlasTi. Students perceive their classroom environment, instructor teaching and academic expectation and chemistry as a subject to be a generally positive experience (ECIAE (pos)= 90) as indicated in **Table 5.11** and **Table 5.16**. Yet 81% of the students agreed and strongly agree that few of their colleagues participate in their chemistry class. Overall, 33 responses from the students interview also indicate a negative experience for their classroom and instructor teaching expectation (ECIAE (neg)= 33) as indicated in **Table 5.17**. The student's perception as being treated fairly in the classroom irrespective of their race, gender, religion, culture, and disability was positive (> 85%) from agree to strongly agree in Table **5.11**. Yet there were some few students who had negative experiences. Students' perception that their success in chemistry is based on their effort was seen to be generally positive (>70%), yet a lot of the students also perceive that some people can never succeed in learning chemistry (70%) as indicated in **Table 5.11**. These results therefore indicate the possibility of students pursuing chemistry as a course because it’s a requirement. Most students also perceived that it is instructors’ responsibility to be mindful of students’ diversity or background and how it has influenced science (>70%). Also, students want instructors to include diversity in science and mathematics content and problem solving (77%) as indicated in **Table 5.11**. Data from the **Table 5.17**, from students’ responses that some showed in-depth understanding of diversity and inclusion (SUDIEA (pos)=82) but also, there were a fair number of instance where students viewed science to be male dominated and saw men to better scientists than women (SUDIEA (neg)=23).

Table 5.11. Results from DISTL Survey

	Item Summary	**Strongly disagree (%)**	**Disagree (%)**	**Neither nor (%)**	**Agree (%)**	**Strongly agree (%)**
Experience: Classroom environment, instructor, teaching, academic expectation from students	Welcoming classroom	0.0	0.0	19	65	16.0
	Welcoming instructor	0.0	0.0	10	68.0	23.0
	Variety of teaching strategies	3.0	16.0	32.0	32.0	16
	Trained to teach diverse students	0.0	10.0	16.0	45.0	29
	Low students' participation	0.0	3.0	16.0	65.0	16.0
	High expectation	0.0	0.0	16.0	68.0	16.0
Experience: Chemistry as subject	Connects with everyday life	0.0	18.5	35.2	38.9	7.4
	Integrates multicultural perspectives	0.0	6	42.0	39.0	13.0
Experience: Fair treatment of all students and time on diversity	Disability	0.0	6.0	6.0	65	23.0
	Gender	0.0	0	3	58	39.0
	Religion	0.0	0.0	10	52	39.0
	Socio-Economic Status	0.0	3.0	3.0	52.0	42.0
	Culture	0.0	3.0	0.0	58.0	39.0
	Time-Diversity	0	6.0	23.0	52.0	19.0
Instructor expectation: From students and how expectations help students	Academic Skills	0.0	0.0	10.0	81.0	10.0
	Develop positive attitude and self-efficacy	0.0	3.0	13.0	74.0	10.0

	Item Summary	**Strongly disagree (%)**	**Disagree (%)**	**Neither nor (%)**	**Agree (%)**	**Strongly agree (%)**
Students' effort and general view of learning chemistry	All can learn	0.0	6.0	26.0	55.0	13.0
	Fail- effort is less	0.0	9.26	18.5	55.6	16.7
	Succeed- effort and hard work	0.0	3.0	10.0	60.0	26.0
	Some can never succeed	0.0	3.0	23.0	55.0	19.0
Instructor responsibility to use information, teaching approaches and know students to support diversity	Student background and experiences	0.0	6.0	16.0	58.0	19.0
	Support diversity	0.0	3.0	16.0	68.0	13.0
	Meeting the needs of students is important	0.0	19.0	26.0	45.0	6.0
Content of math and science courses should help students understand Diversity	Diversity	3.0	0.0	19.0	77.0	0.0
	Problems in the field influenced by diversity	3.0	0.0	16.0	77.0	3.0

Table 5.12. Experience: Classroom environment, instructor, teaching, academic expectation from students

Code	**Freq**	**Comment 1**	**Comment 2**
HCP/HSP	35	My high school chemistry was my favorite high school, chemistry class, my instructor made things easy to understand.	They used students to teach. For example, all our science classes used our names in their word problems.
HRMC	16	I liked chemistry because I like equations the most. The curriculum is what I enjoyed.	I think getting together with study group helped advance knowledge and get a better understanding.
URPS	3	My science teacher did not care if you understood the material, just that you got the correct answers.	I have had teachers who encompassed all the qualities of a good teacher, but some who did not at all. They did not care about us.
RPS	15	Our teachers were basically another family they treated us with respect and made sure everyone was okay. the process.	Most cared about you and wanted to know you on a personal level. I got to know them pretty well also.
UCP	12	Chemistry- the teacher was not good, and I simply had no interest in the class	I hate Advanced Chemistry, strictly because of the teacher I had.
UHRM	11	Chemistry- the teacher was not good, and I simply had no interest in the class	Chem was my worse subject, because I was never really able to understand chem and in high school I didn't have the best teaching environment.

Code	Freq	Comment 1	Comment 2
UVC	4	Not really, and my thought processes could've helped other people when doing discussion posts.	Not really. There were so many students I didn’t think I mattered
VC	12	Yes they were able to talk with you and made sure you were having a great day and if you weren't then they would listen and try to get you on the right track	I felt like i had a role in the labs when they are on campus because you were a part of a team. When working in a team every idea matters to me.

Table 5.13. Experience/General view of Chemistry as subject

Code	Freq	Comment 1	Comment 2
PAC	28	I loved the class our professor was easy to understand and the content that was being presented was easy to comprehend.	I enjoyed labs and having a chance to meet people and have hands on experience
NAC	13	chem sucks, there’s no way around it I feel a little uncomfortable in science classrooms because it is not my favorite subject.	Never have done too well mainly because every professor who has taught it has not related it to the real world. I couldn't care less about science let alone any class if it can't be related to life.

Table 5.14. Experience: Fair treatment of all students and time on diversity

Code	Freq	Comment 1	Comment 2
FAEL	2	Yes. About 85% of my science instructors evaluated my assignment with fairness	Yes. My chemistry teacher treated everyone with fairness
UFAEL	2	NO. There was no fairness in assignment of work	

Table 5.15. Students understanding of DIEA and its impact on students

Code	Freq	Comment 1	Comment 2
SIKDI	15	My understanding of diversity is people being from a different ethnicity or being a part of a different culture. When you have a diverse background people tend to exclude you in particular activities or jobs or even colleges.	Different backgrounds in ethnicity, sexuality and personal viewpoints coming together to show our differences
SPDA	11	it depends on what is disabled, if its their brain probably not, but if its a physical disability they have an equal chance	Yes, they just have to work harder, but that clearly does not stop them

Code	Freq	Comment 1	Comment 2
SPEE	14	No it does not matter backgrounds as long as the person knows science that is all that matters about	Your dedication and findings make you great, nothing else matters. Hate that people think backgrounds and ethnicity matter
SPnSE	2	No, I do not believe that to be true that all scientists are equal	No. Scientist are all not equal
SPOs	2	Usually an older person.	Think that they are cool. Very smart. I think of old man
SPEW	2	Old Male and White, that's what all the super famous scientists are	Almost all white guys, not very diverse
SPGEs	26	I think everyone has an equal opportunity to be a great scientist. I don't think one race sex or age has a better opportunity, its about how hard you work at it	Benjamin Franklin Albert Einstein Thomas Eddison Marie Curie Louis Pasteur
SPGMs	7	Almost all white guys, not very diverse	Albert Einstein Isaac Newton Stephen Hawking Nikola Tesla Alexander Grahm Bell
SPKDI	8	No, I do not think I am in a diverse group. I am a white, middle-class student.	I do not think I am. I mean I might be if you consider being raised by a single father from a diverse group since it is not the norm for most people.

Table 5.16. Students' perception that it is instructors' responsibility to use the content of math and science courses should help students understand Diversity

Code	Freq	Comment 1	Comment 2
WDS	6	Yes, believe it or not small town Iowa has some ethnic diversity. I went to school with a Chinese kid who's parents were from China, he was really smart and I got along good with him. Always has foreign exchange students from Asia and Europe.	Most of the time we were in groups and yes basically every student in that school was Native American but I did not treat them like they were different they were great friends and family to me
WnDS	5	I usually worked with one other person. There weren't too many students in my science classes with diverse backgrounds	No. My hometown is not diverse whatsoever.
DILT	4	Yes, they would do different things to allow everyone a chance at learning how they learn best	Yes. They tried to keep it all diverse on what we learned and talked about and what we did in the classroom.
IIDC	4	I mean not really, didn't change how I learned, diversity based on skin color and ethnic background has nothing to do with my learning.	It honestly didn't make a difference. We all wanted to pass the class and worked together despite being different

Code	Freq	Comment 1	Comment 2
NDITL	4	I did not see either. I do not think she made extra efforts to address diverse groups	Never had any experiences where teachers addressed diversity within the classroom
PIWDS	5	Not a whole lot was said about diversity since my school was mainly Caucasian, but it was addressed to treat everyone the way you would want to be treated no matter what race you were. Be curious towards your fellow man.	Yes I got to learn their language and I also got to learn their culture

Table 5.17. Summary of Students Perception of DIEA in STEM from Interview 1

Students Perception	**Code**	**Positive**	**Negative**
Experience: Classroom environment, instructor, teaching, academic expectation from students	ECIAE	HCP, HRMC, RPS, VC, ECS **90**	UHRMC, UVC, UCP, UCS, URPS **33**
Experience/General view of Chemistry as subject	EGCS	PAC **28**	NAS/NAC **13**
Students' perception that it is instructors' responsibility to use the content of math and science courses should help students understand diversity	IMSCD	DITL, WDS, **10**	NDITL, WnDS, IIDC **14**

Students understanding of Diversity, Inclusion, Equity and Access and its impact on students	SUDIEA	SIKDI, PIDC, PIWDS, SPDA, SPEE, SPOs, SPGs **82**	SPDU, IIDC, SPEW, SPGMs, SPGFs, SPnSE, SPKDI **23**

5.5.4. Results and Discussion of students' interview on DISTL Modules on Conceptual Understanding of Chemistry and DIEA

Responses from students conceptual understanding of chemistry after they had gone through the DISTL module were gathered. This was done through the semi-structured interview and reflective summaries and these data were analyzed with AtlasTi to generate the code frequencies. From the analysis, a majority of students' responses showed a comprehensive understanding of the module (CUM) with a frequency of 100 as shown in **Table 5.18**. Also 61 responses from the students indicated a positive impact of the module on their understanding of DIEA (PIMDI) as indicated in **Table 5.20**. Student perception of DIEA showed an in-depth understanding at a frequency of 19 compared to a partial understanding at a frequency of 3 as indicated in **Table 5.20**. These results show a positive impact of the DISTL modules on the student understanding of the chemistry concepts and DIEA. Also, a frequency of 24 was recorded for students who attested to the fact that gender (GSS), country (CSS) and socio-cultural status (SES) might be some of the main possible reasons why some scientists were not recognized as indicated in Table 5.20. The results also indicate an improved understanding of DIEA in students after the module compared to before they took the module. This could be found in **Figure**

5.5. Awareness was also raised from their comments as the necessity for women and minorities to get more involved in STEM.

Table 5.18. Impact of Module on Students Understanding of Chemistry

Code	Freq	Comment 1	Comment 2
ERM	19	Some examples of physical changes are boiling, dissolving, and cutting. Chemical changes, however, are changes that alter the chemical composition of a substance, like burning a match or rust.	There are three major intermolecular forces: London Dispersion forces, Dipole-Diploe forces, and Hydrogen bonds
HM	52	I learned a lot while reading this module.	My favorite parts that I learned was finding out stars are basically superheated balls of plasma.
PIMDI	61	They used their background, ethnicity and culture to help explain things and explore more in the situation they were learning about.	It wasn't just in the US that science was discovered, it was throughout the whole World. It was really cool and everybody studied it wasn't just one singular person
PAM	3	My favorite part that I learned was finding out stars are basically superheated balls of plasma	This was crazy to me and was probably one of my favorite highlights to learn about and develop a basic understanding about. I didn’t know that they had a bitter tasting characteristic, that they are slippery or smooth to the touch, and have a pH greater that seven.

Code	Freq	Comment 1	Comment 2
IUM	100	States of matter are classified as three distinct physical forms: solid, liquid, and gas. A solid's particles are closely packed together, casing the particles to vibrate against each other instead of moving freely. Liquid particles are still close together, but they conform the container they are in, allowing for particles to bounce off each other and keep a definite volume	Gas particles are spread out and move quickly and freely in their container. However, there is another type of matter, plasma, which although is not common on Earth, is the most common form of matter in space. Plasma consists of particles with high charges and kinetic energy, which is what makes up stars. Figure 1 shows how these different states of matter behave and increase in energy.
PIM	24	Looking back on some of the experiments we did in chem lab where this happened, it is cool to know the difference now	When the word solution came to mind I honestly just thought of a mixing two substances together and bam, solution. I didn't even know that solutions can be heterogeneous or homogenous

Table 5.19. Summary of the Impact of Module on Students Conceptual Understanding of Chemistry

SCUM	
Positive Codes	Negative Codes
HM, CUM, ERM, PAM, PIM 204	UHM, PUM, MM 0

Table 5.20. Impact of Module on Students Understanding of DIEA

Code	Frequency	Comment 1	Comment 2
DF	14	And then the most recent ones are females, and there were a lot. I saw that there were a lot of females	There's, scientists, chemists, philosophers, so it's not all just one thing. So, it's like a ton of different ideas coming in to make a big idea, which is the chemistry.
DC	26	Like they said in the module there are a couple people from Greece and Ireland, and different places throughout Europe, plus India, which is kind of close to Europe.	There's a British scientist, French chemist Greek philosopher and so it's like all coming from different things in different people's ideas coming together
GSS	10	I think the gender could just because a long time ago. Females didn't have the same abilities or rights to do what males could do	Probably yeah. looking at these charts, males got more credit than females did for a lot of stuff.
ASS	4	Honestly, I just sometimes cannot understand chemistry, but I feel like the way you put it, you explained each part of it very well.	So, you did a very good like the job of expanding upon the background of the scientists and their contributions. There are so many discoveries and you included all of them with each of the scientists.
MGD	5	So, there's a lot more males. I feel like that contributed to it.	They're all males except two of them were females

Code	Frequency	Comment 1	Comment 2
NDC	4	Um, it seemed to me that most of the people were originated in like mostly countries where white people are from	Still, it seemed to be like countries that I would see dominating in like people that are white in race
NDF	1	I see similar field work	But again, they're all working for the same thing
NDG	9	So still are the males only one female.	Um, so for that one was also all males
SIKDI	19	Well, I think one thing that it is important is having a good HR department. You need to give the space for people to speak out if there is something that's going on and feel like they have job security and feeling like they're not going to be boxed out.	Scientist should properly be known for what they did. I would make it, so no one had to take credit for his or her work. Also, what they did will be given credit for. So would be my main big focused is equality.
SPKDI	2	Inclusions to me is probably just like. Not very good definition, but just like including people.	I feel like it would be hard to include everyone I don't know. I'm. It doesn't make sense. Um, I don't honestly know how I would include everyone
SES	10	Oh yeah, I definitely think that. I think probably more in the earlier days they could have the people who are more well off, or had	Yeah, definitely. Some people have grown up differently from their family could raise them differently. They could have lived in different

		better access to research or any experiment, since they can afford.	conditions they might not, they might not have the same
USC	10	I think I mean, even in this module, there was that Scientists’ wife who helped a lot with his discoveries and she was not credited until recently, or even like isn't you know regularly credited but it has now been discovered to have helped him. So I just based off of, you know, my basic knowledge that stuff like that has happened. I'm sure that there's plenty of scientific discoveries that have been covered up. And I'm sure that that's at times been because of the person's background, whether they were a woman or a person of color or whatever.	I'm sure that there were lots of people who had, large scientific discoveries over the years that were lost to history or were had their work ripped off or just otherwise we're not recognized and may never be recognized.
CSS	4	I don't know if it's like Finland somewhere like that they have very smart people, so they easily succeed	Again, that that can be based on the location of where they had their education, it can have an effect on their success.

Table 5.21. Summary of Impact of Module on Students Understanding of Chemistry

N= 16	Codes	Positive	Negative
Students understanding of Diversity, Inclusion, Equity and Access after module	SUDIEA - AM	SIKDI 19	SPKDI 2
Students Perception of the Scientist after in STEM Field after DISTL module	SPSSF - AM	DC, DF, DG, PIMDI, ASS 108	USC, NDF, NDG, NDC, MDG, SES, CSS, AnSS 44

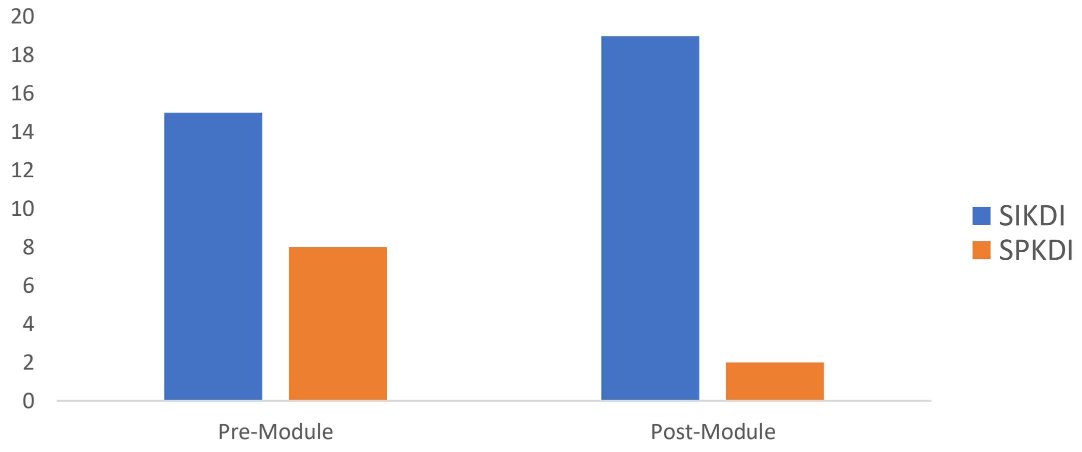


Figure 5.5. Comparison of Students understanding of DIEA pre and post DISTL Module

5.5.5. Impact of DISTL modules on students Attitude

From the data gathered on student attitude using the Bauer Scale, students showed positive gains on emotional satisfaction from 40% - 50.2% at a p-value of 0.03 for students who went through the module. This results also show a statistically significant difference between their pre and post results. For students who did not take part in the module implementation, they showed a negative gain in the emotional satisfaction with a mean reduction from 42 to 36 as shown in **Table 5.22**. Anxiety reduced with a significant difference between the pre and post mean at a p- value of 0.02 as indicated in **Table 5.22** for the DISTL students but increased in students who did not take part in the module. This indicates that the module had a positive impact on the emotional satisfaction and anxiety of students who took went through the module. The mean difference for those who used the module and those who did not shows a positive gain in their intellectual accessibility though the students who used the module showed a significant difference in their mean with a p-value of 0.04. The interest and fear construct of those who did not go through the module showed a negative gain. This result is the reverse for those who used the module with a positive gain in their means though there was not significant difference between their means. A comparative analysis of the students' attitude between those who went through the module and those who did not can be found in **Figure 5.6**. These results indicate that the DISTL module had a positive impact on the five constructs of students' attitude for those who went through the module as three of the constructs showed a significant difference with the other 2 showing a positive gain compared to those who did not. A small population (N=15) was recorded for Non- DISTL group (ND). This is because, only 15 students not participating in the modules completed both their pre and post Bauer survey.

Table 5.22. Analysis of the attitude of students who took part in the DISTL study

Attitude Score, N=24	**Pre-D**	**Post-D**	**P-value**
Emotional Satisfaction	40.8	50.2	0.03
Anxiety	66.5	56.0	0.02
Intellectual Accessibility	28.7	39.3	0.04
Interest or Utility	54.4	61.7	0.12
Fear	47.3	46.5	0.88

Table 5.23. Analysis of the attitude of students who did not take part in the DISTL study

Attitude Score, N=15	**Pre-ND (%)**	**Post-ND**	**P-value**
Emotional Satisfaction	42	36	0.01
Anxiety	59	63	0.12
Intellectual Accessibility	26	33	0.11
Interest or Utility	61	51	0.10
Fear	36	54	0.02

CHAPTER 6- OVERALL CONCLUSION

Summary

The overarching goals of this study were to understand the current role of student-diversity in various chemistry courses, gauge faculty understanding of diversity and related teaching practices at the college level and develop modules which could address the issue of diversity and inclusion in a chemistry classroom. As explained in the introductory chapter, a major gap in the study of diversity and inclusion within the STEM field include the understanding of students' perception of diversity and inclusion and the lack of instructional materials that address DISTL in chemistry courses. To address these gaps in literature, four modules focused on DISTL were developed on various topics that are covered in a first semester of a general chemistry course at the college level. The effectiveness of these modules was studied in two distinct stages of piloting and implementation using a convergence parallel mixed method research design. The research questions for the project were focused on three main ideas.

a) Students' perception or understanding of diversity and inclusion. This was done through gathering responses from students using surveys mounted on questionpro and through semi- structured interviews

b) GTAs perception or understanding of diversity and inclusion which was also done through gathering responses from GTAs using surveys mounted on questionpro and through interviews c) the impact the DISTL modules on students' knowledge and attitude towards chemistry. The effectiveness of the modules was evaluated using exams, pre and post MOSART and CAST, pre and post DISTL quiz and a semi-structured interview. The attitude of the students was assessed using the Bauer survey.

The following are key findings from this study:

1. Students understanding or perception of Diversity and inclusion (Chem 106 and 452)

The data gathered on students understanding of diversity and inclusion suggest that some of the students in general had an in-depth understanding of diversity and inclusion and some had no understanding of DIEA. Students understanding of DIEA increased with a decrease in response of students who had no understanding of DIEA after the module compared to their perceptions before taking the module. Also, students perceived their experience to be positive for classroom environment, instructor teaching, academic expectation, and chemistry as a subject. Their perception was also positive for fair treatment in classroom regardless of race, gender, religion, culture, and disability. Furthermore, helpful instructor had a positive correlation on students' ability to do well and positive attitude of students towards chemistry. Students' perception was negative for the participation of their colleagues in class. This implies that students do not feel valued or respected in class. Finally, students perceived that it is instructors' responsibility to be mindful of diversity and how it has influence on science. These results were common for both Chem 106 and 452 students. The perception of students after going through the module showed a positive increase in their understanding of diversity and inclusion. Also, their perception was positive for the STEM field being diverse.

2. GTAs perception and understanding of Diversity and Inclusion

GTAs perceive their experiences before they went through the module as being negative for classroom environment instructor, teaching, academic expectations from students and general view of chemistry as a subject when they were students in college. Their perception of fair treatment regardless or race, gender, religion, culture, and disability was also negative. The high negative frequency observed for GTAs understanding of DIEA before going through the module indicate that intentional training on this topic for instructors is needed. GTAs understanding of diversity and inclusion after going through module showed a positive perception with no negative perception. Finally, instructors' responses indicated that they perceive the STEM field not to be diverse and that more work is needed to increase diversity.

3. The impact of DISTL module students understanding towards the chemistry concepts and their attitude towards chemistry.

The data showed a statistically significant gain in CAST results and a positive gain in MOSART after the DISTL interviews and the DISTL modules. There was also a significant increase for those students not doing the DISTL modules. There was also a gain in the performance of DISTL quiz and Exams 2-4 and final exams though not statistically significant compared to non-DISTL students. Regarding students' attitude towards chemistry, the Bauer Scale shows all were positive gains but 3 out of the 5 constructs were statistically significant for DISTL students compared to non-DISTL students.

Therefore, based on the results gathered from the study it appears the study was successful in having a positive impact in students and GTA's understanding of DIEA and on students attitude towards chemistry. This study has also proved the necessity for more work to be done on building more modules in chemistry courses which addresses DIEA.

Implications and Recommendations

As stated earlier, there has been no previous work done on developing teaching modules that seek to educate students and instructors on the topics of diversity, inclusion, equity, and access. Also, no work has been done to assess students understanding of diversity and inclusion. The results gathered from this study is indeed an eye opener. One thing we need to understand is that minority groups represent a small population that coexists with a more dominant group. Though it may seem that some responses from the students were generally positive, there were still some few students who had negative experiences. It is possible that these students with negative experiences are those who will possibly drop out or underperform in class. Also, it was interesting to know that, at the higher-level chemistry class (CHEM 452), all the students there were Caucasians and majority were males. This supports the studies made that minorities in STEM drop out as they go higher in their STEM field. Therefore, more focus should be given to typically underrepresented- groups to see how to include them in the class activities.

Though the modules did not show a significant impact on the academic achievement of students, it is interesting to note that it did significantly impact their attitudes towards chemistry. This shows that when students begin to see things in chemistry textbooks that relate to their background, it can increase their persistence and attitude toward chemistry. This was seen from students' responses that it is instructors' responsibility to include diversity and inclusion in science and mathematics content. Results from the GTAs is very alarming since a lot of them had little to no understanding of diversity and inclusion as indicated in their perception on DIEA before going through the DISTL module. Their experience as chemistry teachers to handle diverse students was also negative. Their misconception of diversity and inclusion as instructors may be attributed to their negative experience as chemistry students. Therefore, for there to be a more welcoming, diverse, and inclusive classroom environment for the students, it is important for instructors to be taught about diversity and inclusion and on how to integrate that into their teaching as chemistry instructors. This could be done by organizing a periodic mandatory workshop for instructors on DIEA and how to incorporate the ideas in their classrooms. Also, a system could be put in place to gather information from students how they see their classroom environment with respect to DIEA. A mandatory course on DIEA could also be mounted in the chemistry department to intentionally expose students to the concept of diversity and inclusion. Finally, to be able to experience a greater impact of the module on the conceptual understanding of students, there is a need for the development of additional modules related to other topics covered in general chemistry courses.

Future Works

More DISTL modules will be developed to cover other topics in undergraduate general chemistry course. Training will be conducted for instructors to train them on the use of DISTL curriculum to provide quality experiences for students.

CHAPTER 7- APPENDICIES

APPENDIX A

MODULE 1- STATE OF MATTER

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Abstract

In this module, we will introduce students to state of matter and discuss the contributions of diverse individuals to the discovery of state of matter. The module also includes a brief overview of the background of some prominent philosophers and scientists both from ancient times and modern era who are current researchers in the area. Our goal is to unravel the scientific diversity involved in the study of state of matter.

Keyword: Solid, Liquid, Gas, phase, physical changes, quantum droplet, Bose-Einstein condensates

Introduction to State of Matter

Matter is anything that has volume and mass. Mass is the amount of matter in a substance.

Physical changes involve processes that change the form of a substance but not its chemical composition or the make-up in terms of the constituent particles such as atoms and molecules. It is only change in the physical state of a substance for example cutting, tearing, shattering, grinding, and mixing are further types of physical changes because they change the form but not the composition of a material. Blending a smoothie, for example, involves two physical changes: the change in shape of each fruit and the mixing together of many different pieces of fruit. Because none of the chemicals in the smoothie components are changed during blending (the water and vitamins from the fruit are unchanged, for example), we know that no chemical changes are involved.

Chemical changes involve processes in which a new substance is formed with new chemical compositions. The “ingredients” of a reaction are called the reactants, and the end results are called the products for example rotting, burning, cooking, and rusting are all types of chemical changes because they produce substances that are entirely new chemical compounds. For example, burned wood becomes ash, carbon dioxide, and water.

There are four natural states of matter: solids, liquids, gases and plasma.

Solids

In a solid, particles are packed tightly together so they don't move much. The electrons of each atom are constantly in motion, so the atoms have a small vibration, but they are fixed in their position. Because of this, particles in a solid have very low kinetic energy. Solids have a definite shape, as well as mass and volume, and do not conform to the shape of the container in which they are placed. Solids also have a high density, meaning that the particles are tightly packed together.

Liquids

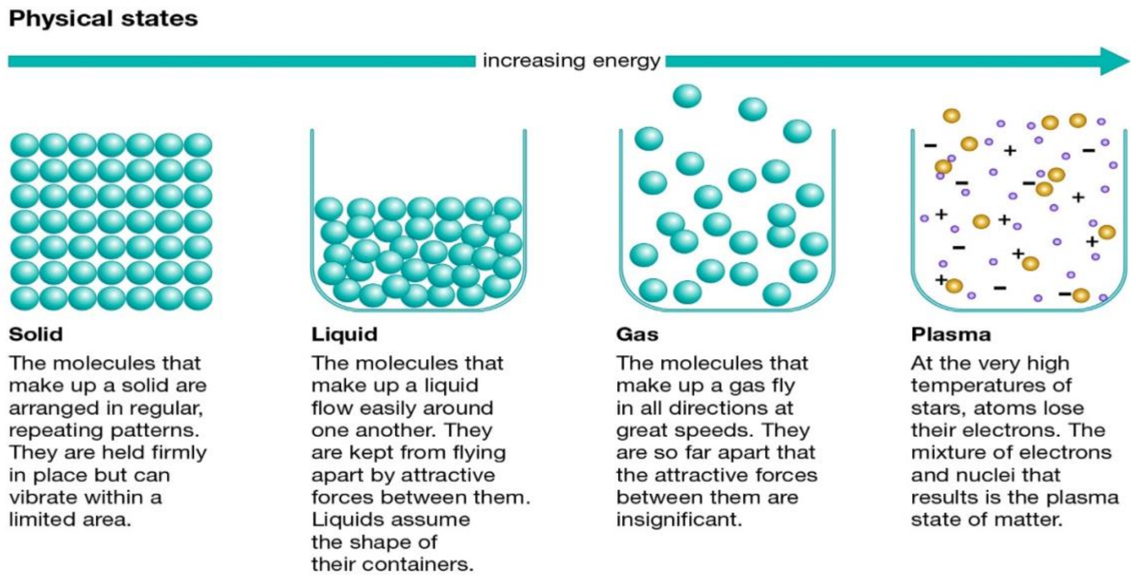
In a liquid, the particles are more loosely packed than in a solid and are able to flow around each other, giving the liquid an indefinite shape. Therefore, the liquid will conform to the shape of its container. Much like solids, liquids (most of which have a lower density than solids) are incredibly difficult to compress.

Gases

In a gas, the particles have a great deal of space between them and have high kinetic energy. A gas has no definite shape or volume. If unconfined, the particles of a gas will spread out indefinitely; if confined, the gas will expand to fill its container. When a gas is put under pressure by reducing the volume of the container, the space between particles is reduced and the gas is compressed.

Plasma

Plasma is not a common state of matter here on Earth, but it may be the most common state of matter in the universe, according to the Jefferson Laboratory. Stars are essentially superheated balls of plasma. Plasma consists of highly charged particles with extremely high kinetic energy. The noble gases (helium, neon, argon, krypton, xenon and radon) are often used to make glowing signs by using electricity to ionize them to the plasma state. Figure 7 shows a comparison of the various states of matter.



Solid The molecules that make up a solid are arranged in regular, repeating patterns. They are held firmly in place but can vibrate within a limited area.

Liquid The molecules that make up a liquid flow easily around one another. They are kept from flying apart by attractive forces between them. Liquids assume the shape of their containers.

Gas The molecules that make up a gas fly in all directions at great speeds. They are so far apart that the attractive forces between them are insignificant.

Plasma At the very high temperatures of stars, atoms lose their electrons. The mixture of electrons and nuclei that results is the plasma state of matter.

Figure 7.1: Comparison between the four main states of matter

A BRIEF HISTORY OF THE STATES OF MATTER

Humanity's first chemical knowledge was mostly **technology**, like metal working, ceramics, cooking, etc. Early civilizations learned to control fire, to cast metals and make alloys, to make glass and ceramics, and so forth. The first chemical thinking, as opposed to chemical applications, asked: What is matter? Matter is stuff. It's what we are made of and what the earth and the air are made of. The gaseous, liquid, and solid states of matter all these have had significant roles in the development of modern chemistry and physics. In ancient India, the Buddhists, the Hindus and the Jains each developed a particulate theory of matter, positing that all matter is made of atoms that are in itself "eternal, indestructible and innumerable" and which associate and dissociate according to certain fundamental natural laws to form more complex matter or change over time. Around the same era, one philosopher of ancient Greece proposed that all matter is made of *water*. He observed that water can "become air" by evaporation or become solid by freezing into ice. He reasoned therefore that water can convert into everything, and matter is made of water. Now, we call those changes in water as the physical changes. The water is still water when it boils and turns into steam. The water is still water when it freezes into ice. We changed its *temperature*, not its nature. Figure 7.2 shows the Ancient understanding of the state of Matter using water from Solid (ice cubes) to Gas (steam)

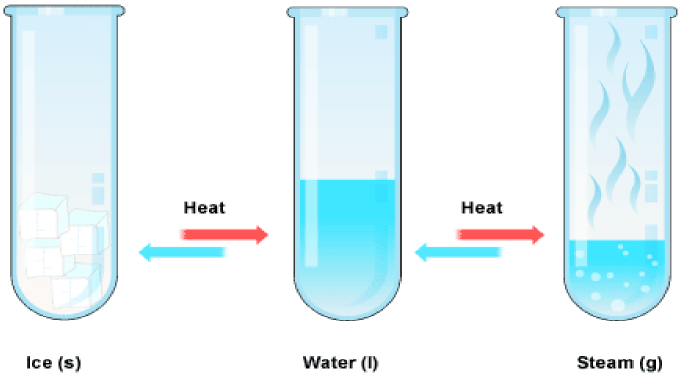


Figure 7.2: Ancient understanding of the state of Matter using water from Solid (ice cubes) to Gas (steam)

Another Greek philosopher said that everything was made of *air*: when air becomes less compressed, it becomes fire, and when more compressed, it turns into water, stones, and so forth. He offered the proof that when you breathe through open lips, the air is warm, and when you compress it by breathing through puckered lips, it's cold, and condenses into liquid or solid.

Years, later, Robert Boyle's experiments with gases that led to his publishing *The Spring of the Air* treatise in 1660. His *experiments* were based on the observation that *gases* are elastic. They return to their original size and shape after being stretched or squeezed. Also, the volume of a gas decreases with increasing pressure and vice versa.

British scientist Joseph Priestley (1733–1804) made a key discovery when he isolated oxygen, a gas he called dephlogisticated air, in keeping with the theory of that time that a mysterious substance called phlogiston was in all substances. The confusion of exactly what Priestley had discovered was solved by French chemist Antoine Laurent Lavoisier (1743–1794) who named the gas oxygen and called it an element, an element being by his definition a unique chemical substance. Priestley did not agree with Lavoisier. The existing concept of elements was very limited, but Lavoisier gained popularity among scientists and the discovery of more elements followed.

Study of gases also contributed to the advancement of the theory that matter is composed of atoms and molecules. Although this theory was not widely accepted at the time Dalton and Avogadro were promoting their ideas, it gained momentum with the growing popularity of Lavoisier's ideas.

Study of liquids played a part in the advancement of the concept that matter is made of atoms with Robert Brown's observation in 1827 of pollen grains moving in a liquid, albeit the influence was slow in coming. Even though evidence was gathering in the support of the existence of atoms and molecules, the concepts were not universally accepted until after Einstein suggested that the motion of the liquid molecules caused Brownian motion. When Einstein presented his ideas in 1905, theoretical physics was not a well-organized science. Einstein's studies attracted other key scientists to advance the theory of atoms and molecules, as well as the science of physics.

The solid state has been particularly influential as a result of Einstein's contributions and the advances in physics that have led to the development of atomic energy. The development of the atomic bomb and the applications of nuclear energy are all encompassed in a scientific discipline that is now called Solid State Physics.

Current Scientific Contributors to State of Matter

Though people have contributed to the formulation of the state of matter from gas to plasma in the past, currently, a lot of work is still ongoing and with the main four states of matter as a basis, new states of matter are coming up due to availability of modern tools such as spectroscopy that are being used by scientits to understand the nature of matter.

New states of matter with fine-tuned interactions such as the quantum droplets (a quasiparticle comprising a collection of electrons and holes inside a semiconductor) and dipolar (a pair of equal and oppositely charged poles separated by a distance) super solids have been proposed using Quantum fluctuations to stabilize Bose-Einstein condensates (BEC) against the mean-field collapse. These are being studied by present scientists like Fabian Böttcher, Jan-Niklas Schmidt, Jens Hertkorn, Kevin S. H. Ng, Sean D. Graham, Mingyang Guo, Tim Langen, amd Tilman Pfau. These scientists have published their most current work in September 2020.

Recently another group of scientists conducted a short pulse laser ablation of semiconductors and metals that was studied using recently developed method of ultrafast time-resolved microscopy. This is to study the characteristic stages of the conversion of solid material into hot fluid matter undergoing ablation. This research on novel states of matter was done by by K. Sokolowski-Tinten, J. Bialkowski, A. Cavalleri, D. von der Linde, A. Oparin, J. Meyer-ter-Vehn, and S. I. Anisimov. Finally, the discovery of a new state of physical matter in which atoms can exist as both solid and liquid simultaneously was conducted by a team led by scientists from the University of Edinburgh. All of this advancement in the states of matter started from the works of early philosophers and scientists. A summary of the accomplishments of early philosophers and modern-day scientists is provided in Table 1

Table 7.1: A summary of the accomplishments of early philosophers and modern-day scientists

Name	**Country**	**Gender**	**Field**	**Key Work**
Kanada, Hinayana, Mahavira	India	Male	Philosophers	Particulate theory of matter
Thales	Greece	Male	Mathematician/ Philosopher	Matter is made of *water*
Anaximander	Greece	Male	Philosopher	Everything was made of *air*
Robert Boyle	Ireland	Male	Philosopher, Chemist and Physicist	Gases are elastic. They return to their original size and shape after being stretched or squeezed
Robert Brown	Scotland	Male	Botanist	Brownian Motion
Albert Einstein	Germany	Male	Theoretical Physicist	motion of the liquid molecules caused Brownian motion
Mingyang Guo	China	Female	Physics	Quantum droplets and dipolar supersolids
J. Meyer-ter-Vehn	Germany	Male	Theoretical Physicist	conversion of solid material into hot fluid matter undergoing ablation

Questions for Self-Reflection (or Discussion)

1. What is your understanding of State of Matter based on this module? Give 1-2 examples.

2. What do you think about diversity with respect to scientific work and contributions of people to the study of state of matter including scientists from the past and those of present?

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APPENDIX B

MODULE 2- INTERMOLECULAR FORCE

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Abstract

In this module, we will introduce students to the intermolecular forces and discuss the contributions of diverse individuals to the discovery of intermolecular force. The module also includes a brief overview of the background of some prominent (or less than) philosophers and scientists both from ancient times and modern era (current science). Our goal is to unravel the scientific diversity involved in the study of the forces in molecules. Also, we seek to engage in a discussion the challenges that may have hindered or marginalized some groups leaving their contributions unrecognized while supported other groups to grow exponentially with respect to the opportunities leading to these contributions.

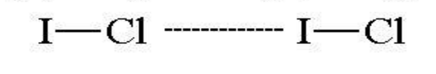
Keywords: Intermolecular forces, Matter, London Dispersion Force,
Dipole-Dipole Force, Hydrogen bond, solvochromism

Introduction to Intermolecular Forces:

Intermolecular forces are very important to understand the fundamentals of chemistry. Properties of any chemical substance such as the melting points, boiling points, surface tension and viscosity, etc. can be explained by the intermolecular forces that exist among the molecules. The understanding of the matter or a chemical substance being a solid, liquid or gas at a given temperature and why rubbing alcohol evaporates more readily than water is all based on our understanding of intermolecular forces. The existence of condensed phases of matter for example the liquid state of water is conclusive evidence of attractive forces between the water molecules. In the absence of the attractive forces, the molecules in a glass of water have no reason to be confined in that space. Also, the fact that water has a definite density and cannot be compressed easily to a smaller volume shows that at short range the forces between the molecules become repulsive.

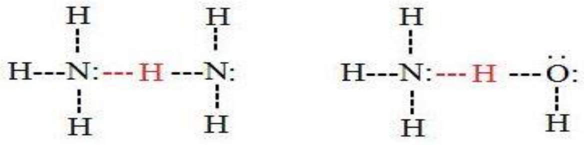
Intermolecular forces can be explained as the forces that act between molecules or discrete atoms and hold them close to each other. Intermolecular forces include London Dispersion forces, Dipole-Dipole Forces and Hydrogen Force

Dipole-Dipole forces: These forces occur when the partially positively charged part of a molecule interacts with the partially negatively charged part of the neighboring molecule. The prerequisite for this type of attraction to exist is partially charged ions especially in case of molecules with polar covalent bonds. They are the strongest of the intermolecular forces. For example, the force between HCl molecules are dipole-dipole forces due to the presence of more electronegative Cl atom that causes the polarity in H-Cl giving a particle positive charge to the oxygen atom and partial negative charge to Cl atom. Below is a reaction involving dipole-dipole force



$$\overset{\delta+}{\mathrm{I}}-\overset{\delta-}{\mathrm{Cl}}\;\text{------------}\;\overset{\delta+}{\mathrm{I}}-\overset{\delta-}{\mathrm{Cl}}$$

Hydrogen bonds (a special case of dipole-dipole forces): This is a special kind of dipole-dipole interaction that occurs specifically between a hydrogen atom bonded to either an oxygen, nitrogen, or fluorine atom. The partially positive end of hydrogen is attracted to the partially negative end of the oxygen, nitrogen, or fluorine of another molecule. For example, the force between water molecules and ammonia. Alcohols for example ethanol and methanol also have H-bonds. Also, hydrogen bonds occur in inorganic molecules, such as water, and organic molecules, such as DNA and proteins. The two complementary strands of DNA are held together by hydrogen bonds between complementary nucleotides. Below is an example of reaction between ammonia molecules and ammonia and water



London-Dispersion forces*:* These are the weakest among the intermolecular forces and that also exist between all types of molecules, whether ionic or covalent (polar or nonpolar) is the London dispersion force. The more electrons a molecule has, the stronger the London dispersion forces are. For example: F_2 and I_2

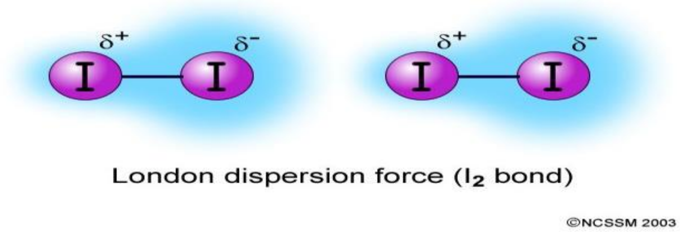


Figure 7.3: A diagram showing the London dispersion force between two non-polar molecules

Differences between intermolecular forces and intramolecular forces:

Note that these forces are much weaker than the stronger attractive forces you have learned about before. The stronger forces that hold the atoms and molecules together are classified as ionic, covalent and coordinate bonds. These bonds are forces that exist between the atoms to hold the atoms together as a molecule or an ionic solid or a complex species such as coordination compounds of transition metals. These bonds can also be referred to as *intramolecular forces* or forces that exist within the molecule.

The intermolecular forces exist “between” the molecules and are able to hold the state or phase of the molecules in bulk matter but intramolecular force exist between atoms. We inhale air which is a mixture of gases to take in oxygen for respiration. We don’t selectively inhale 6 oxygen molecules for the respiration. Also, intermolecular forces plays an important role in our DNA make-up.

A BRIEF HISTORY OF THE INTERMOLECULAR FORCES

The idea that matter is made up of atoms has been known since the ancient times, though the evidence for it did not become persuasive until the eighteenth and nineteenth centuries, when the ideal gas laws, kinetic theory of gases, Faraday’s law of electrolysis and a variety of other works provided evidence about the nature and composition of matter. One will notice that our understanding and applications of the intermolecular forces hinges on the work done by scientists and people from diverse backgrounds. These scientists or early philosophers used their knowledge and expertise to delve deeper into the nature of intermolecular forces and to connect these forces to the states of the matter.

The abstract concepts of force originated around 1200 B.C. among the ancient Egyptians who considered forces in nature as personal beings emanating from a deity. These “divine forces” focused on the natural phenomena that were observed like earthquake, violence and order. Then, the ancient Greeks later came in to propose explanations of forces that were not based on deities or religion. Among these Greek philosophers were Pythagoras, Empedocles, Plato and Aristotl e who discussed four elemental classifications of matter. According to these early philosophers, all the matter in the universe was composed of four indestructible and unchangeable roots or elements: earth, air, fire and water. These were in turn combined with two cosmic principles or moving causes: love (attractive Force) and strife (Repulsive Force). Jean Buridan’s (ca. 1300−after 1358) then came up with the theory of impetus (a step toward our concept of inertia) proposing that a body or object could cause movements of different magnitude in another object. This led to our understanding of the interactions between objects and how forces operating in one body could impact the motion of another body.

Isaac Newton (1642−1727) came up with the revolutionary law of gravitation. He believed that both matter and light were composed of particles (corpuscles) and gravity suggested that particles should attract one another but then 20 years earlier, Robert Boyle in his gas Law had proposed that particles repel. Then down the line, Johannes Diderik van der Waals came up with the Van der Waals forces (1837−1923) which developed the equation of state for gases and liquids, which quantitatively accounted for both the finite size of molecules and the attractive intermolecular forces between them. Then Charles-Augustin de Coulomb (1736−1806) proposed the first force law between electrically charged bodies. Followed by Fritz London who came up with the London Dispersion Force in 1930. Latimer and Rodebush (1920) then propose the concept of Hydrogen bonding. "[A] free pair of electrons on one water molecule might be able to exert sufficient force on a hydrogen held by a pair of electrons on another water molecule to bind the two molecules together”

Modern Scientists working on the Intermolecular Forces for their research

Currently, a lot of modern scientist are using these prior theories to come up with modern theories which gives a clearer understanding of the concept of intermolecular forces. Some of these scientist and theory work is discussed as follows.

Dongli Deng, Yingnan He, Mingyuan Li, Ludan Huang & Jinzhong Zhang (2020) have used hydrogen bond, hydrophobic interaction, and van der Waals force in preparation of multi-walled carbon nanotubes (a tubular molecule composed of a large number of carbon atoms) based magnetic multi-template molecularly imprinted polymer for the adsorption of phthalate esters in water samples. Also another group of scientists for example Tuomas P. Knowles, Anthony W. Fitzpatrick, Sarah Meehan, Helen R. Mott, Michele Vendruscolo and Christopher M. D in the year 2017 demonstrated the role of Intermolecular Forces in defining the material properties of protein nanofibrils. Finally, and H Inomata (2020) made a prediction of the solvatochromic parameters of electronic transition energy for characterizing dipolarity/polarizability and hydrogen bonding donor interactions in binary solvent systems of liquid nonpolar-polar mixtures, CO_2-expanded liquids and supercritical carbon dioxide with a cosolvent. Solvachromism is the phenomenon observed when the color due to a solute is different when that solute is dissolved in different solvents

Table 7.2: A tabulated summary of philosophers and scientist who have contributed to the understanding of Intermolecular Force is as follows

Name	**Gender**	**Country**	**Field**	**Key Work**
Egyptians	Male	Egypt	philosophers	Forces in nature as personal beings emanating from a deity
Pythagoras, Empedocles, Aristotle	Males	Greece	Philosophers	First to propose explanations of forces that were not based on deities or religion. i.e. earth, air, water, and Fire
Jean Buridan	Male	France	Philosopher	The theory of impetus
Isaac Newton	Male	England	Mathematician	Law of Gravity
Robert Boyle	Male	Ireland	Philosopher and chemist	Gas law
Johannes Diderik van der Waals	Male	Netherland	Physicist	Van Der Waal equation
Charles-Augustin de Coulomb	Male	France	Physicist	Coulomb’s law
Fritz London	Male	Poland	Physicist	London Dispersion Force
Latimer	Male	America	Chemist	Hydrogen bond
Dongli Deng	Male	China	Environmental Scientist	Hydrogen bond, hydrophobic interaction, and van der Waals force in preparation of multi-walled carbon nanotubes
Yingnan He,	Male	China	Environmental Scientist	Hydrogen bond, hydrophobic interaction, and van der Waals force

				in preparation of multi-walled carbon nanotubes
Sarah Meehan	Female	England	Chemist	Intermolecular Forces in Defining Material Properties of Protein Nanofibrils
Helen R. Mott	Female	England	Biochemist	Intermolecular Forces in Defining Material Properties of Protein Nanofibrils
Michele Vendruscolo	Female	England	Chemist	Intermolecular Forces in Defining Material Properties of Protein Nanofibrils

Self- Reflection Questions

1. What is your understanding of Intermolecular Force based on this module? Give 1-2 examples
2. What do you think about diversity with respect to scientific work and contributions of people to the study of Intermolecular Force including scientists from the past and those of present?

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APPENDIX C

MODULE 3- SOLUTION CHEMISTRY

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Abstract

In this module, we will introduce the solution chemistry and discuss the contributions of diverse individuals to the study of the solution chemistry. The module also includes a brief overview of the background of some philosophers and scientists both from ancient times and modern era. Our goal is to unravel the scientific diversity involved in the study of solution chemistry.

Keywords: Solution Chemistry, Homogenous Mixture, Heterogenous Mixture, Anisotropic interaction, Dendrimer

A solution is a homogeneous mixture. The major component of a solution is the solvent, while the minor component is the solute. Solutions can have any phase; for example, an alloy is a solid solution. Solutes are soluble or insoluble, meaning they dissolve or do not dissolve in a particular solvent. The terms miscible and immiscible, instead of soluble and insoluble, are used for liquid solutes and solvents.

The statement like dissolves like is a useful guide to predicting whether a solute will dissolve in a given solvent. Solubility is a measure of the maximum amount of solute that can be dissolved in a given amount of solvent to form a stable solution at a given temperature. A solution can either be heterogeneous or homogeneous. Homogeneous means that the components of the mixture form a single phase. Heterogeneous means that the components of the mixture are of different phase or difference consistency of particles constitution in the mixture. For example, a homogenous mixture may be soda pop, a heterogenous mixture may be chocolate chip milkshake

Properties of Solution

The properties of a solvent that show a predictable change upon the addition of a solute are melting point, boiling point, vapor pressure, and osmotic pressure.

Types of solutions

Gaseous Mixture: If the solvent is a gas, only gases (non-condensable) or vapors (condensable) are dissolved under a given set of conditions. An example of a gaseous solution is air (oxygen and other gases dissolved in nitrogen)

Liquid Mixture: If the solvent is a liquid, then almost all gases, liquids, and solids can be dissolved.

Solid Mixture: If the solvent is a solid, then gases, liquids and solids can be dissolved in the solid as minor components or solute. Various types of mixtures are presented in Table 1.

Table 7.3: Summary of the types of Mixtures

Examples of Solutions		**Solute**		
		Gas	Liquid	Solid
Solvent	Gas	Oxygen and other gases in nitrogen (air)	Water vapor in air (humidity)	The odor of a solid results from molecules of that solid being dissolved in the air
	Liquid	Carbon dioxide in water (carbonated water)	Ethanol (common alcohol) in water; various hydrocarbons in each other (petroleum	Sucrose (table sugar) in water; sodium chloride (table salt) in water; gold in mercury, forming an amalgam
	Solid	Hydrogen dissolves rather well in metals; platinum has been studied as a storage medium	Water in activated charcoal; moisture in wood	Steel, duralumin, other metal alloys

Many people from different background including ethnic, cultural, religious and gender have contributed to the discovery and the theory behind solution chemistry. The purpose of this section is to expose you to some of the people who have significant contribution in the area and some scientist who are still making contribution to advance the study of solution chemistry. Some may be very famous, whereas you may not be familiar with the work of some scientist or contributors to solution chemistry because of their background or other possible factors.

A BRIEF HISTORY OF SOLUTION CHEMISTRY

The ionic nature of liquid solutions was first identified by Svante Arrhenius (1859-1927) who, in the early 1880s, studied the way electricity passed through a solution. In 1885, Van't Hoff's investigation of dilute solutions lead to the concept of osmotic pressure. After this breakthrough, Raoult in 1888 published a paper on "The Vapor Pressures of Solutions in Ether." The paper resulted from experiments on the lowering of freezing points of solvents by solutes (also known as the depression of freezing points which finds application for salts to lower the freezing point of ice to prevent the ice road conditions during the extreme winter).

Another important contribution to solution theory was made in 1900 by Jan von Zawidski (Partial Vapour Pressure). Dolezalek in 1908, published what he called a "chemical theory" of liquid mixtures.

In 1910, E. W. Washburn published 'The Fundamental Law for a General Theory of Solutions." His "basic equations" dealt with "(a) osmotic pressure which is defined as the measure of the tendency of a solution to take in pure solvent by osmosis and freezing point which is the temperature at which a liquid becomes a solid; (b) osmotic pressure and vapor pressure which is a measure of the tendency of a material to change into the gaseous or vapor state; (c) osmotic pressure and boiling point which is the temperature at which the vapor pressure at the surface of a liquid becomes equal to the *pressure* exerted by the surroundings . In the year 1965, B. J. Alder greatly increased knowledge of the liquid state by his method of molecular dynamics, a computer simulation method for analyzing the physical movements of atoms and molecules. A comprehensive paper on "The Solubility of Gases in Liquids," by R. Battino and H. L. Clever, was published in (1966).

Some modern Scientists contributions to solution Chemistry

Currently, a lot of scientist are still adding to the knowledge of solution chemistry. For example Christine D. Keating uses aqueous phase Separation as a possible route to the compartmentalization of biological molecules (2012). The purpose of these studies is to understand the internal structure of intermediate evolutionary forms of complex modern cells using aqueous solution chemistry of macromolecules. Macromolecules are molecule containing a very large number of atoms, such as a protein, nucleic acid, or synthetic polymer

Also Viviana C. P. da Costa and Onofrio Annunziata in the year 2015 have worked on unusual liquid–liquid phase (LLP) transition in aqueous mixtures of a well-known dendrimer. A dendrimer is a repetitively branched molecule. In this research, they used LLP as a separation method for separating dendrimer solutions.

Table 7.4: A summary of the contributions of both the early and modern scientists to the solution chemistry

Name	**Country**	**Gender**	**Field**	**Key Work**
Svante Arrhenius	Sweden	M	Chemist	Ionic nature of liquid
Van't Hoff	Dutch	M	Physical Chemist	Osmotic pressure
Raoult	France	M	Chemist	Vapor pressure of solutions
Jan von Zawidski	Germany	M	Chemist	Partial vapor pressure
Dolezalek	Germany	M	Chemist	Chemical theory of liquid mixture
Gilbert Lewis	America	M	Physical Chemist	
E. W. Washburn	America	M	Physical Chemist	Fundamental Law for a General Theory of Solutions
B. J. Alder	Swiss American	M	Chemist	Molecular dynamics using computer
H. L. Clever		M	Chemist	The Solubility of Gases in Liquids
Christine D. Keating	America	F	Chemist	Aqueous Phase Separation
Viviana C. P. da Costa	America	F	Chemist	liquid–liquid phase transition in aqueous mixtures
Onofrio Annunziata	Italy	M	Chemist	Aqueous Phase Separation

Self-Reflection questions

1. What is your understanding of Solution based on this module? Give 1-2 examples.
2. What do you think about diversity with respect to scientific work and contributions of people to the study of Solution including scientists from the past and those of present?

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APPENDIX D

MODULE 4- ACID-BASE CHEMISTRY

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Abstract

In this module, we will introduce students to Acids and Bases and also discuss the contributions of diverse individuals to the discovery of acids and bases. The module also includes a brief overview of the background of these prominent (or less than) philosophers and scientists both from ancient times and modern era (current science). Our goal is to unravel the scientific diversity involved in the study of acids and bases. Also, we seek to engage in a discussion the challenges that may have hindered or marginalized some groups leaving their contributions unrecognized while supported other groups to grow exponentially with respect to the opportunities leading to these contributions.

Keywords: Acids and Bases, Lewis acids, proton transfer, Arrhenius, DNA helix, amino acid

An introduction to Acids and Bases:

Acids are compounds whose aqueous solutions exhibit the following properties: A characteristic sour taste, changes the color of litmus from blue to red, reacts with certain metals to produce gaseous H_2 and also reacts with bases to form a salt and water. Acidic solutions have a pH less than 7 and the lower the pH values the more acidic the solution becomes. Common examples of acids include acetic acid (in vinegar), sulfuric acid (used in car batteries), and tartaric acid (used in baking). Bases have a bitter taste, they are slippery in touch, they conduct electrically, turns red litmus to blue and turns colorless phenolphthalein to pink. In water, basic solutions will have a pH between 7-14. Some common examples of a base are sodium hydroxide (NaOH), potassium hydroxide (KOH) and lithium hydroxide (LiOH). Acid and bases are defined in three ways.

i. **Arrhenius***:* An acid is any substances that increases the concentration of hydronium ions (H_3O^+) in solution and a base is a substance that increases the concentration of hydroxide ions (OH^-) in solution. Example

Acids; Hydrochloric Acid (HCl), Nitric Acid (HNO_3), Sulfuric Acid (H_2SO_4)

Base: Sodium hydroxide (NaOH), Potassium hydroxide (KOH), Magnesium hydroxide ($Mg(OH)_2$)

ii. **Brønsted-Lowry***:* An acid is any substance that can act as a proton donor and a base is any substance that can act as a proton acceptor. For example, **HI, H_2SO_4, H_3PO_4 and CH_3CO_2H**

iii. **Lewis:** An acid is any substance that can accept a pair of electrons and a base is any substance that can donate a pair of electrons. For example.

Acid: H^+, K^+, Mg^{2+}, Fe^{3+}, BF_3, CO_2, SO_3, RMgX

Base: OH^-, F^-, H_2O, ROH, NH_3, SO_4^{2-}, H^-, CO

BRIEF HISTORY OF ACID AND BASE

Acids and bases have been studied for hundreds of years. Our current understanding of acids and bases is based on the studies and contributions of many scientists, chemists, and biologists. The idea that some substances are acids whereas others are bases is almost as old as chemistry, and the terms acid, base, and salt occur very early in the writings of the medieval alchemists. Acids were probably the first of these to be recognized, apparently because of their sour taste. Other properties associated at an early date with acids were their solvent, or corrosive action; their effect on vegetable dyes; and the effervescence resulting when they were applied to chalk (production of bubbles of carbon dioxide gas). Bases (or alkalis) were characterized mainly by their ability to neutralize acids and form salts.

Early Scientist and their work

The first attempt at a theoretical interpretation of acid behavior was made by Antoine-Laurent Lavoisier at the end of the 18th century. Lavoisier proposed that all acids must contain oxygen. Though it is said that his wife translated and also contributed immensely to this work, but she was not recognized. Following the discovery that hydrochloric acid contained no oxygen, Sir Humphry Davy about in 1815 recognized that the key element in acids was hydrogen. The first really satisfactory definition of an acid was given by Justus von Liebig of Germany in 1838**.** According to Liebig, an acid is a compound containing hydrogen in a form in which it can be replaced by a metal.

The whole subject of acid–base chemistry acquired a new look and a quantitative aspect with the advent of the electrolytic dissociation theory propounded by Wilhelm Ostwald and Svante August Arrhenius (both Nobel laureates) in the 1880s. Ostwald and Arrhenius came up with the definition that an acid is any substances that increases the concentration of hydronium ions (H_3O^+) in solution and a base is a substance that increases the concentration of hydroxide ions (OH-) in solution.

To resolve the various difficulties in the hydrogen–hydroxide ion definitions of acids and bases, a new, more generalized definition was proposed in 1923 almost simultaneously by J.M. Brønsted and T.M. Lowry**.** The definition is as follows: an acid is a species having a tendency to lose a proton, and a base is a species having a tendency to gain a proton. The term proton means the species H (the nucleus of the hydrogen atom) rather than the actual hydrogen ions that occur in various solutions; the definition is thus independent of the solvent. Later, the American chemist Gilbert N. Lewis in 1923 proposed that an acid is a species that can accept an electron pair from a base with the formation of a chemical bond composed of a shared electron pair (covalent bond).

These are not the only scientists who have contributed to the success of Acid and Base. Even in the application of Acids and Bases in the field of Biochemistry, we cannot leave out the contribution of James Watson, Francis Creek, and Rosalind Franklin who study the nucleic acid DNA, by determining the double helix structure of the DNA molecule. Found in all life on Earth, DNA contains the information by which an organism regenerates its cells and passes traits to its offspring.

Modern Scientists contribute to the knowledge of acids and bases

In modern science, the scientists like Beth Kelly and Erika L. Pearce in the field of Biochemistry are currently working on to review the mechanisms by which amino acid metabolism promotes immune cell function, and how these processes could be targeted to improve immunity in pathological conditions. Pathological conditions are conditions that result in physical or mental disease. Amino acids, which are the building blocks of blocks of the DNA supporting life are organic compounds containing amine (–NH2) and carboxyl (–COOH) functional groups that combine to form proteins. There are many more scientists who are still working to expand the knowledge of acid- base chemistry

Table 7.5: A tabulated summary of philosophers and scientist who have contributed to the understanding of Acid and Bases

Name	Country	Gender	Fields	Key Work
Antoine-Laurent Lavoisier	Paris, France	Male	Chemist	Proposed that all acids must contain oxygen
Sir Humphry Davy	Cornwall, England	Male	Chemist	Recognized that the key element in acids was hydrogen
Justus von Liebig	Germany	Male	Chemist	An acid is a compound containing hydrogen in a form in which it can be replaced by a metal
Svante August Arrhenius	Sweden	Male	Chemist	Arrhenius definition of acid and base
J.M. Brønsted	Denmark	Male	Chemist	Bronsted Lowry acid and base
T.M. Lowry	England	Male	Chemist	Bronsted Lowry acid and base
Gilbert N. Lewis	American	Male	Physical Chemist	Lewis acid and base
James Watson	American	Male	Molecular Biologist	Determining the double helix structure of the DNA molecule
Rosalind Franklin	England	Female	Chemist/X-ray Crystallographer	Determining the double helix structure of the DNA molecule
Beth Keller	America	Female	Immunologist	Amino Assets
Erika L. Pearce	America	Female	Immunologist	Amino Assets

Self- Reflection Questions:

1. What is your understanding of Acids and Bases, based on this module? Give 1-2 examples.
2. What do you think about diversity with respect to scientific work and contributions of people to the study of Acid and base including scientists from the past and those of present?

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APPENDIX E

BAUER SURVEY

CHEMISTRY IS

1. easy |__1__|__2__|__3__|__4__|__5__|__6__|__7__| hard

middle

2. worthless |__1__|__2__|__3__|__4__|__5__|__6__|__7__| beneficial
3. exciting |__1__|__2__|__3__|__4__|__5__|__6__|__7__| boring
4. complicated |__1__|__2__|__3__|__4__|__5__|__6__|__7__| simple
5. confusing |__1__|__2__|__3__|__4__|__5__|__6__|__7__| clear
6. good |__1__|__2__|__3__|__4__|__5__|__6__|__7__| bad

middle

7. satisfying |__1__|__2__|__3__|__4__|__5__|__6__|__7__| frustrating
8. scary |__1__|__2__|__3__|__4__|__5__|__6__|__7__| fun
9. comprehensible |__1__|__2__|__3__|__4__|__5__|__6__|__7__|
   incomprehensible
10. challenging |__1__|__2__|__3__|__4__|__5__|__6__|__7__|not challenging
11. pleasant |__1__|__2__|__3__|__4__|__5__|__6__|__7__| unpleasant

middle

12. interesting |__1__|__2__|__3__|__4__|__5__|__6__|__7__| dull
13. disgusting |__1__|__2__|__3__|__4__|__5__|__6__|__7__| attractive
14. comfortable |__1__|__2__|__3__|__4__|__5__|__6__|__7__| uncomfortable
15. worthwhile |__1__|__2__|__3__|__4__|__5__|__6__|__7__| useless
16. work |__1__|__2__|__3__|__4__|__5__|__6__|__7__| play

middle

17. chaotic |__1__|__2__|__3__|__4__|__5__|__6__|__7__| organized
18. safe |__1__|__2__|__3__|__4__|__5__|__6__|__7__| dangerous
19. tense |__1__|__2__|__3__|__4__|__5__|__6__|__7__| relaxed

20. insecure |__1__|__2__|__3__|__4__|__5__|__6__|__7__| secure

APPENDIX F

CAST (SAMPLE QUESTIONS)

1. A weather balloon with a 2-meter diameter at ambient temperature holds 525 grams of helium. What type of electronic probe could be used to determine the pressure inside the balloon?

A. Barometric

B. Thermometric

C. Calorimetric

D. Spectrophotometric

2. A scientist observed changes in the gas pressure of one mole of a gas in a sealed chamber with a fixed volume. To identify the source of the changes, the scientist should check for variations in the

A. Air pressure outside the chamber.

B. Molecular formula of the gas.

C. Temperature of the chamber.

D. Isotopes of the gas

3. Why is cobalt (Co) placed before nickel (Ni) on the periodic table of the elements even though it has a higher average atomic mass than nickel?

A. Nickel has one more proton.

B. Cobalt was discovered first.

C. Nickel has fewer electrons.

D. Cobalt has a lower density.

4. Generally, how do atomic masses vary throughout the periodic table of the elements?

A. They increase from left to right and top to bottom.

B. They increase from left to right and bottom to top.

C. They increase from right to left and top to bottom.

D. They increase from right to left and bottom to top.

5. Which of the following elements is classified as a metal?

A. Bromine

B. Helium

C. Sulfur

D. Lithium

6. Which of the following is a monatomic gas at STP?

A. Chlorine

B. Fluorine

C. Helium

D. Nitrogen

7. The reason salt crystals, such as KCl, hold together so well is because the cations are strongly attracted to

A. Neighboring cation.

B. The protons in the neighboring nucleus.

C. Free electrons in the crystals.

D. Neighboring anions.

8. What type of force holds ions together in salts such as CaF2?

A. Electrostatic

B. Magnetic

C. Gravitational

D. Nuclear

9. If the attractive forces among solid particles are less than the attractive forces between the solid and a liquid, the solid will

A. Probably form a new precipitate as its crystal lattice is broken and re-formed.

B. Be unaffected because attractive forces within the crystal lattice are too strong for the dissolution to occur.

C. Begin the process of melting to form a liquid.

D. Dissolve as particles are pulled away from the crystal lattice by the liquid molecules.

10. A teaspoon of dry coffee crystals dissolves when mixed in a cup of hot water. This process produces a coffee solution. The original crystals are classified as a

A. Solute.

B. Solvent.

C. Reactant.

D. Product.

APPENDIX G

MOSART (SAMPLE QUESTIONS)

1. When water goes from solid to liquid, the distances between the three atoms within a molecule:

   a. gets larger.

   b. get smaller

   c. don’t change.

   d. don’t change between H and O, but the angle between hydrogens is larger.

   e. don’t change between H and O, but the angle between hydrogens is smaller.

2. A sample of which of the following substances contains some kind of bond?

   a. Copper

   b. Carbon monoxide

   c. Neither

   d. Both

   e. It depends on the isotope ratio.

3. A portion of the Periodic Table is shown below.

N	**O**
P	**S**

Which element(s) has exactly one more outermost electron than element N?

   a. Only O

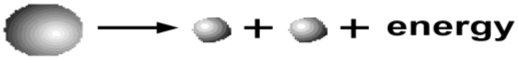
b. Only P.

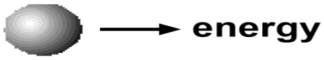
c. and S.

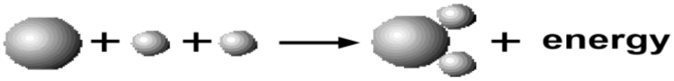
d. All of the other elements have exactly one more outermost electron than element N.

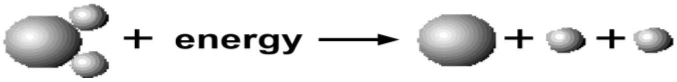
4. Which of the equations below best represents atoms in a fusion reaction?

a.


b.


c.


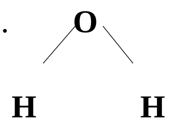
d.


e.


5. Which of the compounds below is most likely to have a dipole moment (be polar)?

1. **H — F**

2. **O ═ C ═ O**

3.


a. 1

b. 2

c. 3

d. 1 and 3

e. 1, 2 and 3

6. The rightmost column of the Periodic Table includes the noble gases, all of which:

   a. are lighter than air.
   b. are never liquid or solid at any temperature.
   c. are found only in Earth's atmosphere.
   d. are missing one electron in their outer orbital.
   e. have filled electron shells.

7. The charge in a nucleus of an atom is:

   a. neutral.
   b. negative.
   c. positive.
   d. continuously changing.
   e. not possible to determine

8. Of the following, which are linked to chemical reactions in humans?

   a. Digestion
   b. Taste
   c. Vision
   d. a and b
   e. a, b, and c

9. What is in between the electrons and nucleus of an atom?

   a. Nothing
   b. Air

c. Water vapor
d. Smaller atoms
e. No one knows.

APPENDIX H

GTAs INTERVIEW QUESTIONS

General Questions on Diversity

1. How would you define diversity and inclusion now with respect to science and in general? What do you think about diversity with respect to scientific work and contributions of people in sciences?

2. What were the situations that would have made some of these scientists or philosophers contribute their ideas in the various modules you have seen (1-4) on topics related to chemistry?

3. Why were some scientists more successful than others? What are some social and cultural factors that would have contributed to their success? What are some social and cultural factors that prevent others in succeeding in science?

4. As you notice in the tables and information in the modules - Why do we see only a few groups/works of few people recognized through the history? Do you think there are others who might have also contributed to the understanding of Acid and Base? What happened to the representation of those people in science? Why is it missing (considering that it is missing)?

5. What are some things you would do in your capacity as a GTA to make chemistry accessible and inclusive for all students? In your view what would teaching a diverse classroom would look like. How will you ensure that all students learn well, are treated fairly and are engaged in learning the subject matter deeply.

6. What are some things that we can do to address the issues related to marginalized voices in science? If you were given a chance to lead a scientific organization or appointed as a head of leading scientific agency in the country what would you do to make sure that opportunities to contribute to science and the progress in science is available to all. How will you make science disciplines like chemistry a level playing field for all the people?

- What should be done?

Interview Protocol- Interview 2: Post modules

About modules:

You had a chance to review four modules on various topics that relate to the first semester of general chemistry course. These include –

a) States of matter
b) Intermolecular forces
c) Solutions
d) Acid-base chemistry

We shared these modules with you to understand your view of the importance of work done by the scientists and how these modules contribute to your knowledge from the standpoint of history and modern science.

Specific questions on modules

With respect to module 1: The states of matter

1. What do you think about **the main ideas presented in this module with respect to work of modern scientists and those from history**? Share some key ideas.
2. If you look table in the module it provides information about various scientists. **What are your thoughts about the diversity of scientists** who have contributed to the states of matter?
3. What is your view of the information presented in this module? **What changes** would you like to see in terms of a) **the content presented and b) examples provided in the text and table for the works of the scientists.**
4. What **other information will help you build on the knowledge for** state og matter and also add **to understanding of diversity**.
5. Should there be more such examples in this module and should we include pictures of scientists and also figures. **Overall, what do you think about this module in terms of its importance for you as a GTA.**
6. Given this module, how would you incorporate teaching matter and measurement to a diverse group of students.

Module 2: Intermolecular forces

1. What is your understanding of Intermolecular Forces based on this module?
2. Share about the works of Early philosophers/ Scientists on this topic based on the module. Were there any scientists whose work was more interesting on IMFs and why?

3. Take a look at Table 2 of module on intermolecular forces if you do not remember. What do you think about the diversity of people who contributing to our understanding of IMS both historically and in modern science?
4. Overall, what do you think about this module on IMFs in terms of its importance for you as a student.
5. What about the diversity of scientists who have contributed to solution chemistry (Table 2 of this module).
6. What changes would you suggest in this module to make it better. Should it have more picture or include figures. What other information will help you build on the knowledge for solutions and also add to understanding of diversity? Overall, what do you think about this module in terms of its importance for you as a GTA.
7. Given this module, how would you incorporate teaching intermolecular forces to a diverse group of students.

Module 3: Solution Chemistry

1. Based on module 3 on solutions, what is your understanding of solutions and what constitutes a solution. What about some properties and types of solution?
2. Let’s talk a bit about the history of solution chemistry. What do you recall about the works of early scientists and their work on solution chemistry?
3. What about the works of modern scientists who are working on solution chemistry?
4. How has this module specifically by including the works of early scientists and modern scientists shaped your understanding of solutions?

5. Overall, what do you think about this module in terms of its importance for you as a student. What about the diversity of scientists who have contributed to solution chemistry (Table this module).
6. What changes would you suggest in this module to make it better. Should it have more picture or include figures. What other information will help you build on the knowledge for solution chemistry and also add to understanding of diversity. Overall, what do you think about this module in terms of its importance for you as a GTA.
7. Given this module, how would you incorporate teaching solution chemistry to a diverse group of students.

Module 4: Acids and Bases

1. What is your understanding of Acids and Bases, based on this module?

2. What do you think about the works of early scientists on acids and bases. What about modern scientists. In your view how are these two related (early work and modern work).

3. Why are acids and bases and various theories related to acids and bases important to understand and learn about?

4. What about the diversity of scientists who contributed to the studies on acids and bases (refer to Table 1 in the module).

5. Overall, what do you think about this module in terms of its importance for you as a student.

6. What changes would you suggest in this module to make it better. Should it have more picture or include figures. What is the importance of teaching about acids and bases in your view? What other information will help you build on the knowledge for acids and bases and also add to understanding of diversity.
7. Given this module, how would you incorporate teaching acid-base chemistry to a diverse group of students.

APPENDIX I

STUDENTS INTERVIEW PROTOCOL- POST MODULES

About modules:

You had a chance to review four modules on various topics that you have learned this semester in your chemistry course. These include –

1. States of matter
2. Intermolecular forces
3. Solutions
4. Acid-base chemistry

We shared these modules with you to understand your view of the importance of work done by the scientists and how these modules contribute to your knowledge from the standpoint of history and modern science.

Specific questions on modules

With respect to module 1: The states of matter

1. What is your understanding of State of Matter based on this module?
2. What do you think **about the main ideas presented in this module** with respect to work of **modern scientists and those from history**? Were there any scientists whose work was more interesting on IMFs and why?
3. If you look at the table in the module, it provides information about various scientists. What are **your thoughts about the diversity of scientists** who have contributed to the states of matter?

4. What is your view of the information presented in this module? What changes would you like to see in terms of;
    - **the content presented and**
    - **examples provided in the text and table for the works of the scientists**.
5. What other information will help you build on the knowledge for state of Matter and also add to understanding of diversity.
6. Should there be more such examples in this module and should we include pictures of scientists and also figures. **Overall, what do you think about this module in terms of its importance for you as a student.**

Module 2: Intermolecular forces

1. What is your understanding of Intermolecular Forces based on this module?
2. Share about the works of Early philosophers/ Scientists on this topic based on the module. Were there any scientists whose work was more interesting on IMFs and why?
3. Take a look at Table 1 of module on intermolecular forces if you do not remember. What do you **think about the diversity of people who contributing** to our understanding of IMS both historically and in modern science?
4. Overall, what do you think about this module on IMFs in terms of its importance for you as a student.
5. What changes would you suggest in this module to make it better. Should it have more picture or include figures.
6. What other information will help you build on the knowledge for solutions and also add to understanding of diversity

Module 3: Solution Chemistry

1. Based on module 3 on solutions, what is your understanding of solutions and what constitutes a solution. What about some properties and types of solution?
2. Let’s talk a bit about the history of solution chemistry. What do you recall about the works of early scientists and their work on solution chemistry?
3. What about the works of modern scientists who are working on solution chemistry?
4. How has this module specifically by including the works of early scientists and modern scientists shaped your understanding of solutions?
5. Overall, what do you think about this module in terms of its importance for you as a student. What about the diversity of scientists who have contributed to solution chemistry (Table this module).
6. What changes would you suggest in this module to make it better. Should it have more picture or include figures. What other information will help you build on the knowledge for solution chemistry and also add to understanding of diversity.

Module 4: Acids and Bases

1. What is your understanding of Acids and Bases, based on this module?
2. What do you think about the works of early scientists on acids and bases. What about modern scientists. In your view how are these two related (early work and modern work).
3. Why are acids and bases and various theories related to acids and bases important to understand and learn about?
4. What about the diversity of scientists who contributed to the studies on acids and bases (refer to Table 1 in the module).

5. Overall, what do you think about this module in terms of its importance for you as a student.
6. What changes would you suggest in this module to make it better. Should it have more picture or include figures. What other information will help you build on the knowledge for acids and bases and also add to understanding of diversity.

General Questions on Diversity

1. How would you define diversity and inclusion now with respect to science and in general? What do you think about diversity with respect to scientific work and contributions of people in sciences?
2. What were the situations that would have made some of these scientists or philosophers contribute their ideas in the various modules you have seen (1-4) on topics related to chemistry?
3. Why were some scientists more successful than others? What are some social and cultural factors that would have contributed to their success?
4. As you notice in the tables and information in the modules - Why do we see only a few groups/works of few people recognized through the history? Do you think there are others who might have also contributed to the understanding of Acid and Base? What happened to the representation of those people in science? Why is it missing (considering that it is missing)?
5. What are some things that we can do to address the issues related to marginalized voices in science? If you were given a chance to lead a scientific organization or appointed as a head of leading scientific agency in the country, what would you do to make sure that opportunities to contribute to science and the progress in science

is available to all. How will you make science disciplines like chemistry a level playing field for all the people?

6. What should be done?

APPENDIX J

IRB APPROVAL

Information Sheet for students

Participation in a Research Project

South Dakota State University

Brookings, SD 57007

Department of **Chemistry and Biochemistry**

Project Director: **Dr. Tanya Gupta** Phone No. 605-688-5328

E-mail tanya.gupta@sdstate.edu Date 07/15/2020

Please read (listen to) the following information:

1. This an invitation for you ***as a student in science and/ chemistry courses*** to participate in a research project under the direction of the Dr. Tanya Gupta. The project is entitled Diversity and Inclusion in Science Teaching and Learning (DISTL).
2. The purpose of the project is to a) understand student-diversity in various science courses including chemistry and biochemistry courses b) develop appropriate DISTL curriculum and supplementary resources for meeting the needs of diverse students and c) educating/ training instructors on the use of DISTL materials/ resources to provide a quality teaching and learning experiences for students d) piloting and implementing the diversity focused resources in science classrooms and laboratories and e) conducting studies to test the impact of DISTL on student diversity and inclusion practices, instructor attitudes, and student learning outcomes in science courses.

3. If you consent to participate, you will be involved in the following process, which will take about **60-75** minutes of your time. The study will involve student surveys, interviews and data collection focused on diversity and inclusion; student performance on assessments related to chemistry content via DISTL curriculum and classroom observations that will be video recorded. Students will experience DISTL curriculum as a part of regular course and there will be no extratime required from students beyond regular classroom hours other than for surveys and interviews as explained above. The vide-recordings will be used by trained researchers to analyze and code data for the classroom observations. This data will be anonymized, and all identifiers will be removed.
4. Participation in this project is voluntary. You have the right to withdraw at any time without penalty. If you have any questions, you may contact the project director at the number listed above. ***There are no known risks*** to your participation in the study.
5. *There are no direct benefits related to your participation. It is likely your participation in this project may improve your understanding of chemistry/ science and diversity and inclusion.*
6. Your responses for surveys, interviews and assessments are strictly confidential. When the data and analysis are presented, you will not be linked to the data by your name, title or any other identifying item.
7. As a research participant, I have read the above and have had any questions answered. I will receive a copy of this information sheet to keep.

8. If you have any questions regarding this study, you may contact the Project Director. If you have questions regarding your rights as a participant, you can contact the SDSU Research Compliance Coordinator at (605) 688-6975 or SDSU.IRB@sdstate.edu.
9. This project has been approved by the SDSU Institutional Review Board, Approval No.: IRB-2007011-EXM.

APPENDIX K

EMAIL TO STUDENTS FOR THEIR PARTICIPATION

Dear CHEM-106 students,

This email is from Albert Aidoo. I am a PhD student working under the supervision of Dr. Gupta (your chem-106 lecture instructor) on the project titled Diversity & Inclusion in Science Teaching and Learning (DISTL).

I am reaching out to you to seek your consent to participate in my project. Please review attached information sheet and complete this attached consent form and submit it in the D2L dropox folder titled DISTL consent form participation. **There are 2 points associated with completion of the consent form and submitting it in D2L dropbox**. I am attaching consent form with this email and the related information sheet for my project.

1. There is an extra-credit survey related to my project. **The survey is worth 5 points**. Once you complete the survey your updated score will be posted on D2L. The survey will take 15 minutes of your time. **In order to participate in the survey, you must complete the consent form and update it on the dropbox.**
2. The survey link is as follows: https://southdakotastateuniversity.questionpro.com/t/CkplBZgg9ok . **This should be done latest by 21st February 2021.**
3. There is a quiz posted on D2L titled DISTL pre-quiz, please attempt this quiz. It has 53 questions and is aimed at helping you practice some questions for the upcoming and final exam for this semester. You need not know all answers to questions if there are certain topics remaining to be covered. You will receive

points for each question answered correctly. You can earn maximum of 13 BONUS points in this quiz. **The quiz is available on D2L under assessments and it is titled as DISTL-pre quiz.**

4. **About DISTL modules (20 points): beginning Feb 20 - March 20th on D2L dropbox**
5. I will be sharing 4 DISTL modules (text files) on various topics in chemistry. These topics will also be covered in class by your instructor. You need to read the modules and write a 1-page summary of each module.
6. You should then submit your summarized work on the modules as a single file of 4 pages (each page representing a summary of one module) on D2L dropbox based on your reading of each module. Your module summary should reflect a) your understanding of key concepts presented in the module and b) the role of diversity in scientific work based on the tables and information presented in each of the four modules about the scientists.
7. Your work should be single-spaced with each module addressing two questions:

a. What is your understanding of key concept presented in the module? Use specific information from the module to share your understanding.

b. What is the role of scientific diversity in advancing the topic that is presented in the module? Use information from module to answer this question.

All DISTL modules will be available on D2L under content: Extra credit DISTL modules 1-4.

Submit your summary as 1 file on D2L dropbox titled DISTL module summaries. **Each summary page = 5 points and there are a total 20 points for the summaries of all 4 modules. I will grade modules for extra-credit as soon as you submit it on D2L dropbox titled module summaries.**

8. Following the module summary submissions, I will be reaching out to some of the students who have consented to participate to schedule a brief meeting with you either via zoom or in person to understand your perspective and your experiences on the teaching and learning of science and diversity. Since you are taking time to meet with me, **this will be worth 10 points that will be added as extra-credit to your CHEM-106 lecture score**.
9. **Overall there will be 65 points of extra-credit added to CHEM-106 lecture course based on your participation in project**. The breakup of points is as follows:
    - **a.** 2 points for consent form – **attached along with. Please complete it and submit in D2L dropbox**
    - b. 5 points for DISTL survey
    - c. ~ 13 points for DISTL pre-quiz
    - d. ~13 points for DISTL quiz 2
    - e. 20 points for module summaries to be submitted on D2L drobox titled DISTL module summaries.
    - f. 10 points for a 30–45-minute meeting 1 via zoom
    - g. 2 points for end of semester survey

Please e-mail me at albert.aidoo@sdstate.edu if you have any questions/concerns regarding your participation.

Thank you for your time.

Mr. Albert Aidoo

PhD Student

Chemistry & Biochemistry

APPENDIX L

CONSENT FORM- STUDENTS

South Dakota State University

Consent to Participate in Research

Study Title: Diversity and Inclusion in Science Teaching and Learning (DISTL)

Principal Investigator: Dr. Tanya Gupta and Mr. Albert Aidoo (graduate student)

You are invited to participate in a research study. This document contains important information about this study and what to expect if you decide to participate. Your participation in this research study is voluntary and you do not have to participate.

The purpose of the research is to a) understand student-diversity in various science courses including chemistry and biochemistry courses b) develop appropriate DISTL curriculum and supplementary resources for meeting the needs of diverse students and c) educating/ training instructors on the use of DISTL materials/ resources to provide a quality teaching and learning experiences for students d) piloting and implementing the diversity focused resources in science classrooms and laboratories and e) conducting studies to test the impact of DISTL on student diversity and inclusion practices, instructor attitudes, and student learning outcomes in science courses .You will be invited to participate in in online surveys and qualitative interviews either via zoom, phone or in person. These interviews are voluntary and will take 30-35 minutes of your time outside classroom. Surveys (conducted online) will take not more than 30 minutes of your time.

Procedures to be followed: Data will be collected after seeking consent from adult college students enrolled in various science, chemistry, and biochemistry courses. In this phase students will be given a survey to generate information about student experiences and the diversity that students bring to the science classrooms. Survey data will be analyzed first, and based on survey data analysis, a select group of students will be invited to participate in interviews to gather detailed information about student diversity (maximum 30-45 minutes). The data collected from surveys, and interviews and will be coded to remove all identities of participants prior to the analysis. It is important to note that all participant identities will be coded and anonymized to retain confidentiality.

There are no expected risks to you as a result of participating in this study. You will not benefit directly from participating in this study. Only the research team will have access to the data. The information that you give in the study will be anonymous. Your participation in this study is completely voluntary and you can choose to withdraw at any time.

For questions, concerns, or complaints about the study you may contact ***Dr. Tanya Gupta* @ *tanya.gupta@sdstate.edu* or *Albert.Aidoo@sdstate.edu*.**

You must be 18 or older to participate.

I have read (or heard) this form, and I am aware that I am being asked to participate in a research study.

______________________	______________________	__________
Printed name of subject	**Signature of subject**	**Date**

APPENDIX M

CONSENT FORM- GTAS

South Dakota State University

Consent to Participate in Research

Study Title: Diversity and Inclusion in Science Teaching and Learning (DISTL)

Principal Investigator: Dr. Tanya Gupta and Mr. Albert Aidoo (graduate student)

You are invited to participate in a research study. This document contains important information about this study and what to expect if you decide to participate. Your participation in this research study is voluntary and you do not have to participate.

The purpose of the research is to a) understand student-diversity in various science courses including chemistry and biochemistry courses b) develop appropriate DISTL curriculum and supplementary resources for meeting the needs of diverse students and c) educating/ training instructors on the use of DISTL materials/ resources to provide a quality teaching and learning experiences for students d) piloting and implementing the diversity focused resources in science classrooms and laboratories and e) conducting studies to test the impact of DISTL on student diversity and inclusion practices, instructor attitudes, and student learning outcomes in science courses .You will be invited to participate in in online surveys and qualitative interviews either via zoom, phone or in person. These interviews are voluntary and will take 30-35 minutes of your time outside classroom. Surveys (conducted online) will take not more than 30 minutes of your time.

Procedures to be followed: Data will be collected after seeking consent from adult college students enrolled in various science, chemistry and biochemistry courses. In this phase students will be given a survey to generate information about student experiences and also the diversity that students bring to the science classrooms. Survey data will be analyzed first, and based on survey data analysis, a select group of students will be invited to participate in interviews to gather detailed information about student diversity (maximum 30-45 minutes). The data collected from surveys, and interviews and will be coded to remove all identities of participants prior to the analysis. It is important to note that all participant identities will be coded and anonymized to retain confidentiality.

There are no expected risks to you as a result of participating in this study. You will not benefit directly from participating in this study. Only the research team will have access to the data. The information that you give in the study will be anonymous. Your participation in this study is completely voluntary and you can choose to withdraw at any time. For questions, concerns, or complaints about the study you may contact Dr. Tanya Gupta @ tanya.gupta@sdstate.edu or Albert.Aidoo@sdstate.edu. You must be 18 or older to participate.

I have read (or heard) this form, and I am aware that I am being asked to participate in a research study.

Printed name of subject	**Signature of subject**	**Date**

APPENDIX N

STUDENTS DISTL SURVEY

Did you do Chemistry in High School? Yes/No

LIKERT – RESPONSE CODES

a) Strongly Agree

b) Agree

c) Neither agree nor disagree

d) Disagree

e) Strongly Disagree

1. I find my science classrooms to be welcoming for all students.
2. I find my science instructors to be respectful of all students.
3. Students in science classrooms are treated fairly regardless of their abilities/ disabilities.
4. Students in science classrooms are treated fairly regardless of their gender.
5. Students in science classrooms are treated fairly regardless of their religious beliefs/ faith.
6. Students in science classroom have treated fairly regardless of their socioeconomic status.

7. Regardless of the cultural differences all students should be taught in the same way.
8. Science teachers have sufficient time to deal with the need of diverse students in a classroom.
9. Some students in the class participate less than other students.
10. The instructors in science classrooms used a variety of teaching strategies to address the learning styles of diverse students.
11. The content presented in science classrooms connects everyday experiences of diverse students with science.
12. Instructors in science classrooms seems to be adequately trained to teach culturally and linguistically diverse students.
13. The content present in science classroom integrates multicultural perspectives (contributions of scientists from different cultures etc.).
14. Science instructors have high academic expectations from all the students.
15. All students in science classes can and will learn regardless of their diverse cultures or languages.
16. High expectations from teachers in science classrooms from culturally (and linguistically) diverse students enables the students to develop positive attitudes, perceptions and high self-efficacy of their academic abilities.
17. Teachers in science classrooms and laboratories expect students to come to their classrooms with a particular set of academic skills that are essential to succeed in these courses.
18. Students who don’t put enough efforts usually fail in science courses.

19. Students who work hard and put enough efforts succeed in science courses.
20. Irrespective of teacher help, some students can never succeed in science courses.
21. Teacher knowledge of the background and experiences of their students is a major element that contributes to student learning and achievement.
22. It is the responsibility of teacher to use different approaches to teaching (lectures, interactive methods, various media) to convey important information, values and actions that portrays the diversity in scientific ideas.
23. Meeting (individual) needs of all students is very important for my science teachers.
24. Math and science materials should help students to understand how people from a variety of cultures and groups contribute to the development of scientific and mathematical knowledge.
25. Math and science materials should help students to understand the ways in which assumptions, perspectives and problems within these fields are often culturally biased and influenced by the dominant culture and practices.

Demographic Information:

1. Gender

    a. Female
    b. Male
    c. Transgender female
    d. Transgender male
    e. Gender/ Variant/ Non-conforming

   f. Not listed ………….
   g. Prefer not to answer

2. I identify my ethnicity as

   a. Black/African American
   b. Caucasian/White
   c. Hispanic/Latinx
   d. Native American
   e. Native Hawaiian or another Pacific Islander
   f. Prefer not to answer
   g. Other-please indicate here……………

3. Age

   a. ____

4. Major:

If declared what is your major.

If undeclared – what area are you interested to major in.

5. Year in College:

   a. Freshman
   b. Sophomore
   c. Junior
   d. Senior
   e. Other (taking college courses etc). please specify

6. English as first language:

   a. Yes

b. No ______Identify your first language

7. Background information:

a. High school year…..

b. GPA in high school

c. Please indicate science courses completed in high school

d. What was your grade in high school courses (answer that apply)?

- Chemistry
- Biology
- Physics
- Earth Science
- Mathematics
- Algebra
- Calculus
- Other
- Computer science/technology

e. SAT score_____ OR ACT score

APPENDIX O

DISTL QUIZ (SAMPLE QUESTIONS)

1. A solid is a state of matter that has a(n)

   a. indefinite volume and an indefinite shape.

   b. definite volume and a definite shape.

   c. definite volume and an indefinite shape.

   d. indefinite volume and a definite shape.

2. In which state of matter are particles packed tightly together in fixed positions?

   a. gas

   b. solid

   c. liquid

   d. compound

3. The state of matter in which particles are arranged in either a crystalline or an amorphous form is

   a. liquid.

   b. gas.

   c. solid.

   d. fluid.

4. Particles of a liquid

   a. are tightly packed together and stay in a fixed position.

   b. have no viscosity.

   c. decrease in volume with increasing temperature.

   d. are free to move in a container but remain in close contact with one another.

5. The surface of water can act like a sort of skin due to a property of liquids called

   a. viscosity.
   b. surface tension.
   c. condensation.
   d. evaporation.

6. In which state of matter do the particles spread apart and fill all the space available to them?

   a. crystal
   b. liquid
   c. gas
   d. solid

7. The change from liquid to solid, or the reverse of melting, is called

   a. condensation.
   b. boiling.
   c. sublimation.
   d. freezing.

8. The freezing point of water is the same as its

   a. melting point.
   b. boiling point.
   c. sublimation point.
   d. evaporation point.

9. What is vaporization?

a. a gas becoming a liquid

b. a liquid becoming a solid

c. a gas becoming a solid

d. a liquid becoming a gas

10. Which state of matter undergoes changes in volume most easily?

a. solid

b. liquid

c. gas

d. Frozen

Indicate if the statement is True or False

11. Ancient India was involved with the early discovery of the particulate theory of matter.

12. one philosopher of ancient Greece proposed that all matter is made of *water*. He observed that water can "become air" by evaporation or become solid by freezing into ice.

13. British scientist Joseph Priestley (1733–1804) made a key discovery when he isolated oxygen, a gas he called dephlogisticated air

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