

COLLABORATION AND ITS LEARNING BENEFITS IN A COMMUNITY  
COLLEGE STEM EDUCATION CLASSROOM

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ABSTRACT

Significant importance has been placed on STEM education to encourage students to enter into careers related to science, technology, engineering, and mathematics. United States education system is looking ways to provide a positive student-learning environment to improve student achievement, critical and rational thinking, analysis, and synthesis of information.

In higher education, the role of community colleges is undergoing a major transformation in the United States education system. Researchers place community colleges as one of the most important innovations for higher education in the 20th century. Community colleges not only provide affordable education, but also offer a wide variety of programs ranging from vocational to transfer. With the growing number of adult/ nontraditional learners across higher education, it has now become an utmost national priority to engage and retain this student population. As per the 2011 data by National Center for Education Statistics, the adult population in undergraduate courses is growing steadily over the last many years to the extent that it could overtake the numbers of the traditional students enrolled in four-year colleges and universities.

The AACC (American Association of Community Colleges) released *Reclaiming the American Dream: Community Colleges and the Nation's Future, A report from the 21st Century Commission on the Future of Community Colleges* in 2012 during the 21<sup>st</sup> Century Initiative to offer recommendations and ideas to promote skills that are needed for students to be successful in college, careers, and life. Later, in 2014, they released *Empowering community colleges to build the nation's future* to help community colleges build a stronger community of students. P21's Framework for 21st Century Learning offers 4Cs, of which collaboration is mentioned as

an important pedagogical technique, an educational outcome, and a key skill in various levels of education. This guide suggests that students learn best when they are provided collaborative learning environments; student achievements are higher when they are engaged with others in their learning environments. Students collaborate by working in teams; learn content by identifying problems and finding solutions. This can not only help build content knowledge, but can also develop critical thinking and creativity. Collaboration can actually help develop the other 4Cs. By implementing this unique pedagogical mode of instruction, in the form of collaboration in biology classrooms, improved student content achievement could be seen, thus improving STEM literacy across the nation.

The purpose of this study was to explore the learning benefits of collaboration in a community college STEM classroom. The participants in this study consisted of students (n=155) enrolled in Biology 101 or Biology 141 at Blue Ridge Community College (BRCC). A descriptive analysis of the students' assessment scores (pretest and posttest), science vocabulary familiarity scale (SVFS), and demographic surveys were conducted. Results revealed that collaborative learning approach in the community-college classroom results in changes to students' biology science content knowledge.

The results of this study have direct implications for the STEM educator within biological sciences, and in future for not only other fields of integrative STEM education, but for non-STEM courses in higher education. Collaboration enables STEM disciplines to increase opportunities for knowledge sharing and exchange, thereby increasing knowledge and competence. In other studies, researchers have found that students who worked in collaborative environments retained information much longer and deeper as compared to students who worked individually in traditional classrooms. In addition, students who studied in an active and

collaborative environment scored better in cognition and psychological activities as compared to students taught in traditional classrooms. The results of this study supported that collaboration was an effective means to improve students' learning outcomes in a biology-based classroom at the community college level.

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GENERAL AUDIENCE ABSTRACT

The purpose of this study was to explore the learning benefits of collaboration in a community college STEM classroom. Collaboration is defined as a “talk, discourse, conversation, communication”, in this case, between two or more undergraduate students in a general biology classroom at the community college (Bush, 2001). It was found that when students learn in collaboration, then they tend to do better in understanding the conceptual process and terms of a subject. They also do better on the assessment test than students who learn in a traditional environment. Collaboration increases opportunities for knowledge sharing and exchange. Researchers have found that students who worked in collaborative environments retained information much longer and deeper as compared to students who worked individually in traditional classrooms. In addition, students who studied in an active and collaborative environment scored better on tests as compared to students who were taught in traditional classrooms. The results of this study supported that collaboration was an effective means to improve students’ learning outcomes in a biology-based classroom at the community college level.

## DEDICATION

This dissertation and my years of commute to Virginia Tech. could not happen without the love and support of my wonderful family. My family believed in me and motivated me in every step of my way. I want to thank my husband, son, daughter, father, and mother who are the reason I was able to finish this difficult journey with so much ease and happiness. My father taught me to be independent, fierce, and strong. My mother taught me to be humble, patient, empathetic, and kind. My kids, Tripat and Sifti, motivated me every day to keep moving forward, one-step at a time, even when things did not take the right turn for me. They instilled in me the power to keep fighting. Without my supportive and loving home, I would not have the patience and endurance to finish my PhD. Finally, thank you to my wonderful and loving husband, my best friend, and my soul mate, who supported me in every step in my path that I took. Sometimes he walked with me, sometimes behind me, and sometimes clearing my path in front of me. He supported me in every possible way. Hearing you say that you are proud of me is one of the moments that I will forever treasure in my heart.

To my wonderful husband and best friend, Parminder, I dedicate this dissertation to you!

# STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

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## TABLE OF CONTENTS

ABSTRACT.....	ii
DEDICATION.....	vi
ACKNOWLEDGMENTS.....	vii
LIST OF TABLES.....	xiv
LIST OF FIGURES.....	xv
CHAPTER ONE.....	1
Introduction.....	1
Overview.....	1
Significance of the Problem.....	2
Conceptual Underpinnings of the Study.....	5
Community Colleges.....	5
Adult Learners/Nontraditional Learners.....	6
Finding the Right Pedagogical Tool.....	8
Collaboration: Classroom Method for Integration.....	9
Rationale for the Study.....	10
Purpose of the Study.....	11
Significance of Study.....	12
Research Questions.....	13
Limitations and Assumptions.....	13
Limitations.....	13
Assumptions.....	14
Design of the Study.....	14
Definitions of Terms.....	15
Summary.....	18

# STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

CHAPTER TWO.....	19
Literature Review.....	19
STEM Education.....	20
STEM Literacy and Education.....	22
STEM Challenges in Science Classrooms.....	23
STEM Education and Women.....	24
American Association 21 <sup>st</sup> Century Initiative.....	25
21 <sup>st</sup> Century Skills: 4Cs.....	25
Nontraditional Learners/ Adult Learners.....	27
Characteristics of Adult Learners.....	29
Theoretical Framework and Practical Approaches for Adult Learning.....	33
Adult Learning Theories.....	33
Learning Styles of Adult Learners.....	36
Barriers for Adult Learners.....	38
Differences between Adult Learners and other Levels of Learning.....	39
Community Colleges.....	42
Community College Classrooms.....	46
Pedagogies in Higher Education/Community College Classrooms.....	47
Science Literacy.....	48
Collaborative Learning in Classrooms.....	51
Collaboration and Collaborative Learning.....	51
Theoretical Framework for Collaboration.....	52
Collaboration Construction in Classrooms.....	54
Classroom Design Layout.....	54
Criteria for Implementing Collaborative Learning in Classrooms.....	56

Advantages and Benefits of Collaboration.....	57
Drawbacks of Implementing Collaborative Learning Environment in Classrooms .....	59
Role of Students in Collaboration.....	61
Role of Instructors in Collaboration.....	62
Summary of the Literature Review.....	63
CHAPTER THREE.....	65
Research Methodology Overview.....	65
Research Questions and Hypotheses.....	66
Research Design.....	67
Population and Sample.....	68
Population.....	68
Sample.....	69
Courses.....	69
Biology 101.....	69
Biology 141.....	70
Biology Vocabulary.....	70
Topic: Cell Biology.....	71
Instructional Pedagogy.....	72
Collaborative Learning Environment.....	73
Guided Concepts during Collaboration.....	74
Traditional Learning Environment.....	75
Assessment for Students' Conceptual Understanding.....	77
Instruments.....	77
Pretest Posttest Questions.....	78

# STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Science Vocabulary Familiarity Scale Survey.....	78
Demographics Survey.....	79
Data Collection Procedure.....	79
Data Analysis.....	80
Descriptive Analysis.....	81
Role of Researcher.....	82
Summary.....	83
CHAPTER FOUR.....	84
Introduction.....	84
Profile of Participants in Study.....	85
Student Demographics: Gender, Age, Race/Ethnicity.....	87
Student Demographics: Education Background, Career, Work Study, and Student Status.....	90
Research Question One.....	94
Analytical Approach.....	94
Supplemental Information for RQ1.....	96
Research Question Two.....	98
Analytical Approach.....	98
Supplemental Information for RQ2.....	99
Research Question #3.....	101
Analytical Approach.....	101
Age.....	102
Work Status.....	102
Race and Ethnicity.....	104
Gender.....	104

Summary.....	105
CHAPTER FIVE.....	107
Introduction.....	107
Summary of Study.....	108
Summary of Findings.....	108
Discussion of Results.....	110
Research Question #1.....	110
Research Question #2.....	112
Research Question #3.....	114
Student Participants' Demographics.....	114
Age .....	115
Work Status and Number of Credits.....	117
Race/Ethnicity and Gender.....	118
Prior College Science Courses and Current Field of Study.....	120
Highest Level of Education desired.....	120
Implications of Study.....	121
Collaboration: The Right Pedagogical Tool.....	121
Professional Development for Professors and Instructors in Community Colleges.....	122
Improve National Priority in STEM Education.....	123
Suggestions for Future Research.....	124
Conclusion.....	126
REFERENCES.....	128
APPENDICES.....	158
Appendix A.....	158

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Appendix B.....	162
Appendix C .....	164
Appendix D.....	168
Appendix E.....	170
Appendix F.....	172
Appendix G.....	177
Appendix H.....	182
Appendix I.....	185
Appendix J.....	188
Appendix K.....	190
Appendix L.....	192
Appendix M.....	194
Appendix N.....	201
Appendix O.....	203
Appendix P.....	205
Appendix Q.....	207
Appendix R.....	209
Appendix S.....	211
Appendix T.....	215
Appendix U.....	217
Appendix V.....	220
Appendix W.....	222
Appendix X.....	224

## LIST OF TABLES

Table 1: <i>McConnell's Traditional vs. Collaborative Learning Characteristics</i> .....	48
Table 2: <i>Classes that Participated in the Research Study</i> .....	86
Table 3: <i>Summary of Community College Students' Demographics for Biology 101</i> .....	88
Table 4: <i>Summary of Community College Students' Demographics for Biology 141</i> .....	88
Table 5: <i>Summary of Collaborative Learning Environment Students' Demographics for Biology 101</i> .....	92
Table 6: <i>Summary of Collaborative Learning Environment Students' Demographics for Biology 141</i> .....	93
Table 7: <i>Pretest and Posttest Scores Assessment Scores for Collaborative Learning Environment for Both Classes</i> .....	95
Table 8: <i>Posttest Achievement Scores for Traditional and Collaborative Learning Environments for Both Classes</i> .....	99
Table 9: <i>Group Statistics: Age and Posttest Scores in a Collaborative Learning Environment</i> .....	102

# STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

## LIST OF FIGURES

Figure 1. <i>Conceptual framework of the study</i> .....	19
Figure 2. <i>Thinking Skills in Bloom’s Taxonomy</i> .....	24
Figure 3. <i>Partnership for 21<sup>st</sup> Century Learning</i> .....	26
Figure 4. <i>Instructional Pedagogy for Control and Experimental Groups</i> .....	73
Figure 5. <i>Collaborative Learning Classroom Layout</i> .....	74
Figure 6. <i>Steps to incorporate Collaborative Learning Environment in Classrooms</i> .....	75
Figure 7. <i>Steps to incorporate Traditional Learning Environment in Classrooms</i> .....	76
Figure 8. <i>Data Analysis Flowsheet</i> .....	81
Figure 9. <i>Frequency Distribution of All Student Participants</i> .....	86
Figure 10. <i>Frequency Distribution of Students in Biology 101 and Biology 141</i> .....	87
Figure 11. <i>Frequency Distribution of Students in the Two Learning Environments</i> .....	87
Figure 12. <i>Frequency of Male and Female Students in Research Classes</i> .....	89
Figure 13. <i>Science Vocabulary Familiarity Scale for Collaborative Learning Environments</i> .....	96
Figure 14. <i>Pre and Post SVFS for BIOLOGY 101: Collaborative</i> .....	97
Figure 15. <i>Pre and Post SVFS for BIOLOGY 141: Collaborative</i> .....	97
Figure 16. <i>Mean Posttest Scores for all Classes in Both Environments</i> .....	100
Figure 17. <i>Mean PreSVFS and postSVFS for Both BIOLOGY 101 and BIOLOGY 141 in Both Environments</i> .....	101
Figure 18. <i>Group Statistics: Work Status and Posttest Scores in Collaborative Learning Environment</i> .....	103
Figure 19. <i>Group Statistics: Race/Ethnicity and Posttest Scores in Collaborative Learning Environment</i> .....	104
Figure 20. <i>Group Statistics: Gender and Posttest Scores in Collaborative Learning Environment</i> .....	105
Figure 21. <i>Summary of Implications of the Study</i> .....	121



# STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

## **Collaboration and its Learning Benefits in a Community College STEM Education Classroom**

### CHAPTER ONE

#### INTRODUCTION

##### **Overview**

The United States' educational system is looking to provide an environment to its students in the field of science, technology, engineering, and mathematics (STEM), by providing them opportunities where critical thinking and problem solving become an important part of their classroom learning (Atkinson & Mayo, 2010; Bybee, 2013; Moore, Johnson, Peters-Burton & Guzey, 2015; National Academy of Science [NAS], 2007). To strengthen student learning, there have been continuous reforms undertaken since 1983, by the National Commission on Excellence in Education's *A Nation at Risk* (1983) and the National Science Board's *Undergraduate Science, Mathematics and Engineering Education* (1986) (Thomasian, 2011). Duncan (2011) writes, "Our nation's long-term economic prosperity depends on providing a world-class education to all students, especially in mathematics and science" (para. 4). In the past years, numerous studies have identified pedagogical tools that can be used to improve student achievement, critical and rational thinking, analysis, and synthesis (Bryan, Glynn, & Kittleson, 2011; Ketelhut & Nelson, 2010; Treagust, 2007; Yoo, 2005). So in order to improve STEM skills in students, policy makers have called for the implementation of programs that can help improve inquiry-based scientific research methods in classrooms (National Research Council, 2011a). Hallman writes that "Given the current assessment driven climate in public education, any research that connects student perceptions on inquiry-based science instruction, ethnicity, gender, and science achievement can improve student instruction" (2014). With the

growing number of adult learners across higher education, colleges and universities are looking to serve this large growing adult learner population. It has now become an utmost national priority to engage and retain the nontraditional adult learner student population studying at the community colleges (*America's Untapped Resource: Low-Income Students in Higher Education*, edited by Richard Kahlenberg, 2004; National Science foundation, 2010).

With the growing number of nontraditional students, the role of community colleges is undergoing a major transformation in the United States education system. Community colleges provide vocational training, on-site job training, and academic training to their students (Kasper, 2003). According to the Council on Undergraduate Research (2009), the federal and state government and workforce are looking towards community colleges to contribute towards the economic workforce development. Community colleges could be a great place to study adult learners entering STEM fields because they provide positive and rich experience for students in these fields, provide affordable education, and offer a wide variety of career and technical education (CTE) programs. Nettles & Millett (2008) refer to community colleges as “one of the most important innovations for higher education in the 20<sup>th</sup> century” (p.1). In 2007, 6.6 million of the 15.6 million undergraduates in U.S. were enrolled in community colleges (Planty, Provasnik, Hussar, Snyder, & Kena, 2009). In the past twenty years, both part-time and full-time attendance has grown more rapidly at community colleges than at four-year institutions (Nettles & Millett, 2008). Hence, it is important to study the role of community colleges in motivating adult learners towards the STEM goals.

## **1.2 Significance of the Problem**

Policy makers and educational leaders are trying to find various factors that can improve academic and cognitive outcome and help progress STEM literacy (Bybee, 2013). The National

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Science Board has identified the need for the United States to improve literacy in STEM fields by “(imposing) new ideas flowing through research; to have the best technically trained, most inventive and adaptable workforce of any nation; and to have a citizenry able to make intelligent judgments about technically-based issues” (NSB, 1986, p. 1). Since that time, most of the focus has always been on K-12 education (Fairweather, 2009). However, now the focus on higher education in STEM literacy is also increasing (Arum & Roska, 2011). The NSB researches that “the deterioration of collegiate science, mathematics and engineering education is a grave long-term threat to our nation’s scientific and technical capacity, its industrial and economic competitiveness, and the strength of its national defense” (1986, p.1). Atkinson & Mayo (2010) reinforce the same fact that “STEM [education] is so important that we can’t afford not to have every student in America given the best STEM education, with the hope that this will increase the likelihood that at least some of them will go into STEM jobs” (2011, p. 6). Bybee (2013) states that “education should contribute to a STEM literate society, a general workforce with 21<sup>st</sup> century competencies, and an advanced research and development workforce focused on innovation” (p. X).

According to the National Science and Engineering Indicator report, “raising student achievement, reducing performance gaps...are high priorities for education reform across the United States” (NSB, 2014, p. 1-41). As per National Governor’s Association and President’s Council of Advisors on Science and Technology, policy makers, STEM educators, and professionals are trying very hard to find ways to improve cognition and learning in STEM by finding ways to improve STEM literacy (NGA, 2011; PCAST, 2012). The Partnership for 21<sup>st</sup> Century Learning recognizes that “all learners need educational experiences in school and

beyond, from cradle to career, to build knowledge and skills for success in a globally and digitally interconnected world” (Partnership for 21<sup>st</sup> Century Skills, 2011).

While the focus of STEM literacy has majorly been implemented on the K-12 educational system, some attention has also been placed on undergraduate education. The 4C’s (Creativity, Critical thinking, Communication, and Collaboration) have been introduced into the K-12 education system, but it will be an important step if these could be introduced into the higher education system as well. Arum and Roska (2011) have stated some interesting conclusions on the state of undergraduate students. They report that:

Gains in critical thinking, complex reasoning and written communication are either exceedingly small or empirically nonexistent... While students may have developed subject-specific skills...in terms of general analytical competencies assessed, large number of U. S. College students can accurately described as academically adrift. They might graduate, but they are failing to develop the higher-order cognitive skills that are widely assumed college students should master. (p. 121-125)

Collaboration induces creativity (John-Steiner, 1997). As compared to the traditional way of teaching and learning, collaboration can improve students’ “creativity, autonomy, independent thinking, competence, confidence, and self-esteem and as making students dependent, conforming, and nonthinking” (Marlowe & Page, 1998, p. 13). It then becomes important for the faculty members to focus and to make the transition from ‘teacher-center’ theory of teaching to ‘student-centered’ framework (Steffe & Gale, 1995). Collaboration “not only provides a common ground but the collaborative process invites divergent thinking and multiple perspectives in order to produce innovative and unique outcomes” (Bush, 2001). This type of learning can go beyond our own perspectives and may help students to see a very different

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

viewpoint. Gokhale (1995) writes that collaborative learning environments not only induce subject interest in students, but also promotes critical thinking and problem solving. Johnson & Johnson (1998) researched that students who work in collaborative environments retain information much longer and deeper as compared to students who work individually in traditional learning classrooms. Terenzini, Cabrera, Colbeck, Parente, & Bjorklund (2001) found that students who studied in an active and collaborative environment scored better in cognition and psychological activities as compared to students taught in traditional classrooms. When students share their knowledge, personal experiences, ideas, and engage in group discussions, they become better critical thinkers (Totten, Sills, Digby, & Russ, 1991).

Collaboration has been promoted in the K-12 education since the middle to late 1900's (Bush, 2001). There has been a lot of research done and books written that introduce, describe, and encourage collaboration in schools. In spite of so many recommendations by researchers and administrators, collaboration and collaborative learning has mostly been researched in K-12 education, especially at the primary and secondary levels. There is very little evidence of the benefits of collaboration and collaborative learning at the community college and university levels (Gokhale, 1995).

### **1.3 Conceptual Underpinnings of the Study**

This study is framed by the composition of various topics, theoretical frameworks, guiding principles, and features that are arranged as follows: community colleges, adult learners/nontraditional learners, and the use of collaboration as the right pedagogical tool in classrooms. Though ultimately interrelated, these topics have been separated to better understand the learning benefits of collaboration in a community college STEM classroom.

#### **Community Colleges:**

Community colleges play a very important role to help establish a bridge for STEM students to enter four-year colleges, thus helping to provide labor forces in growing STEM careers. According to the American Association of Community Colleges (AACC), about 44% of engineering and science graduates have attended community colleges in some phase of their lives (Tsapogas, 2004). There are an increasing number of high school students who are now opting to first enroll in community colleges over four-year institutions (AACC, 2014; Hoffman, Strarobin, Laanan & Rivera, 2010). National Science Board (2014) reports that “This is evidenced by increasing associates degree enrollment, which accounted for 49.8% of total higher education enrollment increases from 2000 to 2011, in contrast to enrollment in baccalaureate education, which accounted for 6.8% of the total increase in enrollment” (as cited in Gess, 2015). NSB (2014) also reported that between 2010 and 2011, there was an increase in the following Associates’ degrees in STEM fields earned from community colleges: engineering (11%), biology sciences (16.3%), agricultural science (8.7%), earth sciences (4.2), mathematics (36.1%), computer sciences (13.7%), physical sciences (24.9%), and non-engineering technologies (9.6%). As compared, earned bachelor degrees in STEM fields have failed to increase as rapidly. They have increased as following: engineering (4.7%), biology sciences (4.3%), agricultural science (10.4%), earth science (9.4%), mathematics (6.6%), computer sciences (8.0%), physical sciences (4.1%) and non-engineering technologies (5.3%). Looking at the statistics of the degrees conferred in STEM fields, it can be clearly concluded that community colleges play a very important role in imparting degrees related to STEM literacy.

#### **Adult Learners/ Nontraditional Learners:**

Kasworm (2003) describes an adult learner as a student who is at least 25 years or older, and is balancing responsibilities of his/her family, job, society, community, and studies. Adult

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

learners may also be classified as non-traditional learners, who are described as any student who “attends part time, works full time, is financially independent, has dependents other than a spouse, [or] is a single parent” (Gilardi & Guglielmetti, 2011, p.34). They are characterized as having “delayed enrollment, part time attendance, financial independence, [and] full time employment” (Deggs, 2011, p. 1543). These non-traditional students may have delayed their entrance into higher education due to various reasons. Even though the adult learners make up a big part of the educational system, they are classified as nontraditional students because the major part of their lives is spent as working and not as students (Wirt, Choy, Gerald, Provasnik, Rooney, Watanabe, & Tobin, 2002). They may be considered as minorities, as most higher education is focused on traditional students who come directly out of high school (Nelken, 2009).

As per the data by National Center for Education Statistics (NCES, 2012), the nontraditional learners’ population in undergraduate courses is growing steadily over the past decade to the extent that it could overtake the enrollment numbers of traditional students. Between 2000 and 2010, the number of undergraduate adult learners increased by 42% as compared to traditional students, whose number only increased by 34% (NCES, 2011). It has also been projected that by 2020, the number of nontraditional (including adult learners) will be increased additionally by 20% (NCES, 2011). “Given the faster rate of increase for the adult postsecondary population, this signals an impending shift in the demographic composition of our nation’s institutions of higher education with regard to age” (Hernandez, 2013, p. 9). This new fast pace change in higher education is now starting to become visible (Callan, 2009).

There are various societal factors such as demographics, educational trends, economic conditions, global factors, technological changes, and knowledge explosion, which are causing

the nontraditional learner population to increase statistically (Apps, 1988; Cross, 1981). With the growing number of nontraditional learners across higher education, community colleges are looking to serve this large growing learner population (Bruininks, Keeney, & Thorp, 2010, p. 115). College experience is of utmost importance to the emerging nontraditional learners. “Those who attend college change their value and attitudinal positions in a number of different areas but that they do so as a consequence of attending a college or university and not simply in response to normal, maturational impulses or to historical, social, or political trends” (Pascarella & Terenzini, 1991, p. 325). There are other advantages of studying in community colleges: smaller class sizes, low financial burden, financial aid opportunities, and recognition for hard working students, scholarship opportunities, and an easy transfer to four-year degree colleges. Community colleges provide vocational training, on-site job training, and academic training to its students (Kasper, 2003).

Recent research finds that more women are now returning to community colleges as adult learners to continue with their education (Compton et al., 2006). Community colleges are also a place to witness diverse students. The average age of students at the community college level is twenty-four, of which 35% of students are over the age of thirty (Provasnik & Planty, 2008). According to the National Science Foundation (NSF, 2009), over 35% of students enrolled at community colleges are students who belong to minority groups.

### **Finding the Right Pedagogical Tool:**

There is no research to identify a single pedagogical tool to improve STEM teaching and learning in an undergraduate classroom. There is also very little agreement among STEM scholars and professionals to define a STEM-literate individual (Zollman, 2012). Partnership for 21<sup>st</sup> Century Skills describes a STEM-literate student to not only have a thorough grasp on

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

content information, but to also be able to synthesize, analyze, critically think, and problem solve, and “benefit from the economic gains generated by innovation” (2011). Bybee (2013) suggests that STEM literacy offers the opportunity to learn to “apply basic content and practices of the STEM disciplines to situations they encounter in life” (p. 5).

Gess states, “Effective instruction strategies can promote conceptual change” (2015). Such strategies may include, for example, making lectures interactive, having students work in group settings, incorporating hands-on learning, and providing classroom environments, which can encourage problem solving and critical thinking. The implementation of systematic instructional practices in classrooms can help students gain conceptual knowledge (NRC, 2015). In fact, the learning in higher education should be such that “the classroom per se does not dominate the locus for instruction and learning to the degree that it does in k-12 settings” (Coppola & Krajcik, 2013, p. 631).

### **Collaboration: Classroom Method for Integration:**

Kestler describes that there can be three different types of approaches that can be taken by the educator to provide opportunities for students to enhance conceptual achievement in an undergraduate classroom setting. “When collaboration exists among a variety of disciplines, the process becomes cross-disciplinary and gives rise to different collaborative methodologies: multidisciplinary, interdisciplinary, and transdisciplinary” (Kestler, 2017, p. vi). In a multidisciplinary approach, each student will look at the problem from their perspective and try to solve the problem based on the content knowledge that they each have (Kestler, 2017). Kestler (2017) explains an interdisciplinary approach as “cross discipline collaboration” (p. 4). The last collaborative approach comes in the form of transdisciplinary research and can be defined as, “(an) extension of interdisciplinary research in which the work is produced under a shared

framework” (Kester, 2017, p. 5). Among the various options that have been proposed by Drake and Burns (2004), the transdisciplinary model seems to be the “most appealing” for implementing STEM literacy in undergraduate classes (Dugger, 2010). Implementing transdisciplinary approach in classes may help reach the goal of STEM literacy and persistence, improve cognitive outcome, improve achievement scores, and help create a “STEM-literate society whose population is globally engaged and makes informed decisions using critical thinking and other such 21<sup>st</sup> century skills” (NSB, 2007; NRC, 2011b; Partnership for 21<sup>st</sup> Century Skills, 2011; NSB, 2014).

#### **1.4 Rationale for the Study**

There are reports of a growing number of students transitioning into higher education. Since 2008, STEM disciplines have seen increased enrollments of undergraduate students in the fields of biology and engineering (Jacobs & Sax, 2014). In order to accommodate learning for all students, it is vital that educators must adapt to a pedagogy that can engage, develop, and motivate the diverse population of students (Osterholt & Barratt, 2012). College students today need more than just content knowledge. They need to learn to translate their learning and thoughts into effective actions (Starr & Minchella, 2016). Collaborative learning fosters an environment in which students are exposed to critical thinking through discussions, idea clarifications, and idea evaluations (Gokhale, 1995). In a general biology or a life science classroom, educators are realizing that “recent advances throughout the life sciences require new approaches to preparing biology majors and premedical students” and that collaborative techniques are needed “to prepare all undergraduates, regardless of their eventual career paths” (AAAS, 2011, p. viii).

Educators can “infuse opportunities in the college classrooms to teach students competencies beyond the content when a collaborative setting is established by choosing to

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

become well-versed in this design and to expand the very value of class time” (Osterholt & Barratt, 2012, p. 44). Collaboration works in unison with the traditional authoritative approach of the instructor in most of the classroom settings. Working in collaboration can help students to integrate information and expand their knowledge base beyond the classroom setting. Osterholt & Barratt state that “Then it takes learning a step further using its interactive and reflective nature to build social competencies and cooperation; raise confidence and empathy among its learners” (2012, p. 44). In education, STEM literacy needs to be viewed as a “dynamic” learning process where three parts of STEM literacy process should be highlighted: content knowledge, critical thinking and higher cognition, and social and personal growth (Zollman, 2011). “By helping students learn beyond the classroom, value is added to their degrees and the ways they view themselves and navigate the world are transformed” (Starr & Minchella, 2016).

### **1.5 Purpose of the Study**

In order to improve STEM literacy and STEM readiness, it is important to focus research efforts at the community college. With the growing number of undergraduate students at the community colleges in STEM fields, it is important to retain these students by keeping them engaged in their learning fields. There has been growing evidence for the employment of collaborative learning pedagogical approach in K-12 STEM classrooms as a means to improve student engagement, persistence, critical thinking, motivation, STEM literacy, and knowledge transfer (Cajas, 2001; Gokhale, 1995; Hmelo, Holton, & Kolodner, 2000; National Education Association, 2010). However, there is hardly any research about using collaborative techniques in a biology based STEM classroom at the community college level. The research presented in this study addresses that undergraduate students in a biology science course who studied collaboratively, scored significantly higher on measures of assessment (pretests versus posttests) than students who studied individually in a traditional classroom setting.

This research was designed to reveal the extent of changes in undergraduate student learning outcomes in a collaborative learning environment. This research was conducted in biology classes at the community college level. This study examined the differences between traditional learning versus collaborative learning in the conceptual understanding of a topic in cell biology.

### **1.6 Significance of Study**

Collaboration is mentioned as an important pedagogical technique in various levels of education, and most models of 21<sup>st</sup> century skills include collaboration as a key skill (Fadel & Trilling, 2012). The P21 Framework for 21<sup>st</sup> Century Learning includes Collaboration as one of the important 4Cs to have, along with Creativity, Critical Thinking, and Communication. As Dede (2010) has observed:

The nature of collaboration is shifting to a more sophisticated skillset. In addition to collaborating face-to-face with colleagues across a conference table, 21<sup>st</sup> century workers increasingly accomplish tasks through mediated interactions with peers halfway across the world whom they may never meet face-to-face....collaboration is worthy of inclusion as a 21<sup>st</sup> century skill because the importance of cooperative interpersonal capabilities is higher and the skills involved are more sophisticated than in the prior industrial era. (p. 2)

According to Mazur and Watkins (2013), students have more opportunities to share ideas when they work in a collaborative environment in a STEM classroom. When students work in groups, they have opportunities to work in environments that require critical thinking, conceptual knowledge, and metacognitive skills. This then helps increase class enrollment, student retention in classrooms, and knowledge retention (Mazur & Watkins, 2013). By implementing a unique

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

pedagogical mode of instruction in the form of collaboration in biology classrooms, improved achievement and representation can be seen, thus improving STEM literacy across the nation.

It is observed that traditional classrooms facilitate very little student interaction, and students write down notes copied from board or presentations. This results in students finding very little interest in attending classrooms (Mazur, 1996). In a science class, students memorize their facts with little or no meaning attached to their learning. According to Mazur (1996), students lose their ability to concentrate in the first 15 minutes of the traditional lecture. This can lead to lower performance, dwindling attendance, and lower achievement scores in STEM fields. In a traditional classroom, “little time is spent on building capabilities in group interpretation, negotiation of shared meaning, and co-construction of problem resolutions” (Dede, 2009, p. 3).

### **1.7 Research Questions**

The research questions examined in this study were:

1. To what extent does a collaborative learning approach in the community-college classroom result in changes to students’ biology science content knowledge?
2. Are there identifiable differences in achievement for groups of students learning traditionally and groups of students learning collaboratively?
3. What differential learning impacts are identifiable in a STEM educational environment employing collaborative learning?

### **1.8 Limitations and Assumptions**

Limitations and assumptions should be considered while reviewing the results of this study.

#### **Limitations**

There are a few limitations inherent in this study. First, this research study involves a limited sample size and homogeneity of student population as only one community college was

sampled. Because the sample size of this study was small and selective, it is possible that the results from this study will not be applicable to other college settings and geographical areas. However, it is possible that the results of this study could be shared with other colleges across the region and a “ripple effect” could be created to involve more classrooms using collaborative learning (Andrew & Lewis, 2002). Second, sampling may be a limitation as this study involves students who have self-signed up for the biology class. This enrollment method makes random sampling impossible. Third, the study employs only one departmental standardized assessment (detailed in Chapter 3). This means that other than the learning benefits and assessment gains, the various other factors of collaborative learning are beyond the scope of this research.

### **Assumptions**

One assumption is that all students in the research classroom will participate in the collaborative exercises and will engage in positive collaborative dialogue with their classmates. Another assumption is that all students that are placed in a collaborative environment can read, write, and comprehend at a very basic level. Third, all faculty members teaching biology will be willing to participate in this study. Fourth, it can be assumed that difficulties can arise in the planning, implementation, lesson delivery, student management, and assessment of this research study in classrooms.

### **1.9 Design of the Study**

This study used a quantitative approach for data collection and analysis using scores from assessment questionnaires (pretest and posttest). This study was a quasi-experimental, pretest-posttest, control group design. The sample consisted of students enrolled in general biology (Biology 101 and Biology 141) classrooms at Blue Ridge Community College (BRCC). The classrooms were divided into two groups: traditional learning (control) and collaborative

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

learning (experimental). The sample consisted of students who, prior to the start of the semester, self-enrolled in these two general biology courses.

### **1.10 Definitions of Terms**

The following terms are relevant in the context of this study:

**Adult Learner:**

Is a student who is at least 25 years or older, and is balancing responsibilities of his/her family, job, society, community, and studies. They may also be classified as non-traditional learners. (Kasworm, 2003)

**Biology (Biology Science):**

Branch of science that involves study of life, and includes various sub-disciplines like general biology, anatomy and physiology, botany, ecology, zoology, etc.

**Collaboration:**

It is a “talk, discourse, conversation, communication”, in this case, between two or more undergraduate students in a general biology classroom at the community college (Bush, 2001)

**Collaborative Learning:**

“Refers to an instruction method in which students at various performance levels work together in small groups toward a common goal” (Gokhale, 1995, p. 22).

**Community Colleges:**

A community college is a type of educational institution that provides workforce education and college transfer academic programs. These colleges provide grant associate degrees, diplomas, and certificates to students.

**Critical thinking:**

It is the intellectually disciplined thinking, in the field of biology science, that involves analysis, synthesis, and evaluation of the process of cell biology in a general biology classroom.

Higher Education:

Education beyond high school, especially at a two-year college or a four-year university

Integrative STEM education:

“The application of technological/engineering design based pedagogical approaches to intentionally teach content and practices of science and mathematics education concurrently with content and practices of technology/engineering education. Integrative STEM education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels” (Wells & Ernst, 2012, para. 2).

Literacy:

“An essential part of a democratic society through the study of five essential components of industrial art study: health, economic, art (aesthetic), social and recreational” (Bonser & Mossman, 1923, p. 6-14).

Nontraditional learner:

any student that “attends part time, works full time, is financially independent, has dependents other than a spouse, [or] is a single parent” (Gilardi & Guglielmetti, 2011, p.34). These students have delayed their entrance into the higher education due to various reasons.

STEM:

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Acronym for the integration of the fields of science, technology, engineering and mathematics education (Sanders, 2009).

STEM literacy:

“A deictic means (composed of skills, abilities, factual knowledge, procedures, concepts, and metacognitive capacities) to gain further learning” (Zollman, 2012, p. 12)

Student achievement:

This will be measured by pretest and posttest scores on the conceptual understanding of the process of cell biology in an undergraduate general biology classroom at the community college level.

Traditional Learning:

“(Traditional) instruction methods in which students work individually at their own level and rate toward an academic goal” (Gokhale, 1995, p. 23)

Traditional students:

A traditional student enters higher education right after high school, comes from an average income family, depends on parents or family for financial assistance, and may or may not work a part-time job (Gilardi & Guglielmetti, 2011; Bailey, 2007).

21<sup>st</sup> Century Skills:

“21<sup>st</sup> Century Skills transform how learning is practiced each day, and to expand the range of measures in student achievement, all in order to meet the new demands of the 21<sup>st</sup> century skills such as critical thinking, problem solving and communication into the teaching of core academic subjects such as English, reading or language arts, world languages, arts, mathematics, economics, science, geography, history, government, and civics” (2009, p. 9).

### **1.11 Summary**

The purpose of this study is to establish the need for collaboration and explore ways to teach biology in an integrative setting at the community college level. This dissertation is based on (a) exploring the effects of collaboration in a biology classroom at the community college, (b) explaining findings focused on the content taught in a science (Biology) classroom using collaboration, and (c) offering suggestions on how other science and STEM faculty members in community colleges can create or enhance pedagogical tools and partnerships to better utilize the strengths of their disciplines.

CHAPTER TWO

2.1 Literature Review

In order to better understand the learning benefits of collaborative environments in community college nontraditional classrooms, it is necessary to understand the foundation for basis of this research study. The literature review is divided into the following four sections:

1. STEM education in the United States: STEM literacy and education and STEM challenges
2. Adult/ nontraditional learners: theoretical foundations for learning STEM
3. Higher Education in the community college setting
4. Collaboration and collaborative learning environments

The four sections are not independent of one another but are connected throughout the investigation. Figure 1 is an overview of the contents of the literature review that helped in the investigative nature of this study.

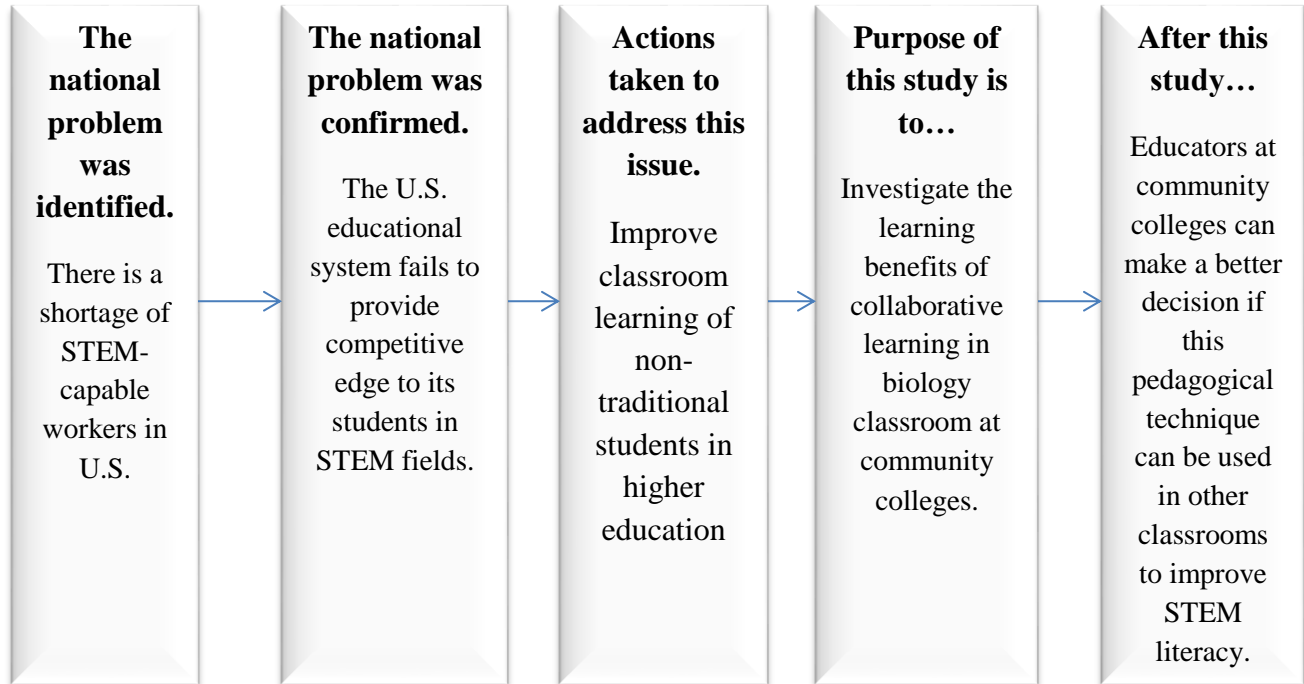


Figure 1. Conceptual framework of the study.

## 2.2 STEM Education

In 1986, the National Science Board (NSB) recognized that, “the deterioration of collegiate science, mathematics, and engineering education is a long-term threat to our nation’s scientific and technical capacity, its industrial and economic competitiveness, and the strength of its national defense” (p. 1). For the last 30 years, STEM experts and educators continue to call for an integrative transdisciplinary approach to teach content and practice of each disciplinary area in STEM (NRC, 2014; NRC, 2013; Wells & Ernst, 2012). Program for International Student Assessment (PISA) is a test coordinated by the Organization for Economic Cooperation and Development (OECD) and is conducted by the National Center for Education Statistics (NCES) in the United States to assess U.S. students’ literacy in the fields of math, science, and literacy for students entering higher education (Gess, 2015). The statistical results show that the mathematics results of the US were substantially lower than the international OECD averages, while in science, the results were average of the international OECD scores. In addition, “the U.S. average mathematics, science, and reading literacy scores in 2012 were not measurably different from average scores in previous PISA assessment years with which comparisons can be made (2003, 2006 and 2009 for mathematics; 2006, and 2009 for science; and 2000, 2003, and 2009 for reading)” (NCES, 2012). Despite investing time, effort, and money, the United States has still not been able to show improvement in scores. The United States was also not able to gain competitiveness in STEM fields as compared to other developed nations as evidenced by both national and international test results. Facts show that students in the United States do well in elementary and middle schools, but the content knowledge of students in higher education, especially in math and science, was below average as compared to their previous scores. According to NCES, “the 2012 long-term trend results show 9- and 13-year-olds scoring higher in both reading and mathematics than students their age in the 1970s. At age 13, the overall

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

average score in each subject was also higher in comparison to the last assessment in 2008. At age 17, however, the 2012 reading and mathematics average scores were not significantly different from those in the respective first assessment year” (NCES, 2013).

There are various concerns on the widening gap between STEM literacy and the average citizens (National Research Council, 2011). The President’s Council of Advisors on Science and Technology (PCAST, 2010) state that only a few students have interest in STEM fields in the U.S. as compared the international statistics of students in other countries. According to the National Research Council (2005), only 30% of US students pursue STEM disciplines at the university level as compared to 63% of Asian students.

The National Science Board (NSB, 2015) reports that approximately 26 million jobs in the United States require significant STEM knowledge in at least one field, and 16.4 million jobs require a bachelor’s degree or higher of STEM expertise (Stith, 2017). The National Research Council’s *Successful K-12 STEM Education Report* (2011) reported that only 4% of the nation’s workforce is comprised of scientists and engineers. It is vital to improve STEM education at higher education levels (U.S. Department of Labor, 2007). The United States Congress Joint Economic Committee (USCJEC, 2012) stated that:

improving STEM education at the K-12 level and moving more young people into the STEM pipeline will not be enough if college is unaffordable or out of reach, or if the postsecondary education system more generally does not function effectively to take talented, STEM-interested young people and provide them with the degrees, certifications, and skills to succeed (p. 9).

The United States Department of Education stated that “The United States cannot remain at the forefront of science and technology if the majority of its [higher education] students view science

and technology as uninteresting, too difficult, or closed off to them” (U.S. Department of Education, 2010, p. 36).

### **STEM Literacy and Education**

STEM seems to be a fad word in education (Bybee, 2010). “If STEM education is going to advance beyond a slogan, educators in the STEM community will have to clarify what the acronym actually means for educational policies, programs and practices” (Bybee, 2010, p.31). STEM education has been defined, and is implemented in various ways in K-20 classrooms. The acronym ‘STEM’ was first coined by Judith Ramaley in 2001 (Zollman, 2012). Researchers and educators have tried to define STEM acronym and STEM education in various ways. Gonzalez & Kuenzi (2012) refer to STEM education as “teaching and learning in the fields of science, technology, engineering, and mathematics. It typically includes educational activities across all grade levels— from pre-school to post-doctorate—in both formal and informal settings” (p. 2). Tsupros, Kohler, and Hallinen (2009) defined STEM education as:

An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (p. 2).

There have been arguments over using the correct definition of STEM and its’ scope in classrooms. Until date, there is no consensus on a uniform definition of STEM accepted in education, and the implementation of the STEM program is unknown (Gonzalez & Kuenzi, 2012). Zollman (2012) gives a different perspective and refers to STEM literacy as “a deictic means (composed of skills, abilities, factual knowledge, procedures, concepts, and metacognitive

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

capacities) to gain further learning” (p. 12). Wells and Ernst (2012) suggest that STEM be taught in K-20 education in an integrative way, where both content knowledge and application practice are presented together to provide context for deep understanding and learning. They define Integrative STEM Education (I-STEM) as:

The application of technological/engineering design based pedagogical approaches to intentionally teach content and practices of science and mathematics education concurrently with content and practices of technology/engineering education. Integrative STEM education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels (para 2).

Zollman (2012) challenges all educators to use STEM literacy for teaching and learning for societal, economic, and personal needs of students. STEM literacy does not mean that the students will have content knowledge in all four silos of STEM (Toulmin & Meghan, 2007); rather they should be able to integrate skills, processes, and concepts from each of the four disciplines and extend it towards its application.

### **STEM Challenges in Science Classrooms**

STEM literacy cannot only help students to think beyond their classroom setting, but can also prepare them to think critically and rationally (Gokhale, 1995). Students will have better understanding of the facts and concepts and thus may do better on assessments. Duncan (2011) writes, “Our nation’s long-term economic prosperity depends on providing a world-class education to all students, especially in mathematics and science” (para. 4).

In order to improve STEM skills in students, policy makers have called for implementation of certain programs that can help improve inquiry-based scientific research methods in classrooms (NRC, 2011). “Given the current assessment driven climate in public

education, any research that connects student perceptions on inquiry-based science instruction, ethnicity, gender, and science achievement can improve student instruction” (Hallman, 2014). Researchers have identified pedagogical tools that can be used to improve student achievement, analysis, synthesis, and critical and rational thinking (Bryan, Glynn, & Kittleson, 2011).

According to the National Research Council (NRC, 1996), “there should be less emphasis on activities that demonstrate and verify science content” and more emphasis on pedagogy that “investigate and analyze science questions” (p. 113). Teaching science requires a pedagogy that values student-led instruction in classrooms. Dewey (1938) stated, “Scientific principles and laws do not lie on the surface of nature. They are hidden and must be wrested from nature by an active and elaborate technique of inquiry” (p. 32). There is a challenge for educators and instructors to create such a pedagogical tool that will help students make a connection between science and real world, and simultaneously come up with ways of assessment that follow the national standards. One approach would be to focus time, effort, and finances towards higher education. Second would be to implement teaching tools in classrooms that incorporate active learning, inquiry-based learning, or collaboration- all of which help students to think critically, analyze, synthesize, evaluate, create, and apply knowledge (see Figure 2).

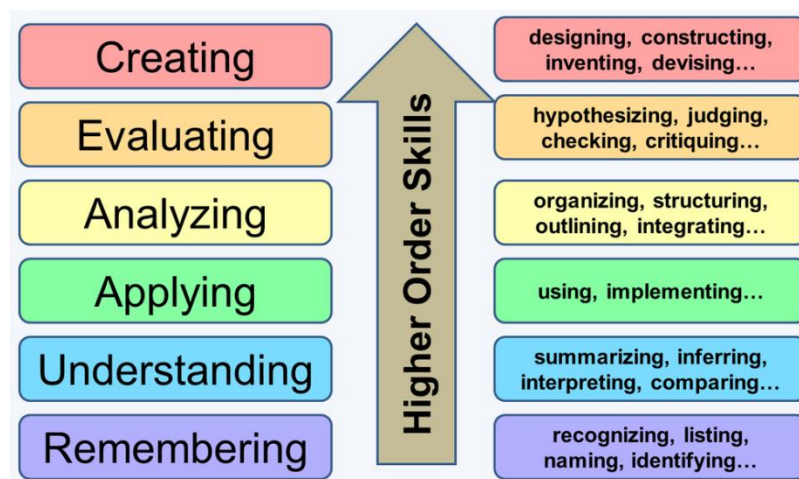


Figure 2. Thinking Skills in Bloom’s Taxonomy (Illustrated by Scott Brande)

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

### **STEM Education and Women:**

Women make up about two-thirds of undergraduate student population but are underrepresented in the majority of STEM fields with the exception of medical fields and some branches of life sciences (National Science Foundation, 2013). The US data in NSF (2013) data suggests that women make up only 45% of postgraduate and 41% of STEM doctoral students in the US. Moreover, women working in STEM professions only make up 27% of the workforce (NSF, 2013). This can have a great impact on the US economy as these figures could cause a shortage of skilled and trained workers in some STEM fields, like physics, mathematics, and engineering (Department for Education and Skills, 2004). Some reasons for this underrepresentation may include “lack of mentoring, under preparedness for the rigors of STEM study, lack of confidence toward degree completion” (Huziak-Clark, Staaden, Bullerjahn, Sondergeld, & Knaggs, 2015). Other reasons could be lack of interest in traditional classrooms, low interactions, and lack of communication in schools and higher education colleges.

### **2.3 American Association 21<sup>st</sup> Century Initiative:**

The AACC (American Association of Community Colleges) released *Reclaiming the American Dream: Community Colleges and the Nation’s Future, A report from the 21<sup>st</sup> Century Commission on the Future of Community Colleges* in 2012 during the 21<sup>st</sup> Century Initiative (AACC, 2012). Later, in 2014, they released *Empowering community colleges to build the nation’s future* that could help community colleges to build a stronger student community (AACC, 2014). This guide recommends the *Three R’s* (AACC, 2014): “Redesign students’ educational experiences, Reinvent institutional roles, and Reset the system so it better promotes student success”. These three recommendations are infused with seven guiding principles, and one idea is to incorporate a collaborative learning environment for students in classrooms.

## **21<sup>st</sup> Century Skills: 4Cs**

P21's Framework for 21<sup>st</sup> Century Learning "was developed with input from teachers, education experts, and business leaders to define and illustrate the skills and knowledge students need to succeed in work, life and citizenship, as well as the support systems necessary for 21<sup>st</sup> century learning outcomes" (Partnership for 21<sup>st</sup> Century Skills, 2011). A STEM-literate student should be able to think critically and make rational judgments by managing, analyzing, and synthesizing from multiple sources of information (Partnership for 21<sup>st</sup> Century Skills, 2011). The guide also "supports the development of individual and collaborative, as well as critical and creative, thinking skills [and] direct application of advanced content and thinking skill in real-world experiences [to] provide a solid foundation for future problem solving". The 4Cs are summarized as skills that are needed for students to be successful in college, careers, and life. These 4Cs are creativity, communication, collaboration, and critical thinking. Of these, collaboration is mentioned as an important educational outcome and a key skill. This guide suggests that students learn best when they are provided collaborative learning environments; student achievements are higher when they are engaged with others in their learning environments. Students collaborate by working in teams; learn content by identifying problems and finding solutions. This can not only help build content knowledge but can also develop critical thinking and creativity. Collaboration can actually help develop the other three Cs (see Figure 3).

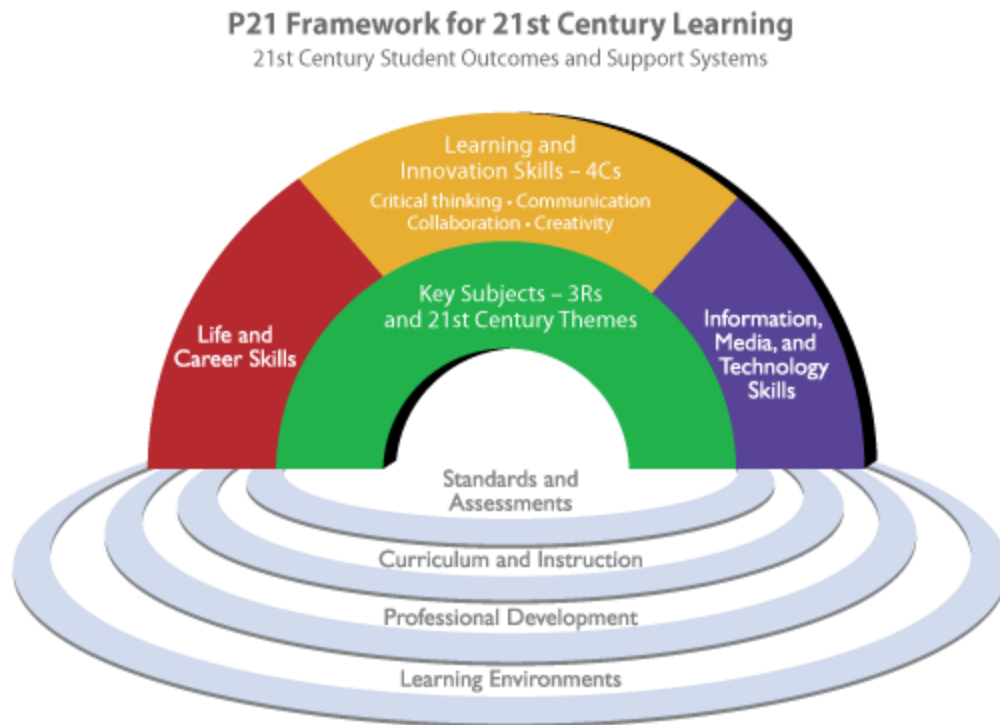


Figure 3. Partnership for 21<sup>st</sup> Century Learning. (Partnership for 21<sup>st</sup> Century Skills, 2011).

#### 2.4 Nontraditional Learners/ Adult learners

Kasworm (2003) describes an adult learner as a student who is 25 years or older and is balancing responsibilities of his/her family, job, society, community, and studies. These could also be called as non-traditional students, who are described as any student that “attends part time, works full time, is financially independent, has dependents other than a spouse, [or] is a single parent” (Gilardi & Guglielmetti, 2011, p.34). These non-traditional students have delayed their entrance into the higher education due to various reasons. As per the data by National Center for Education Statistics (NCES, 2011), the adult population in undergraduate courses is growing steadily over the last many years to the extent that it could overtake the numbers of the

traditional students enrolled. Between 2000 and 2010, the number of undergraduate adult learners increased by 42%, as compared to traditional students, whose number only increased by 34% (NCES, 2011). It has been projected, that by 2020, the number of adult learners will increase additionally by 20% (NCES, 2011). “Given the faster rate of increase for the adult postsecondary population, this signals an impending shift in the demographic composition of our nation’s institutions of higher education with regard to age” (Hernandez, 2013, p. 9). This new fast pace change in higher education is now becoming visible in community colleges and four-year universities (Callan, 2009).

This increase in the adult student population can be attributed to various factors. According to the Center on Education and the Workforce (CEW), “between 2008 and 2018 there will be just under 47 million job openings” (Carnevale, Smith, & Strohl, 2010, p .26). Of these 47 million jobs, around 24% will require a bachelor’s degree (Carnevale et al., 2010). According to the Council for Adult & Experiential Learning (CAEL), 2008, it has been predicted, that in order to balance and improve the economy of U.S., adult learners’ population is needed in the workforce with a bachelor’s degree. In reality, there is a steady increase in enrolment numbers of adult learners in higher education. Even though these adult learners make up a big part of the education system, they are classified as nontraditional students because the major part of their life is spent as working and not as a student (Wirt, Choy, Gerald, Provasnik, Rooney, Watanabe, & Tobin, 2002). They are considered nontraditional as most of the higher education is focused on traditional students who come directly out of high school (Nelken, 2009).

With the growing number of adult learners across higher education, colleges and universities are looking to serve this large growing population (Bruininks, Keeney, & Thorp, 2010, p. 115). The college experience is of utmost importance to the emerging adult learners.

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

“Those who attend college change their value and attitudinal positions in a number of different areas but that they do so as a consequence of attending a college or university and not simply in response to normal, maturational impulses or to historical, social, or political trends” (Pascarella & Terenzini, 1991, p. 325). Recent research finds that more women are now returning to community colleges and universities, as adult learners, to continue with their education (Compton et al., 2006)

Research indicates that since adult learners can play many roles at the same time, they have different needs than those of a traditional student (Kohler, Grawitch, & Borchert, 2009). Since these students are experienced as compared to traditional students, they have different styles of learning, (Kasworm, 2003). Anderson adds, “The success of the local, state, and national economies will depend on the ability of higher education to provide access to students whose age, background, socioeconomic status, and race-ethnicity are varied” (Anderson, 2003, p. 11).

### **Characteristics of adult learners:**

Adult learners become motivated to incorporate learning by making associations with their various social events, psychological characteristics, individual beliefs, experiences, and memories (Wigfield & Eccles, 1992). In addition, from an individual learner’s perspective, adult learners are more motivated, problem-oriented (Knowles, Holton, & Swanson, 2005), and self-directed (Straka, 2000). The adult learner, as explained by Arnett (2007, p. 152), experiences “identity exploration”, “instability”, “self-focus”, and “feelings of being in-between” while exploring a wide range of life opportunities and “possibilities”. Murphy, Blustein, Bohlig, & Platt (2010) find that adult learners have difficulty in “narrowing career choices” and “identifying abilities and interests” (p. 178), and hence suffer from a lot of stress (Arnett, 2000).

In contrast, it is found by Pascarella & Terenzini, (2005) that it is not easier for the adult learners to mingle themselves in higher education as “blank slates” (Swanson, 2013, p. 20) because they come to college with past societal, cultural, environmental, and work experiences. Adult learners can be attentive students but “information processing strategies such as repetition, elaboration, and organization are effective instructional tools because they aid in committing information to memory” (Weinstein & Meyer, 1991, as cited in Swanson, 2013, p. 41). Haggis (2002) has found that adult learners are autonomous, and can work independently in their educational setting, but ‘confusion’ and ‘disorientation’ was common in this group (p. 216). “A sense of direction was often absent, with only ‘an interest’, ‘a feeling’ or ‘a sense’ guiding what was seen more as an exploration than the execution of a predetermined plan” (Haggis, 2002, p. 216). It was also found that adult learners interact socially with their family, friends, peers, instructors, supervisors, and partners (Haggis, 2002). For the adult learners, it is not only the time spent in classroom that involves and inculcates learning, but it also includes the motivation to learn, which is offered in the form of instruction by their faculty (Wlodkowski, 2003).

Sometimes helping adult learners can be challenging, as “adults do not want to feel as if they are being treated like teenagers or young adults, yet they still need all of the same information—sometimes even more” (Bailey, 2007). There are distinguishable separations between adult learning and the traditional way of learning. Bailey (2007) researches that an adult learner needs an interactive learning environment, extra help like extended office hours, child day care, a friendly college environment, satisfactory time with their academic advisor, quick response times, and financial aid. Adult learners need to be engaged in classrooms because of the varied learning styles they possess. Student engagement has become necessary for higher education and serves as an indicator for quality education in higher education across institutions

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

(Matthews, Andrews, & Adams, 2011). Student engagement can be explained as “Education, at its core, requires one mind engaging with another, in real time: listening, understanding, correcting, modeling, suggesting, prodding, denying, affirming, and critiquing thoughts and their expression” (Hieronymi, 2012, p. 34). Adult learners need to “make sense and meaning out of new information and connect it to what is already known” (Barkley, 2010, p. 5). Teacher’s pedagogical tools, learning environments, and students’ interaction play a very important role in student engagement. Educators must make an effort to incorporate strategies to actively involve adult students in their classrooms. Handelsman, et al. state that, “The extent to which the teacher is engaged might be a strong predictor of student engagement and, subsequently, student learning” (2005, p. 190). According to Comings, Parella, & Soricone (1999), there are two characteristics of adult learners that can correlate with persistence: past educational experience, and a future goal in place. Students who had a previous experience in basic skills education or skills training are more likely to complete an education course or degree as compared to who did not. In addition, adult-students who had a specific goal or purpose to enter the program are more likely to persist as compared to those who had no idea of their intentions in their educational program. Adults are classified as self-directed learners, “bring experience to learning, be responsible for their decisions on learning that is task or problem-centered, and exhibit a relatively very high level of internal motivation” (Knowles, 1980; Knowles, 2011, as cited by Guan, Ding, & Ho, 2015). Since adult learners have unique learning styles and abilities, Ross-Gordon (2003) focusses on the importance of active learning for this specific student group. Adult learners have a vast experience in life and at work, so it is important that strategies that involve and support “cognitive growth and transformational learning, and their desires for immediate application of knowledge” (Ross-Gordon, 2003, as cited by Guan et al., 2015) are

used in classrooms. Ross-Gordon focusses the importance of using flexibility and structure in classrooms to help adult learners gain a great learning experience in classrooms (2003, as cited in Guan et al.). Even though the adult learners are complex and emotional, they “were ‘in control’ of their learning in the sense that they did not give up, they found strategies to enable them to cope with difficulty, and they were able to use difficulty, ‘intuition’, and emotion to enable themselves to continue learning in a way that was often also experienced as extremely positive” (Haggis, 2002, p. 217).

Educational psychology hardly focusses on adult learning, but with growing societal developments, adult learning has made a special niche in today’s education. In order to promote adult learning, it is important to find ways to motivate adult learners, and to find ways to incorporate learning styles and strategies that adult learners use (Wlodkowski, 2008). The theoretical models of adult learning believe in incorporating participation of adult learners in the education system (Schmidt, 2009). Salas & Cannon-Bowers (2001) also focus adult learning on non-mandatory professional development, training, and participation of adult learners to incorporate self-efficacy and self-confidence in this group. Eccles (1983) proposed the expectancy-value theory to explain how adult students learn. Various researches have applied the expectancy-value theory to adults’ learning motivation. According to this theory, as adult learners gain experience in their educational setting, self-ability and self-determination are developed and later becomes more stable and specific to their interest of learning (Denissen, Zarrett, & Eccles, 2007). Emotions and memories also play a very important role in adult learning (Pekrun, Goetz, Titz, & Perry, 2002). Positive memories improve learning opportunities for adults, and continuous negative performance feedback results in their frustrations (Weiner, 2010).

### **2.5 Theoretical Framework and Practical Approaches for Adult Learning**

Currently, there is no pure theoretical framework that defines and differentiates between adult learning and childhood learning. Some researchers believe that certain characteristics attributed to adult learning already exist in students of all ages (Gorges & Kandler, 2011). There are various ways by which theoretical perspectives and practical approaches that interlace the adult learning are described. Haggis (2002) writes that there are no straightforward applications of theory to practice in adult learning environments. Some researchers explain this theory based on curriculum planning and development. Others tend to focus on the characteristics of adult learners, adult learning processes, or instructional methods employed by instructors in classrooms. Some have explained this theory using student advising. Haggis (2002) further writes that there is no ‘universal truth’ about adult student learning theories and practices as there are “multiple factors involved in teaching and learning interactions” among the adult learners and their learning environments (p. 210).

#### **Adult learning theories:**

Various researchers have different frameworks of adult learning theory, of which, there are three that are the most studied- andragogy, self-directed learning, and transformative learning (Ross-Gordon, 2003). The first two types of adult learning theories focus on how adults learn, and the characteristics of adult learning, while the third theory focusses on collaborative learning environment (Guan, Ding, & Ho, 2015). The first adult learning theory focusses on andragogy, in which the theoretical approach is to find ways to teach the adult learner. Andragogy (in contrast to pedagogy) deals with “establishing a suitable physical and psychological climate for learning [of adults in classrooms]” (Ross-Gordon, 2003, p. 44, as cited in Guan et al.). The second framework of adult learning theory is self-directed learning. Self-directed learning is the

manner in which adult students learn based on a given situation (Ross-Gordon, 2003), which could even be outside of the classroom or in everyday life (Merriam, Caffarella, & Baumgartner, 2007). Transformative learning is a unique theoretical learning framework that helps adult learners to understand the information in classrooms, and process it to help create a new set of meaning based on their experiences (Taylor, 2008; Kasworm, 2008). The transformative learning is the third framework of adult learning that helps to interlace between the theoretical perspectives as well as practical approaches that adult students learn in classrooms. Providing a collaborative learning environment would be an example of transformative learning. Kasworm (2008) writes, that interlacing andragogy and self-directed learning perspectives with a collaborative learning environment could help develop ‘self-authorship’ amongst the adult learners. Transformative learning theory is an adult learning theory that helps to “reflect back on prior learning to determine whether what we have learned is justified under present circumstances” (Mezirow, 1990, p. 5). Adult learners have accumulated various life and work experiences that “are dispositions and capabilities that make up everyday involvement” (Mezirow, 1990, p. 4). Mezirow (1990) explains, “Adulthood is the time for reassessing the assumptions of our formative years that often have resulted in distorted views of reality” (p. 13). The process of transformation is understood as the “process of using a prior interpretation to construe a new or revised interpretation of the meaning of one’s experience in order to guide future action” (Mezirow, 1996, p. 162). Mezirow further explains, “the epistemology of how adults learn to reason for themselves” (p. 23) in the classrooms, which is so unique in adult learner populations. The transformative learning theory explains adult learners in education to be “an active participant in and an observer of the experience” (Hoggan, Simpson, & Stuckey, 2009, p. 15). In addition, this theory helps the adult learner by “triggering a person [adult learner] to

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

critically reflect upon their assumptions, worldviews or habit of mind...providing a new sense of knowing and a perspective transformation” (Hoggan et al., 2009, p. 18). “Critical reflection can be defined as the mental process of uncovering and challenging our taken-for-granted assumptions, considered as necessary in order to turn an experience into a transformative learning experience” (Cranton, 2006; Kegan, 2000; as cited by Hoggan, Simpson, & Stuckey, 2009, p. 14). Taylor (2007), explains transformative learning theory as the best theoretical framework for understanding adult learning. These adult students are of varying ages and come from different work, social, economic, and racial backgrounds. Due to a large diverse population of adult students, it is difficult for researchers to focus on a single, universal adult learning theory (Goddu, 2012). Baumgartner (2007) writes, “the study of pathways of adult cognitive development—that is, how thinking patterns change over time—is often linked to a combination of factors, primarily the interaction of maturational and environmental variables.” With so many adult learning theories, the good thing is that they all value personal development (Chen, 2014). Most adult theories “identify a crucial moment where learners transition from an externally driven perspective to an internally motivated and personally meaningful one by realizing the inadequacy of prior perspectives” (Chen, 2014, p. 409).

A few researchers have explained the term self-authorship as, “The challenge of higher education in serving adults is to create both learning that reflects the current adult learner’s world and creates possible alternative understandings of that world in relation to the enhancement of critical thinking, multiple worldviews, and self-authorship” (Kasworm, 2008, p. 31). Baxter Magolda (2008) defines self-authorship as the “internal capacity to define one’s beliefs, identity, and social relations” (Evans, Forney, Guido, Patton, & Renn, 2010, p. 183). Donaldson &

Graham introduce a comprehensive model that utilizes six adult learning theoretical elements that help make correlation to what adult learners learn in higher education. These elements are:

(a) prior experience; (b) orienting frameworks such as motivation, self-confidence, and value systems; (c) adult's cognition or the declarative, procedural, and self-regulating knowledge structures and processes; (d) the connecting classroom as the central venue for social engagement and for negotiating meaning for learning, (e) the life-world environment and the concurrent work, family, and community settings, and (f) the different types and levels of learning outcomes experienced by adults. (1999, p. 24).

Rachal (2002) researches the link between adult learning theory and coaching by the definition "The learner is perceived to be a mature, motivated, voluntary, and equal participant in a learning relationship with a facilitator whose role is to aid the learner in the achievement of his or her primarily self-determined learning objectives" (p. 219). Whitmore (2003) refers to coaching as "unlocking a person's potential to maximize their own performance. It is helping them to learn rather than teaching them" (p. 8). Adult students need that extra coaching that can help them to be successful in their program of study. The International Coaching Federation's (2002) defines coaching to a process that "helps people produce extraordinary results in their lives, careers, businesses, or organizations. Through the process of coaching, clients deepen their learning, improve their performance, and enhance their quality of life" (p. 1).

### **Learning styles of adult learners:**

Students have various learning styles and strategies. Learning is a process that incorporates an ability to do something from the acquired knowledge and fosters a change in an individual's behavior (Shuell & Lee, 1976). To foster learning, learning activities are important,

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

and they are described as specific techniques that learners employ to enhance their learning (Garner, 1988). Hallahan, Kauffman, & Lloyd (1996) defined learning styles as “preference for how information should be taught, presumably based on different ways learners process information” (p.576). “Learning styles are preferences and tendencies students have for certain ways of taking in and processing information and responding to different instructional environments” (Felder, 2010, p. 4). It has been found that there are “stable variations among learners in ways of perceiving, organizing, processing, and remembering information” (Schunk, 2012, p. 490). Hartman (2005) describes learning style of an adult to be an “effort devoted to the solitary pursuit of excellence [that] must far exceed efforts directly influenced or controlled by others” (Kirschenbaum, 1984, p. 159). Sarasin (1998) explained that learning style is “basically the preference or predisposition of an individual to perceive and process information in a particular way or combination of ways” (p.3). Sarasin further states, “Learning may be analyzed and understood according to the primary sense involved— visual, auditory, and tactile or kinesthetic” (p.9). Adult learners can incorporate learning using one of the two approaches as explained by Stevsson (1977):

1. Deep learning approach, in which adult learners actively analyze and search content to make connections between their learning and their experiences (Schmeck, 1988)
2. Surface learning approach, in which the learners are not able to make any personal connections between the content information, and learn it just for the purpose of taking a test and earning a grade.

Learning strategies are “techniques, principles or rules which facilitate the acquisition, storage, manipulation, retrieval and expression of information across different situations and settings” (Alley & Deshler, 1979). The three practical foundations of adult learning are

mentioned in the article by Chen (2003). First, Chen writes that adult learners are self-directed and use their experiences to their learning processes. Second, in adult learners, transformative learning also happens wherein long-standing beliefs are challenged. Transformative learning is defined as learning which ‘transforms problematic frames of reference to make them more inclusive, discriminating, reflective, open, and emotionally able to change’ (Mezirow, 2009a, p. 22). The third practical foundation of adult learning is critical reflection, which is defined as ‘active, persistent and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it and the further conclusion to which it tends’ (Dewey 1993, p. 9). Critical thinking involves “challenging assumptions, exploring alternatives, and developing reflective skepticism’ (Chen, 2014). Nelken (2009) writes that adult learners are not ‘blank slates’ (p. 183) and use their past experiences to associate their learning in classrooms, and also to redefine their goals for future.

### **Barriers for adult learners:**

Cross (1981) mentions many barriers that can affect the adult learners in higher education. Cross explains situational barriers like lack of time, lack of transport, family difficulties, financial constraints, etc. Adults can also face institutional barriers, like problems in classroom, inconvenient schedules, lack of guidance and support from financial aids and career advisors, etc. Kerka (2005) writes, adult learners deal with institutional barriers- if they are disadvantaged, then they may suffer from low self-esteem, self-confidence, self-perception, and can have a negative attitude towards education. Cross (1981) researches disposition barriers as obstacles for adult learners. Adult learners “have to deal with educational attitudes, self-efficacy, resilience, and attribution of failure” (as in Petty & Thomas, 2014, p. 474). Bandura (1977) explains the concept of self-efficacy as a way an adult learner may perceive the capacity to learn

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

in the classroom of a higher education institution. Madden (2001) writes that adult learners, with age, show age-related changes such as in cognition, processing of new information, changes in mental and oral reasoning, and spatial abilities. Lack of self-efficacy is associated with underperformance (Derakshan & Eysenck, 2009) and anxiety (Compeau & Higgins, 1995). In a study by Gist, Rosen, & Schwoerer (1988), it was found that adult learners show lower performance as compared to their younger counterparts. Martocchio (1994) found a negative relation between age and content knowledge given in classrooms. Young learners have more passion, interest, and desire to learn “since the purpose of development activity is to acquire additional knowledge and skills” (Phipps et al., 2013, p. 18). Phipps et al. also theoretically and empirically suggest that “age, ability, self-efficacy, and learning intentions play a central role in successful learning among adults” (p. 21).

### **Differences between adult learning and other levels of learning:**

Rogers & Illeris (2003), in their debate, explain the differences between child and adult learning. Illeris explains that the important difference between these two groups is the level of motivation. Children are dependent on their family and peer for support and education- in fact, forced to learn in their social and cultural setting. Adult learners, on the other hand, are independent. They are able to make their own decisions and take responsibility for their actions (Rogers & Illeris, 2003). Illeris further explains that children learn what they are asked to learn, while adult learners are inclined towards what will benefit them later on in their lives. Adult learners’ reasoning’s moves from facts and reasoning’s to critical thinking, and they have the ability to connect their life experiences into a dialectic thinking (Labouvie-Vief, 1980). Adult learners view the role of a teacher to be a collaborator or facilitator of knowledge (Merriam, 2001), while the traditional student thinks of the teacher to have an authoritative role.

There are distinguishable separations between adult learning and other levels of learning. Adult learners are different than a child learner, and according to various researchers, both these groups learn differently. A very prominent researcher on cognitive development, Piaget (1972) explained that, children's thought process comes from using symbols and words to depict objects, to understanding concepts and related ideas, to be able to use hypothetical and logical reasoning to understand a concept, and make an association to their learning. Schroeder (2001) explains that adults learning can be explained by the theory of constructivism, which fosters critical thinking, and which in turn enables adult learners to learn objectively and strategically based on their personal experiences. Since adult learners have more life experiences, both at work and personal, they tend to make personal connections of their experiences to the content data. Adult learners can mostly be classified as deep learners but sometimes as surface learners, and it all depends if they are able to make personal connections with the material and restructure it so that it can be coded into the long-term memory. Adult learners learn by making interconnections between their life experiences with the classroom information. Since the adult learners have had more experiences in life, their perspective in classrooms is different from the traditional students. Pizzolatto (2008) has identified three major areas that adult learners consider:

(1) identifying and achieving realistic goals, (2) making connections between academic courses so that learning becomes more integrated, and (3) becoming aware of how one's own academic experiences connect to one's life (p. 19-20).

Adults are different from children learners because adults are physiological, psychological, and socially more developed and have already established norms, values, self-concepts, and are self-determined (Schwartz, 1992). Petty & Thomas (2014) write that adult-learners need continuous

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

motivation for retention in their educational programs. The most important goal of an institution should be to maintain motivational levels, especially for their adult-learners (Tagg, 2003). Wise (2003) describes motivation to be “challenging tasks + good instruction + success + recognition = motivation” (p. 42). Comings (2007) mentions that adult-learners need career development programs in which career counselors can counsel adult learners regarding skill requirements and future career placements. It has also been found that adult learners need proper orientation before the start of their program so that dropout rates of these students could be reduced. The students that participate in adult-learning education belong to diverse cultures, backgrounds, socio-economic statuses, language differences, life and work experiences (Alabama State Department of Postsecondary Education, 2010). Kerka (2005) writes that differences in adult learner populations is based on age, sex, motivation levels, education levels, family circumstances, employment status, health factors, transportation, child care, and personal factors. Kasworm (2008) explains that adult learners enter higher education with a unique set of beliefs and notions, which are build, based on their personal, social, and work experiences, and this could affect their learning experience in an adult degree program.

Researchers and educators place a lot of importance to student retention (Sidle & McReynolds, 2009). It has also been found that, (adult) student retention and their success is directly related to self-persistence of these students (DeBerard & Spelmans, 2004; Kuh, 2005). Self-persistence comes from students regularly attending classes on their college campuses to finish a course of study (Kerka, 1998; Ponton, Derrick, & Carr, 2005). This self-persistence can come not only from past and present experiences of students, but can also come from interactions between the student and their institution (Tinto, 1975). Some researchers have given a lot of

importance to the role of self-determination, self-direction, and self-perception in adult learning theories.

The role of higher education is “to generate and transmit knowledge” (Levinson, 2010, p. 211). Colleges in the 21<sup>st</sup> century are facing many problems because of “Changing enrollment demographics, increased economic pressures and evolving instructional delivery platforms” (Swanson, 2013, p. 19). Asberg, Bowers, Renk & McKinney (2008, p.482) report that 69% of students who enter higher education suffer from extreme stress levels as compared to traditional students. For these adult learners, the high stress level can serve as a roadblock in their academic performances (Ji & Jhang, 2011). As noted by Murphy, Blustein, Bohlig, & Platt (2010, p.175), “Research is needed to elucidate how researchers, teachers, practitioners, and employers might help emerging adults create a positive trajectory for their personal and professional lives during this presumably pivotal time”.

## **2.6 Community Colleges**

Based on statistical data, about 44% of engineering and science graduates have attended community colleges in some phase of their lives (Tsapogas, 2004). There are some research inquiries done on the relationship between the community colleges and STEM students studying in them (Starobin, Laanan, & Burger, 2010). Community colleges play a very important role to help establish a bridge for STEM students to enter four-year colleges, thus helping to provide labor forces in growing STEM careers. (Starobin, Laanan, & Burger, 2010). NSF (2006) has proposed that there should be an increase of community college students entering into university programs because of the ‘leaky pipeline’, especially in STEM education. Hence, it is important to study the role of community colleges in motivating adult learners towards the STEM goals.

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Community colleges provide vocational training, on-site job training, and academic training to their students (Kasper, 2003). There are other advantages of studying in community colleges: smaller class sizes, low financial burden, financial aid opportunities, recognition for hard working students, scholarship opportunities, and easy transfer to four-year degree colleges. It is also a great educational place to witness diversity of students, who come from different backgrounds, cultures, ethnicities, and socioeconomic statuses. Students have easy access to their faculty, which can help non-traditional students to take on the “non-linear path” (Perez & Ceja, 2009) towards their degree completion and career goals. Tsapogas (2004) writes that females who are in STEM careers have attended a community college at some point of their lives, and it has been recognized that community colleges play a very important role in introducing women and train them to enter the fields in STEM areas (Starobin & Laanan, 2005). Netties and Millett (2008) refer to community colleges as “one of the most important innovations for higher education in the 20<sup>th</sup> century” (p.1). Students can choose to opt out of community colleges and can chose to attend once their problems outside home are solved providing an advantage over studying at a four-year college (Fry, 2002).

Community colleges are responsible for stimulating economic development by the service that they provide to the community by providing excellent educational training programs. Community colleges offer career and technical education (CTE) programs that allow certificate programs to students, who can directly enter the workforce and improve their self-sufficiency (Starobin, Laanan, & Burger, 2010). Community colleges have been a perfect place in research to study adult learners entering STEM fields because community colleges provide positive experiences for these students. The average age of students at the community college level is twenty-four years, of which 35% of students are over the age of thirty (Provasnik & Planty,

2008). According to the NSF (2009) statistics, over 35% of students enrolled at community colleges are students that belong to different ethnic groups. Community colleges provide an excellent opportunity for students irrespective of their age or color. Nontraditional female students at the community college bring a different environment with them as compared to the female students at the traditional four-year institution (Li, 2007). For instance, as per NSF (2007), twenty percentages of female students were married, while 15% were single parents at the community colleges.

There are various differences seen in the experiences and needs of students pursuing STEM fields at four-year colleges versus community colleges. Chang (2009) reports that there is more competition for grades seen at the university level as compared to at the community college level. At the community college, collaboration and group work is highly encouraged, which is not seen at the university level. Community college transfer students describe the community college classrooms as “breeding grounds for interest in the sciences and their university lecture halls as weeding grounds to relieve impacted majors” (Chang, 2009, p. 62). For example, community colleges not only provide academic opportunities for its students, but also provide a strong social support system for them to be successful in STEM fields (Valenzuela, 2006). Students who have studied at community college get accustomed to studying together in a collaborative learning environment. They inculcate the habit of learning in a collaborative learning environment. For example, in a study by Elena-Reyes (2011), when transfer female students work together in collaboration to study mathematics, they found that they were more confident in their ability to work on problems. A Mexican American graduate student (A. Cortes) attributes her success in mathematics to a group of transfer students who would meet “over the kitchen table at one of the women’s parents’ house” (interview cited in Elena-Reyes, 2011).

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Research has found that if nontraditional students feel a sense of belonging at the institution, then they stay and try to complete their STEM major degree. In community colleges, students interact more with their faculty members, have more one-on-one interactions, and can easily associate their faculty to be their role models. Community college students often look up to their professors for guidance and motivation.

Community colleges have an open door policy for all students (Zamudio, 2015).

Researchers place community colleges as one of the most important innovations for higher education in the 20<sup>th</sup> century. Community colleges not only provide affordable education, but also offer a wide variety of programs ranging from vocational to transfer. In 2007, 6.6 million of the 15.6 million undergraduates were enrolled in community colleges (Planty, Provasnik, Hussar, Snyder, & Kena, 2009). In the past twenty years, both part-time and full-time attendance has grown more rapidly at community colleges than at four-year institutions (Nettles & Millett, 2008). In the 2013-2014 academic year, 46% of students who completed a degree at a 4-year institution report attending a community college at some point in their schooling careers (National Student Clearinghouse, 2015). This implication points to the importance of retention programs at community college as being one of the most important student services programs that encourages enrollment to grow in the 2-year sector of higher education. Students who belong to a lower SES are more likely to attend community college as a bridge program towards a 4-year institution (Adelman, 2005). Data by Malcom (2010) indicates that STEM students who are females or first generation are more inclined to enroll in a community college to attain their bachelor's degree. According to the National Center for Education Statistics (2012), there were 17.7 million undergraduates enrolled in postsecondary degree-granting institutions. While students get a personal attention at the community college level, universities are structured very

largely and may not cater to the individual needs of students (Raeff, Greenfield, & Quiroz, 2000). There is a big difference in statistics between the community college and a four year institution- over 35% of students enrolled in community colleges are students of color and 21% of students are women of color (NSF, 2009). Comparatively, students of color make up 27-30% of the total student population in a 4-year institution. The number of nontraditional students at the community colleges is higher as compared to the traditional students: twenty percent of students are married with children, and around 15% of students are single parents (Li, 2007).

### **Community College Classrooms:**

As per the American Federation of Teachers (2010), about three quarters of the faculty teaching at community colleges are part-time adjunct (AFT, 2010). “Many of these faculty members do not embrace a cohesive presentation of STEM nor do they acknowledge relevance of STEM initiatives to their daily teaching practice” (Breiner, Harkness, Johnson & Koehler, 2012 as cited in Gess, 2015, p. 19). Most of the STEM faculty of community colleges spend 16% more time in lecturing and significantly less time in incorporating pedagogical techniques that involve active learning to improve self-confidence and learning in adult learning classrooms (Hyde & Gess-Newsome, 2000). John Savery (2006) sums the problem when he asserts that, “teaching discipline specific content using a traditional lecture approach does not prepare students to apply knowledge in alternate contexts or clinical application, which, in this age of information, is constantly changing” (p. 10). Furthermost, these faculty members are not prepared to teach a classroom of diverse students in a way that integrative STEM learning occurs across these diverse ways of learning (Gess-Newsome, Southerland, Johnston & Woodbury, 2003). Compared with university students, community college students come from environments with limited possibilities (Strawn & Livelybrooks, 2012).

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Steinberg (1996) writes that students have changed over the last 25 years for time and engagement that they put in classrooms and in class assignments and homework. Steinberg (1996) defines engagement as “the degree to which students are psychologically ‘connected’ to what is going on in their classes” (p. 15). Furthermore Steinberg claims that a few years ago a classroom had a few handful disengaged students, but currently more than half the students have “checked out” (p. 28). He further researches that disengagement in classrooms is more harmful to our country’s future than some other social problems involving youth. Disengagement results in underachieving students and this can lead to many other national issues. So in order to prevent this from happening, student engagement must be the top priority of all educators, administrators, parents, and researchers.

### **Pedagogies in Higher Education/ Community College Classrooms**

Historically the most common and dominant pedagogy of teaching has been the “culture of isolation and autonomy” (Bush, 2001, p. 19). Lortie (1975) writes that the teachers are “assigned specific areas of responsibility and are expected to teach students the stipulated knowledge and skills without assistance from others” (p. 15). “The current trends in education support the position of working together for the betterment of the students” (Bush, 2001, p. 39). Furthermore, Hallmark adds, “in the science classroom, strategies to increase student engagement in the learning process have led to the development of a student-centered pedagogy” (2014, p. 21). It is found that women and minority students learn better and are more engaged when they learn in a collaborative environment compared to traditional authoritative lecture based pedagogy (Chinn & Malhotra, 2007). Currently, the most common form of teaching an undergraduate classroom is by the traditional way of teaching where there is a “teacher-centered transmission of information via lecture in which student interactions, examination of ideas, and

multiple perspectives are constrained” (Smith & MacGregor, 1992, p.16). This creates an environment in which the student feels isolated and lonely and is working in competition with classmates (Table 1). When a student feels lonely then this concept may prevent the student from approaching teachers and other students from asking questions, and thus prevents an engaging and meaningful conversation (Osterholt & Barratt, 2012).

Table 1.

*McConnell’s Traditional vs. Collaborative Learning Characteristics*

<b>Traditional Learning</b>	<b>Collaborative Learning</b>
Passive students	Active students
Instructor-centered	Student-centered
One way communication: instructor to student	Multidirectional communication: instructor to student, students to instructor, and between students
Competitive learning environment	Interactive, motivated, and supportive learning environment
Individual learning	Group learning
Quiet classroom	Noisy classroom because of interaction and communication

## 2.7 Science Literacy

Learning science through inquiry requires a science pedagogy that places emphasis on student led instruction. Inquiry-based instruction is grounded in Deweyian techniques. Dewey (1938) stated, “Scientific principles and laws do not lie on the surface of nature. They are hidden, and must be wrested from nature by an active and elaborate technique of inquiry (p. 32). In order to improve student engagement and retention in science classrooms, it is important to develop student-centered pedagogy. Dewey believed that “all genuine education comes from experience”

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

(Dewey, 1938, p. 25). Science learners should be able to critically think, solve problems, and monitor their competency continually such that they should be able to apply their classroom knowledge to the real-world problems (Bransford, Sherwood, Vye, & Rieser, 1986). Wolf and Fraser (2008) researched the positive effect of hands-on laboratory activities on science achievement and retention. Although researchers emphasize scientific inquiry and design as key components (NRC, 2012) in teaching science, NRC suggests that science literacy also includes:

...making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results (NRC, 1999, p. 23).

It is important that faculty members should have students "...work as scientists, have them feel like scientists and ensure changing their scientists image" (Karacam, 2015, p. 205). There is tremendous amount of research on the positive effects of active learning strategies leading to inquiry-based science instruction. "Effective instruction capitalizes on students' early interest and experiences, identifies and builds on what they know, and provides them with experiences to engage them in the practices of science and sustain their interest" (NRC, 2011, p. 18). In an effort to understand the downward trend of STEM literacy in the U.S., it is necessary to view various other factors that may have a positive influence to improve STEM literacy. There has been a lot of research on using effective pedagogical tools to influence students' interests in the fields of science, engineering, and mathematics. "Scientific inquiry includes evaluation of the investigation, reviewing of procedures, examining evidence, identifying faulty reasoning, pointing our statements that go beyond the evidence and suggesting alternative explanations for

the observations” (NRC, 1996, p. 171). The current pedagogy for science learning in classrooms focuses on “developing understanding on a deeper level that enables to the student to link the new information to prior knowledge, and organize and assimilate the new information” (NRC, 1999, p. 9). Concepts of science can be developed by students answering questions to achieve a deeper understanding of the scientific concepts and applications (Kuhn, Black, Keselman, & Kaplan, 2000).

Kanter & Konstantopoulos (2010) researched the impact of inquiry-based collaborative pedagogy on the science achievement of minority students in high schools. They used pretest and posttest differences on student participants to determine effect of collaborative learning strategies on ethnic groups. Teacher use of collaborative strategies like students explaining concepts to one another and analyzing data had a positive relationship to student interest in doing science. Inquiry-based science pedagogical strategies may help to improve student understanding of the concepts of science, thereby increasing their success and perhaps increasing the number of students pursuing STEM majors (Hallman, 2014). Mezirow (1997) writes, students who come from environments with limited possibilities learn better from others’ experiences. There are lots of research studies that point that community college students are mostly first generation college attending students who come from environments with limited visions (Strawn & Livelybrooks, 2012). Mazur in his research found that his students learned the concepts of science much better in a group guided by an instructor than just from the instructor (Hanford, 2011).

NSES suggested that science faculty, in general, spends more time teaching the content of science and give less time for the students to critically think about the topics learned (Brown, Brown, & Merrill, 2012). The students should be kept engaged in such a way that they are able to apply the knowledge to engage in scientific practices (Ayres, 2016). Collaborative approaches

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

are strongly recommended in science classrooms by educational facilities and government institutions (Moore, 2002).

### **2.8 Collaborative Learning in Classrooms**

#### **Collaboration and Collaborative Learning:**

Educators at all levels are using various forms of collaborative techniques in classrooms, and it has found to be a very successful pedagogical tool in STEM classrooms (Pazos, Micari, & Light, 2010). There are so many ways in which the term collaboration has been defined by educators and researchers. In the *Culture of Education*, Bruner (1996) defines collaboration as “sharing the resources of the mix of human beings involved in teaching and learning” (p. 87). In *Shared Minds: The New Technologies of Collaboration*, Schrage (1990) defines collaboration as “the process of shared creation – two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own” (p. 40). John-Steiner (1997) defines, “Collaboration operates through a process in which the successful intellectual achievements of one person arouse the intellectual passions and enthusiasms of others, and through the fact that what was at first expressed only by one individual becomes a common intellectual possession instead of fading away into isolation” (pp. 187-188). The term collaboration has been used in a variety of ways in education: in schools, colleges, universities, educator’s professional development, teacher training, and in problem solving and decision-making (Bush, 2001). The term “collaborative learning” refers to an “instruction method in which students at various performance levels work together in small groups toward a common goal” (Gokhale, 1995, p. 22). Collaborative groups are characterized by students working with other students to problem solve or practice skills without direct help from their instructor; the instructor’s role is to be the facilitator or guide for groups when they

need help. Traditional classrooms, on the other hand, are characterized by lecture or individual seatwork with feedback provided only by the teacher: a one-way communication.

Collaborative learning induces creativity and creativity is a self-reflective process (John-Steiner, 1997). Schrage (1990) believes that creative people “invent peer groups appropriate to their projects [and] therefore invents new forms of collaboration’ (p. 44). Collaborative learning has been promoted in the K-12 education since the middle to late 1900’s (Bush, 2001). There is a lot of research done and books written that introduce, describe, and encourage collaboration in schools. A few of these being: *Collaborative Practitioners Collaborative Schools* by Pugach and Johnson (1995); *Interactions: Collaboration Skills for School Professionals* by Friend and Cook (1996; Second edition); and *Best Practice: New Standards for Teaching and Learning in America’s Schools* by Daniels and Zemelman (1998). Bush (2001) writes, each of these books viewed collaboration in relation to problem solving, learning, and communication; during that time collaboration was classified as being an integral part of constructivism- the most widely known theoretical framework for collaboration.

In spite of so many recommendations by researchers and administrators, collaboration and collaborative learning has mostly been researched in K-12 education especially at the primary and secondary levels. There is very little evidence of the benefits of collaboration and collaborative learning at the community college and university levels (Gokhale, 1995)

### **Theoretical Framework for Collaborative Learning:**

Dillenbourg, Baker, Blaye, & O’Malley (1995) describe three distinct theoretical framework approaches for collaboration. First approach is the social constructivist theory, in which collaboration helps students’ cognitive development, as described by Piaget (Chi & Wylie, 2014). Second is the socio-cultural approach, inspired by Vygotsky, which is a constructivism

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

theory in which collaboration helps in building interactions and communications and which leads in learning benefits. A good example of this concept is Vygotsky's (1978) Zone of Proximal Development that proves that as compared to traditional learning, students learn better in a group under the guidance of an adult. The third is interactionist approaches, in which researchers write that social interactions are the basis for learning in classrooms (Plucker & Barab, 2005).

The main theoretical framework for collaboration lies in constructivism theory whose main proposition is "learning, constructing, creating, inventing, and developing one's own knowledge". Learning in constructivism environment comes from questioning, reasoning, engaging, interpreting, and analyzing information; then thinking and building on current conceptual knowledge, and integrating current experiences with past knowledge (Bush, 2001). On the other hand, the traditional way of teaching encompasses rote memorization, knowledge accumulation, and recitation, which are more orderly in nature, time efficient, under control, and predictable.

Collaborative learning seems to fall under the constructivism theory (Marlow & Page, 1998). Perkins (1999) describes three learner roles in constructivism- active learner, social learner, and creative learner. These three learner roles could also be implied to collaborative learning. Active learners "discuss, debate, investigate, and hypothesize", social learning students work in cooperation with others, and creative learning students creates and recreates knowledge" (Perkins, 1999, as cited in Bush, 2001, p.48). Lamber (1995) also classifies collaborative learning under the framework of constructivism because conversation is a way by which collaboration is done and is characterized by "shared intention of 'truth- seeking,' remembrances and reflections of the past, a search for meaning in the present, a mutual revelation of ideas and information, and respectful listening" (p. 85). According to Vygotsky (1978), "Every function in

the child's cultural development appears twice: first, on the social level, and later on the individual level; first between people (interpsychological) and then inside the child (intrapsychological)" (p. 57).

### **Collaboration Construction in Classrooms:**

"Since the earliest American study on collaborative learning in 1897, hundreds of studies have been conducted attesting to the validity of employing grouping techniques in the classroom" (Wood, 1992, p. 96). Collaboration is an active learning process in which learners construct new ideas based on their prior content knowledge (Brooks & Brooks, 1993). As compared to the traditional way of teaching and learning, collaboration can improve students' "creativity, autonomy, independent thinking, competence, confidence, and self-esteem and as making students dependent, conforming, and nonthinking" (Marlowe & Page, 1998, p. 13). It is very important for the faculty members to make the transition from 'teacher-center' theory of teaching to focusing on student-centered framework, and failure to do this could be one of the biggest obstacles for teachers in classrooms (Steffe & Gale, 1995).

Osterholt & Barratt (2012) suggest that collaboration can be started with forming pairs, then having groups of three or four, and with practice can form large clusters. Grouping for collaborative learning can depend on instructor experience, classroom size, and subject content. An experienced instructor could begin with having four students in one collaborative learning environment group. Osterholt & Barratt further write that as the group size increases, students can practice their skills better and hence can be found to be more engaging and build self-confidence.

### **Classroom Design Layout:**

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

As compared to traditional classroom layout in which the instructor stands in front of the classroom and students are seated in front facing the instructor, collaborative learning classroom design is very different. In a collaborative classroom, students sit in groups of 2-4 students facing each other in such a way that they can easily communicate with one another, and at the same time can see the instructor. Jorion et al. (2016) writes that the arrangement of tables and chairs is very important to have a successful collaborative learning environment. Jorion et al. researched an undergraduate STEM class and found that students were more engaged with one another, and the instructor was engaging with all students in a classroom where students were seated in such a way that they faced each other. Jorion et al. (2016) interviewed instructors teaching undergraduate courses and in their study, the instructors noted that:

“Table setup of the [collaborative] facilitated relationship building between students, which helped formulate community among them and stronger ties with the university. Cultivating such a student community within the classroom motivated students to do better academically and stay on task, which impacted learning outcomes.” (p. 728)

In traditional classrooms with front-facing desks, students often hesitate to ask questions to their instructors because either they may be scared or nervous to ask, or they do not want to appear unintelligent in front of their classmates (Jorion et al., 2016). Students feel more comfortable facing each other and asking simple questions to their peers rather than raise their hands to ask for explanation in front of the whole class. In their study, Jorion et al. (2016) also found that the height of the tables should be elevated so that the instructor should be at level with the students. This arrangement not only “made it easier for the instructor to look at the students’ work and provide feedback, but it had a psychological impact as well: no longer was the teacher “looking down” at the student, but rather guiding them as a mentor” (p. 728).

### **Criteria for Implementing Collaborative Learning in Classrooms:**

Role of instructor has been thoroughly researched in collaborative learning environments in classrooms, but the criteria for implementing collaboration in classrooms is not much researched, and must be thoroughly planned and implemented by the instructor. There are three criteria that are discussed by Osterholt & Barratt (2012) in their research which are the guiding principles for implementing collaborative learning in classrooms. (1) the instructor should have knowledge on collaborative-based learning in classrooms; (2) the instructor should prepare activities based on the content that needs to be taught in a way that induces critical thinking opportunities for students working in collaborative groups and hence incorporates a learning benefit to all student members of the collaborative group; and (3) the instructor should be present during the collaborative exercises and must be available to provide any guidance to the students if necessary. Not only should the instructor be effective in implementing collaboration, but he/she should also “help students enhance their emotional intelligence to become successful learners” (Wilkinson, 2009)

According to Stephen Brookfield (Osterholt & Barratt, 2012), before implementing collaboration in classrooms, it is important for the instructor to briefly talk about the content topic and the expectation from the unit to be taught. Second, instructors should ask some questions “to develop an awareness of how the students are experiencing learning” (p. 24). Third, helping build trust amongst the students and helping build confidence in them, which in turn, can help in increasing “self-awareness and self-regulation”, which will also help strengthen their communication skills. Sousa (2006) suggests that instructors should incorporate collaboration into their classrooms every day, which can help students to get into the practice of working in groups. Once the groups are formed, Osterholt & Barratt write, “faculty should direct

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

the collaboration by setting the purpose, identifying specific outcomes, and assigning various roles to the group members” (p. 24). Once the roles has been assigned, different members of the group should take turns to manage the group and make sure that each and every member is actively engaged in the collaborative learning environment. Groups should be changed regularly to ensure that every student in the classroom has the opportunity to work with every other student in the classroom. The instructor must make sure that students understand the benefits of working in collaboration, and the most important point to consider when planning collaboration is to make sure that every student feels motivated to interact in the collaborative setting. The instructor should make sure that “an all-inclusive component is built in so no one is exempt from participating” (Osterholt & Barratt, 2012, p. 24).

### **Advantages and Benefits of Collaborative Learning:**

Schmoker (1999) states that collaboration can result in higher student achievement and “an expanded pool of ideas, materials, and methods” (p. 12). Collaboration enables STEM disciplines to increase opportunities for knowledge sharing and exchange, thereby “increasing knowledge awareness, sensitivity and competence” (Ejiwale, 2014, p.35). Ejiwale further describes that absence of collaboration, in education, can be problematic as “facilitating collaboration across Science, Technology, Engineering, and Mathematics (STEM) fields in program development is critical to providing a strong educational foundation to all learners in STEM education” (p. 35). Collaboration “not only provides a common ground but the collaborative process invites divergent thinking and multiple perspectives in order to produce innovative and unique outcomes” (Bush, 2001). This type of learning can go beyond our own perspectives and may help students to see a very different viewpoint. Gokhale (1995) writes that collaborative learning environments not only induce subject interest in students but also

promotes critical thinking and problem solving, which can induce learning benefits. Johnson & Johnson (1986) researched that students who work in collaborative environments retain information much longer and deeper as compared to students who work individually in traditional classrooms. Terenzini, Cabrera, Colbeck, Parente, & Bjorklund (2001) found that students who studied in an active and collaborative environment scored better in cognition and psychological activities as compared to students taught in traditional classrooms. When students share their knowledge, personal experiences, ideas, and engage in group discussions, they become better critical thinkers (Totten, Sills, Digby, & Russ, 1991). Both Piaget and Vygotsky have recognized the interconnection between cognition and social development (Osterholt & Barratt, 1992) and have found that collaboration has positively improved “academic achievement, intergroup relations, acceptance of mainstream students, and increased self-esteem” (Slavin, 1981). Johnson & Johnson (1997) researches that “it is only through collaboration with another that students will develop positive expectations about working with others, constructive attitudes toward controversy, and the ability to adopt another person’s perspective” (as cited in Osterholt & Barratt, 2012, p. 22). In contrast to a lonely environment that is created when the pedagogical tool is teacher-centered authoritative environment, Osterholt & Barratt research that collaborative learning environment:

...puts a meshing of student learning and content coverage within an interdependent participatory community front and center. It reshapes the roles and relationships of teacher-student and student-student, questions long-held assumptions, and greatly alters the expectations of students to be active participants and colleagues in the learning process. All of these elements foster the social and emotional growth of students. (p. 23)

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Johnson, Johnson, & Smith (1998) found that students who learned in collaborative environments scored higher on achievement scores than traditional learners. These students also scored higher than students who studied in competition with one another. Jorion, Taeyaerts, & Jeanes (2016) write that collaboration helps to improve “measures of knowledge acquisition, retention, creativity, procedural skills, and higher-order thinking, as well as indicators of student motivation, perseverance, self-esteem, and meta-cognitive thought. These results held true across math, science, engineering, and verbal domains” (p. 725). With all the learning benefits and achievement gains that collaborative learning environments provide, it is important to incorporate collaborative learning environments in classrooms in higher education. Dede (2010) describes collaborative learning environment as an important 21<sup>st</sup> century skill that “is not merely a means to an end, but crucial to enhance” (p. 55)

### **Drawbacks of Implementing Collaborative Learning Environment in Classrooms:**

With all the advantages that collaborative learning environment techniques offer, these pedagogical techniques are not easy to implement in classrooms. Buzbee Little (2005) determined that even though collaborative practices enhance student learning and experiences, they provide many challenges in their implementation- one of them being teacher willingness. For example, teachers may lack skills for implementation of collaboration in classrooms (Leonard & Leonard, 2001). Hallway describes, “Teacher efficacy, time constraints, fragmented vision, competitiveness, and conflict avoidance are other challenges to successful collaboration” as the major obstacles in its implementation (2014). In addition, educators feel that their schools and colleges do not consider or support “regular, high levels of collaborative involvement” (Leonard, 2002, p. 11). Leonard also found that teachers and educators did not have enough time in their schedules to incorporate collaboration on a daily basis. The start-up energy that it takes

to begin the collaborative process is more than some teachers are willing to invest (Bush, 2001). Sawyer & Rimm-Kaufmann (2007) research other obstacles in implementing collaborative learning environment: unwillingness of instructors to give up class planning time, and little or no support from administrators. In addition, Little (1990) states that “group settings more readily reveal uncertainties in the classroom. Although the promise of praise and recognition is greater, so too is teachers’ exposure to criticism and conflict” (pp. 530 – 531). Another important reason could be the lack of funding to support such pedagogical techniques (Drago-Severson & Pinto, 2006). Amongst all this, the educators, who are under pressure to follow standards of learning and introduce collaboration, may not get any formal training in the implementation of collaboration in classrooms and among peers and colleagues. “The very nature of collaboration as an unpredictable, teacher-led process encourages some administrators to erect the safe simulation of contrived collegiality that can be more controlled than the reality of collaboration (Bush, 2001, p. 40).

In irony, among the students, establishing collaborative relationships may not be easy because of differences in lifestyles, experiences, background, and socio-economic statuses (Stowell, 2005). Because of all diverse backgrounds seen in classrooms, it can be hard to implement collaboration in classrooms. Glaser (1995) writes that when collaboration is not done effectively, then it “fails in a cloud of mutual distrust and hatred. It can be a treacherous and dangerous business” (p. 103).

In a study involving undergraduate students, it was found that trust was a very important factor in classroom collaborating learning environment, absence of which can foster insecurities amongst students (Bush, 1998). Teacher experience also plays a very important role in the proper implementation of collaboration in classrooms. An experienced teacher might be more flexible in

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

making pedagogical changes in classrooms because of the comfort with the content area. A new teacher/faculty member might not feel comfortable in adding active learning in classrooms because of insecurity with the content area (Bush, 2001). Gokhale (1995) researched that some students thought that it was a waste of time explaining material to other students.

Some researchers have argued that collaborative learning pedagogical technique might compromise on the content knowledge- meaning it may take away from teacher's class time. But Smith & MacGreggor, 1992) explain that collaborative environments do not sacrifice content but rather facilitate a deeper understanding of the materials in the subject taught such that the applications of the content are discussed rather than just rote memorization of the concepts. Collaboration just does not mean that students are working together in groups; rather it is a pedagogical tool that instructors implement in classrooms to benefit all members of the learning environments.

### **Role of Students in Collaboration:**

According to Stowell (2005), one of the most important things, students should be able to “collaborate with his/her team members and create a culture where members value and listen to alternative views and seek out win-win objectives. This can be accomplished by clearly identifying common needs and objectives; and certainly should occur on multiple occasions over time.” In this student-centered pedagogy, it is important that the students become responsible and discuss, debate, engage, and re-evaluate as learners in classrooms (Perkins, 1999).

There will be strong students in a group and there will be weak links, and it is important that the group members not only support one another but also motivate and gently guide the weakest links in their collaborative learning group (Marchand, 2009).

### **Role of Instructors in Collaboration:**

Hargreaves (2002) points out that “strong professional communities depend on teachers’ capacity to blend commitment with doubt and a shared passion for improving learning and achievement along with healthy disagreement about and inquiry into the best ways to do it” (p. 404). In other words, teachers need to have the skills, commitment, and leadership support to collaborate effectively. Implementation of a collaborative environment should be done in such a way that the faculty members should impose discipline and be able to solve any problems that arise amongst student members (Ejiwale, 2014). Faculty members should also foster “synergism by tapping into the individuals’ strength rather than focusing on their weaknesses” (Ejiwale, 2014, p. 36). Gokhale (1995) sums up the role of an instructor as:

For collaborative learning to be effective, the instructor must view teaching as a process of developing and enhancing students’ ability to learn. The instructor’s role is not to transmit information, but to serve as a facilitator for learning. This involves creating and managing meaningful learning experiences and stimulating students’ thinking through real world problems. (p. 30).

The instructor should take up the role of a facilitator and guide and give up the teaching role. Pazos et al. (2005) find in their study that the way in which the students interact and communicate in their groups had a direct relationship with their confidence to succeed in the course. So it is utmost important for the facilitator/instructor to organize the collaborative environment in such a way that students can find benefit in studying in collaboration with other student members of the group and also show self-efficacy related to one’s ability to do well in the course. In addition, the collaborative learning in classrooms should be organized to counteract negative classroom stereotypes (Bransford, Brown, & Cocking, 2000)

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Ejiwale (2014) suggest that in collaboration, faculty members should guide the students such that the activity should be inclusive and open to all, helps to build consensus amongst participants, and provide an environment in which decision-making is not rushed. When a conducive collaborative environment is provided and “when people with multiple talents are placed in teams, they will interact, cross-fertilize ideas, and collaborate to produce” (Jassawalla & Sashittal, 2006). Educators need to break all barriers “with appropriate delivery methods and approaches”, be successful collaborators and “be prepared to deal with challenges as well as reap the benefits of effective communication and increased student achievement.” (Ejiwale, 2014, p. 38). An integration of STEM fields will only be possible if faculty members in a department support each other and encourage open communication with one another. The unity of the department and cooperation amongst the faculty members can “further the collaboration and present an effective instructional advantage to students” (Ejiwale, 2014, p. 39).

Faculty members with deep content knowledge become facilitators in classrooms and guide their students towards a content inquiry process. There are two important roles of an instructor in a collaborative classroom: “(1) the ability to work with others whose professional orientation, talents, and knowledge differ; and (2) the ability to take maximum advantage of the different professional orientations, talents, and knowledge of the individuals in the group” (Hart, 1998, p. 109). The instructors also have a challenge to make sure that there is no passivity, negativity, or discouraging behaviors in groups.

### **2.9 Summary of the Literature Review**

Improving student success in higher education is a national priority and it is important to highlight community colleges as one of the main resources to improve number of graduate students in STEM education. The previous president Obama, during his administration, talked

about the importance of community colleges playing a key role in improving number of graduates, and preparing graduates to be leaders in the twenty-first century workforce (White House, 2016). The President had directed funds towards community colleges during his administration in support of a goal for the U. S. to lead the world in numbers of higher education graduates by 2020 (White House, 2016). His initiative, America's College Promise, had laid out the goal of making the first two years of community college free (White House, 2016).

The design of this study is to help educators understand the benefits of a collaborative learning environment in a biology classroom at the community college setting. The purpose of this study is to establish the need for collaboration and explore ways to teach biology in an integrative setting at the community college level. This dissertation is based on three important things: (a) exploring the effects of collaboration in a biology classroom at the community college, (b) explaining findings from an educator's study focused on the content taught in science (biology) classroom using collaboration, and (c) offering suggestions on how other science and STEM faculty members can create or enhance pedagogical tools and partnerships to better utilize the strengths of their disciplines.

CHAPTER THREE

RESEARCH METHODOLOGY

**3.1 Overview**

On page 3 of a pamphlet published by the Royal Institution, London, titled *Advice to a Lecturer*, Michael Faraday writes that “a lecturer should exert his utmost efforts to gain completely the mind and attention of his audience, and irresistibly make them join in his ideas to the end of the subject” (as cited in Fagen, 2003). One effective way to involve students in a large classroom is by providing a collaborative learning environment that induces interest in learning. Fagen (2003) identifies that the field of biology education research is less researched than other STEM fields. Undergraduate education in biology largely involves presenting factual information which students memorize and then regurgitate on the exam. This type of learning does not translate into true understanding of the underlying concepts of biology, which in future could jeopardize with the learning of biology (Mintez et al., 2000). Mintez et al. also found that such students graduate from school with distorted views of the biological world, and seem to have no interest in the field. There has been a growing awareness of using various pedagogical and classroom tools to refocus biology education on creating interest, and at the same time, help students understand the core concepts of biology (Mintez et al., 1998, 2000).

This research was designed to reveal to what extent changes in undergraduate student learning outcomes occurred in a collaborative learning environment in a biology classroom. This research was conducted in general biology (Biology 101 and Biology 141) classes at the community college level. The goal of this study was to address research need by providing evidence that undergraduate biology students who studied collaboratively scored significantly higher on measures of assessment (pretests versus posttests scores) than students who studied

individually in a traditional classroom. This study used the quantitative approach for data collection and analysis using scores from assessment questionnaires (pretest and posttest). This study was a quasi-experimental, pretest-posttest, control group design. The sample consisted of students enrolled in general biology (Biology 101 and Biology 141) classrooms at Blue Ridge Community College (BRCC). The classrooms were divided into two groups: traditional (control) and collaborative (experimental).

In this chapter, the investigative methods for this study are described in the following sections: Research questions and hypotheses, research design, population and sample, Biology 101 and 141 courses, instructional pedagogy, instruments, data collection procedures, data analysis (quantitative), quality criteria, role of researcher, and summary.

### **3.2 Research Questions and Hypotheses:**

The three research questions for this investigation developed by the researcher will provide a detailed exploration of collaborative learning in a biology classroom at the community college level.

**RQ1:** To what extent does a collaborative learning approach in the community-college classroom result in changes to students' biology science content knowledge?

**RQ1-  $H_0$ :** Collaborative learning approach in the community-college classroom does not result in changes to students' biology science content knowledge.

**RQ1-  $H_A$ :** Collaborative learning approach in the community-college classroom results in changes to students' biology science content knowledge.

**RQ2:** Are there identifiable differences in achievement for groups of students learning traditionally and groups of students learning collaboratively?

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

**RQ2-  $H_0$ :** Identifiable differences in achievement are not identified for groups of students learning traditionally versus groups of students learning collaboratively

**RQ2-  $H_A$ :** Identifiable differences in achievement are identified for groups of students learning traditionally versus groups of students learning collaboratively

**RQ3:** What differential learning impacts are identifiable in a STEM educational environment employing collaborative learning?

**RQ3-  $H_0$ :** Differential learning impacts are not identifiable in a STEM educational environment employing collaborative learning.

**RQ3-  $H_A$ :** Differential learning impacts are identifiable in a STEM educational environment employing collaborative learning.

### 3.3 Research Design

The methodology used in this study was a quasi-experimental design because the sample students were not randomly assigned in the research experiment. The sample of students in this study attended Blue Ridge Community College at Weyer's Cave main campus during the Spring 2018 semester. These students either self-enrolled in the general biology courses, or were enrolled by their academic advisor. The independent variable in this study was the treatment group, while the dependent variable were the assessment tests. Two measurement instruments were employed to assess the conceptual understanding of the topic: a pretest and a posttest, and a pre and post science vocabulary familiarity scale (preSVFS and postSVFS). A demographic survey was also taken at the beginning of this research to help researcher determine what factors may influence the study.

Two different learning environments were provided in classrooms: traditional and collaborative. So that students begin at the same learning platform, all students in both the

traditional and the collaborative learning environments were introduced to the vocabulary required for the basic understanding of the material. The students in both the collaborative and traditional learning environment were chosen based on their lab section. For each participating class, students in the first lab section were exposed to the traditional environment, while the students in the second lab section were exposed to the collaborative learning environment.

To demonstrate group equivalency, a pretest was given at the beginning of the term to identify that all groups are equally matched on the study's dependent variables. Students in both the learning environments were exposed to the same constant variables: instructors in this study used the same textbook, (Biology: Life on Earth, 2013), same course objective and student learning outcome, same weekly labs, same amount of instruction time, introduction to vocabulary terms, and online lectures for students' self-learning.

### **3.4 Population and Sample**

#### **Population**

This study was conducted on the campus of the Blue Ridge Community College (BRCC), which serves the residents of the Central Shenandoah Valley of Virginia. The Central Shenandoah Valley of Virginia encompasses the counties of Augusta, Bath, Highland, Rockbridge, Rockingham, Buena Vista, Harrisonburg, Lexington, Staunton, and Waynesboro. The total population of this region is approximately 300,000, comprising of 3.6% of Virginia's population (Virginia Department of Recreation and Planning, 2013).

BRCC is a two-year public community college. At BRCC, of the approximately 4200 students enrolled, 32% are full-time and 68% are part-time; 42% of students are male and 58% are female. Of these students, 79% are White, 9% are Hispanic/Latino, 5% are Black, 2% are Asian, and 5% belong to other races. Of the total enrolled, 74% students are age 24 and under

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

while 26% are 25 years and older. This percentage of the younger student population is higher because BRCC offers dual enrollment to high school students in its district.

### **Sample:**

The participants in this study consisted of students, who at the beginning of the term, either self-enrolled themselves or were enrolled by their academic advisors, into one of the eight seated sections of Biology 101 and 141. Four separate instructors taught these eight sections of general biology on separate days and times (See Appendix A). Of these eight general biology classes, four were Biology 101, and the other four were Biology 141 classes. A maximum of 24 students were enrolled in each of these eight sections, for approximately 190 students. Since not all sections were completely filled to the maximum capacity, the total number of true sample participants' size was only 155 students. Every instructor had two sections (based on the seating availability in the lab). The students in the first section were placed in a traditional learning environment, while the students in the second section were placed in a collaborative learning environment. All research activities were performed in the lab room where the seating arrangement was such that the students were facing each other rather than all facing the instructor in the front.

### **3.5 Courses**

#### **BIOLOGY 101:**

Biology 101 is the first part of a two-part course that students take at the Virginia Community College System (VCCS) colleges. This course focusses on the foundations of general biology, where students understand and appreciate the common biological topics like cellular structure, metabolism, genetics, evolution, structure and function, information flow, ecology, and systems biology. Students take this course over a 16-week period. It is a four-credit hour course

with 84-contact hours, and is composed of two and half hours of lecture and three hours of lab per week. Both STEM and non-STEM students take this course as a foundation course towards earning an Associate degree in Science (A.S), an Associate degree in Applied Science (A.A.S), or an Associate in Arts (A.A) degree.

**Biology 141:**

Biology 141 is the first part of a two-part course that students take at the Virginia Community College System (VCCS). This course focusses on the integration of anatomy and physiology of cells, tissues, organs, and systems of the human body. It integrates concepts of chemistry, physics, and pathology. Lecture portion is comprised of three hours, while labs run for three hours as well. Students spend a total of around five-six hours per week in this class. Students who aspire to enter into nursing or in allied health fields take this course as a prerequisite.

The two courses (Biology 101 and Biology 141) required no official prerequisites, but recommended readiness to enroll in ENG 111 course. In addition, students must have completed four math placement tests. (see Appendix B for course details and prerequisite requirement for Bio 101 and Bio 141).

Biology 101 and Biology 141 are set in such a way that they teach the same factual and conceptual content in the first three chapters (see Appendix C for class schedule). Chapter One teaches the general information and foundations of the course; chapter two teaches chemistry; chapter three deals with cellular biology: cells, organelles, and functions of organelles. After chapter three, Biology 101 diverges into cellular biology, genetics, and plant biology, while Biology 141 branches into human anatomy and physiology: tissues, structure, organs, and function of organ systems.

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Student participants enrolled in these courses were demographically diverse; some students had studied biology all through their high school years, while there were others who had never worked in a biology lab setting. This diverse setting in biology classrooms made it an ideal classroom to research collaborative learning.

### **Biology Vocabulary:**

Memorization of vocabulary words is an important part of learning science (Posner, 1996). “Unfortunately, rote learning of vocabulary, algorithms and facts is characterizes much undergraduate science education” (Fagen, 2003, p. 97), and this could act as a block for many students learning science (Wandersee, 1988). Yager (1983) finds that biology students learning new vocabulary find it just as difficult as students learning a new language. According to Dunbar (1995), “the need to have words that refer to specific phenomena is extremely important in science: failure to do so results in unnecessary talking at cross purposes, wastes people’s time and holds up the advancement of science.” For the purpose of this study, the instructors presented all students with vocabulary needed to have a basic understanding of the topic of cell structure and function (cellular biology). The instructors presented all students with 15 minutes of vocabulary instructional time to explain “clastron” terms needed to comprehend the chapter. After this initial vocabulary session, vocabulary surveys in the form of preSVFS (Science Vocabulary Familiarity Scale) and postSVFS were given to both the learning environment groups to measure familiarity to the vocabulary needed for understanding the chapter on cellular biology. Vocabulary surveys were given before and after treatment along with the pretest and posttest assessments.

### **Topic: Cell Biology:**

For some difficult yet important topics in biology there are various instruments developed to measure some biological concepts: evolution (Bishop & Anderson, 1985), diffusion and osmosis (Odom, 1995), cell biology (Wandersee, 1988) and genetics (Fagen, 2003). Cell biology was used in this research study because it is a fundamental biological topic that students often struggle to understand and comprehend. Overall, students lack an understanding of the functions of a cell and the structural and functional anatomy of its various organelles. Studying cells helps students understand how organisms function. It is the cells that enable organisms to meet their basic needs, undergo metabolic reactions, make energy, and expend energy. Learning about cells could also help students understand the various other branches of life: genetics, medicines, forensic medicine, biotechnology, biochemical engineering, plant biology, etc. Cell is considered the basic structural and functional unit of life and studying cells help understand how organisms, including humans, function. After all, all forms of life, including humans, are made up of trillions of cells. In future, by learning about cells, students would be able to find answers to questions dealing with: protecting cells, to prevent infections; observing characteristics of cells, to diagnose diseases; treating cells, to maintain homeostasis; and find answers to questions dealing with various physical and chemical factors causing harm to these cells.

### **3.6 Instructional Pedagogy**

Two different instructional environments were used in this study: traditional (control) and collaborative learning (experimental). All students, in both experimental and control groups, were introduced to the vocabulary required for the understanding of the material. Students in both learning environments were assessed using the pretest and posttest assessment tools. The summary of steps in implementing these two learning environments is discussed in the next section. A summary of this research is shown in Figure 4.

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

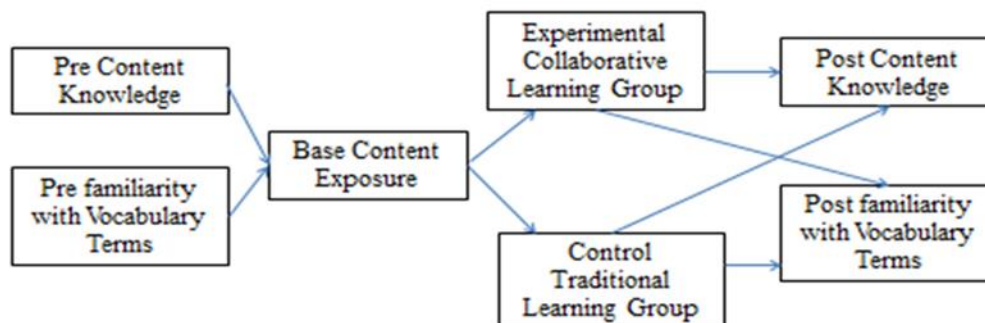
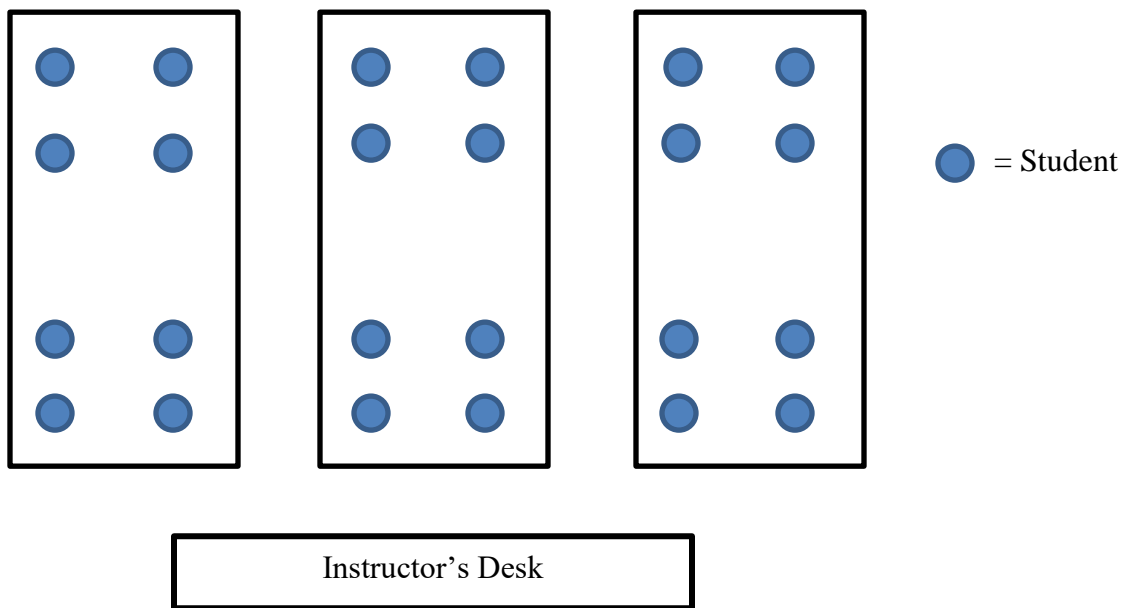


Figure 4. Instructional Pedagogy for Control and Experimental Groups.

### **Collaborative Learning Environment:**

The students in the second lab section for every class were exposed to the collaborative learning environment. At the beginning of the collaborative learning environment, students were given a demographic survey, a preSVFS (a science vocabulary familiarity scale for terms in cell biology), and a set of pretest questionnaire to test their initial knowledge on the topic of cellular biology. The students were then divided into groups of four students based on their seating arrangements at their tables, where they had an opportunity to self-select their collaborative partners. Explanation of the classroom layout for a collaborative learning environment is shown in Figure 5. The instructor used the first fifteen minutes to introduce the basic vocabulary terms needed to work together in collaboration. Later, students were given 45 minutes to collaborate and work together to understand the learning objectives of the chapter. During this collaboration, students were given guided course objectives (see Appendix D) that helped them to keep on track for their learning objectives for the chapter on cell structure in cell biology (see Appendix

E). These questions were given because they “provide students with opportunities for conceptual change by allowing students time to reconstruct their ideas about a given concept” (p. 54, McKnight, 2015). The instructor was available to help students if they had any questions during collaboration. A summary of steps to incorporate collaborative learning environment in classrooms is shown in Figure 6.



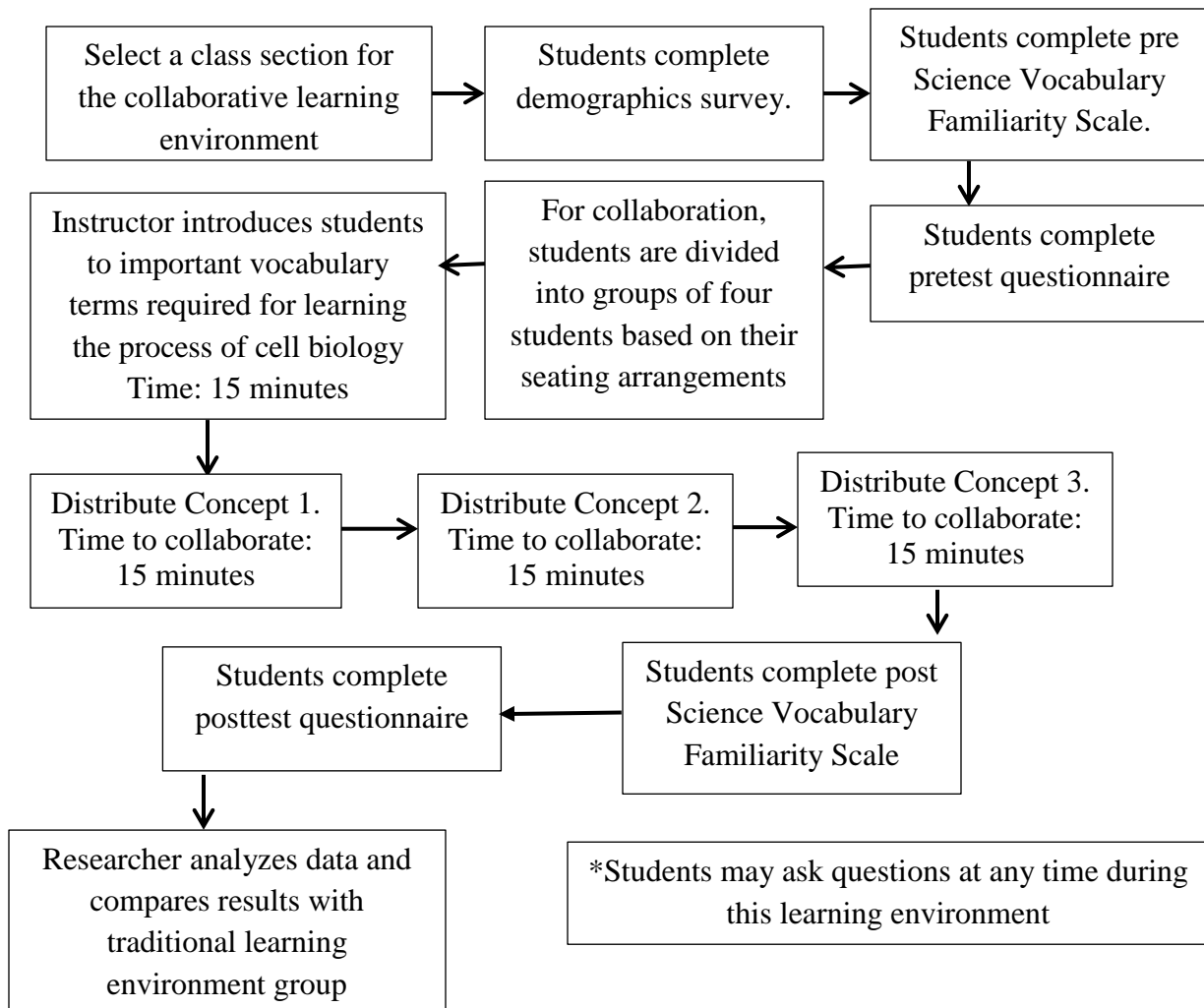
*Figure 5. Collaborative Learning Classroom Layout*

### **Guided Concepts during Collaboration:**

So that students in the collaborative learning environment are able to complete the entire chapter of cell biology in the allotted time of 45 minutes, the instructor provided them with a key of three steps of guided concepts. These three concepts were based on the course objective and student learning outcomes for the chapter of cell biology. These guided concepts helped students to stay on track for the student learning objectives for the chapter on cell biology (see Appendix

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

E). The students were asked to use resources that may help them understand the concepts of cellular biology. Some of the resources available to students were cell models, copy of the entire chapter on cells from their textbook, PowerPoint notes from the traditional learning environment, and access to online resources and database (see Appendix F).



*Figure 6.* Steps to incorporate Collaborative Learning Environment in Classrooms.

### **Traditional Learning Environment:**

In the traditional learning environment, to begin with, students were given a survey questionnaire on demographics, a preSVFS (science vocabulary familiarity scale), and a set of

pretest questionnaire to assess their initial knowledge on the topic of cell biology. The instructor took fifteen minutes to introduce the basic vocabulary terms that were needed to comprehend and understand the chapter. The instructor then lectured in a traditional authoritarian way, using PowerPoint slides for the next 45 minutes, explaining the fundamental conceptual process of cell biology. The seating position of students is different from the collaborative learning environment wherein the students all faced their instructor and not each other. During and after lecture, students were given opportunities to ask questions. Finally, the students were given a postSVFS and a posttest to assess their understanding of the basic concepts learned in the classroom. Detail process of the implementation of the traditional learning environment is shown in Figure 7.

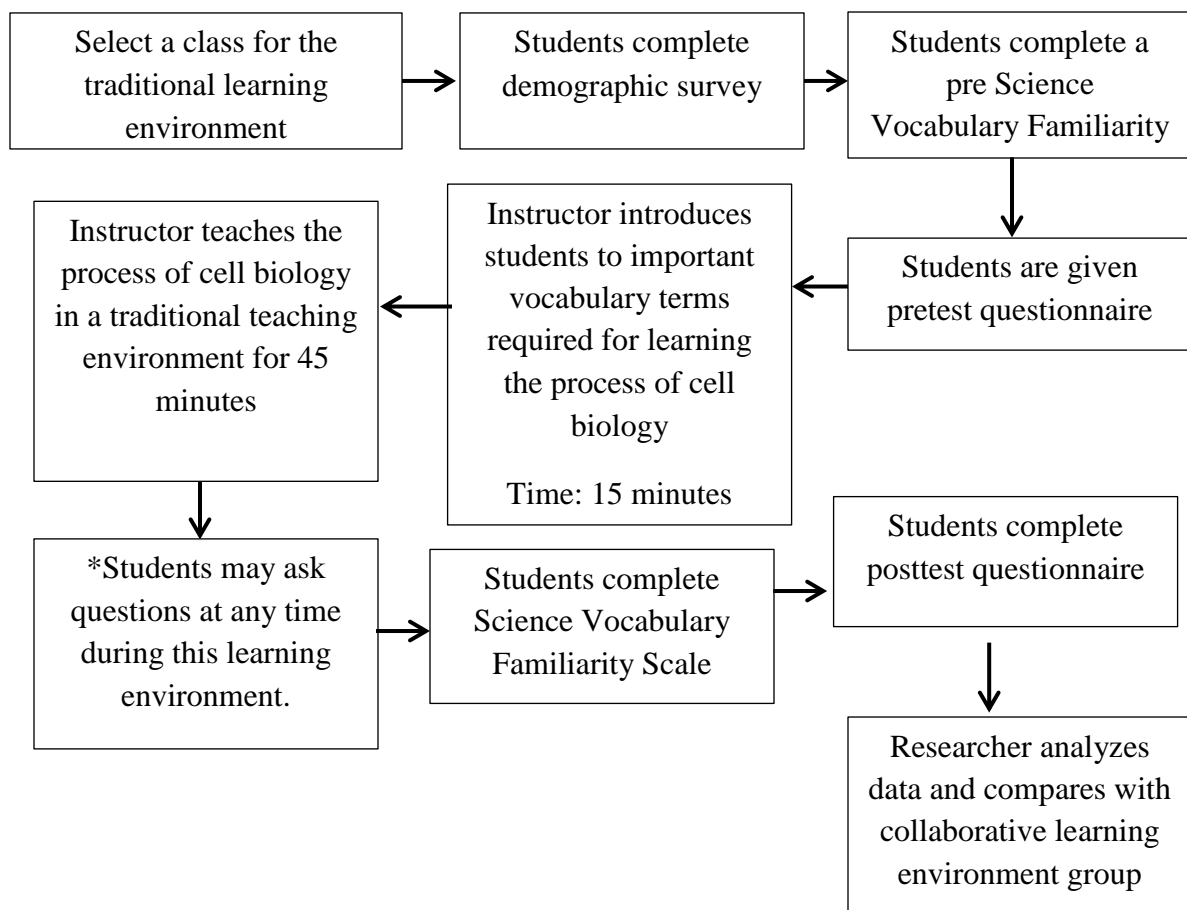


Figure 7. Steps to incorporate Traditional Learning Environment in Classrooms.

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

### **Assessment for Students' Conceptual Understanding:**

A standard assessment for students' understanding of a concept is very important (Stokstad, 2001). A test would allow instructors to find if there are differences in learning gains of collaborative learning over traditional learning. An assessment test would also allow instructors to find if their students are struggling in understanding conceptual information, and if they needed to spend extra time to target their misconceptions. These tests could also guide instructors to assess if they are using the right instructional technique in their classrooms (Sadler, 1992). They are administered at the beginning and end of a unit/topic, and are a direct evaluation of learning progress of students. To demonstrate progress, the posttest score should be higher than the pretest score for both the control and experimental groups. Both scores were compared by using appropriate statistical methods that are discussed later in Chapter Four. A twelve-question multiple-choice assessment was used as pretest-posttest survey. Multiple choice questions were used because they are easy to administer and can be quickly scored for a large number of students in a class. For this research study, results from assessment scores were compared between the two learning environment groups and within the collaborative learning environment group.

### **3.7 Instruments**

Two instruments were used to measure achievement in this research study: pretest-posttest questionnaires (Wandersee, 1986; Fagen, 2003) and pre and post science vocabulary familiarity scale (preSVFS and postSVFS). Participant sample in both the learning environments also completed the demographics survey.

**Pretest Posttest Questions:** The pretest-posttest questions were prepared so that they matched the learning objectives of the biology 101 and 141 courses taught at the Blue Ridge Community

College (BRCC). Twelve standardized multiple choice questions were used to assess the conceptual understanding of the introduction chapter of cellular biology (see Appendix G for pretest and posttest assessments). Both pretest and posttest items followed similar format, and had no negative options provided. The posttest assessment tests followed a similar format to the pretest assessment, but involved questions that were slightly higher-level and involved some critical thinking. They also involved questions that were in-depth as compared to the pretest questionnaire. For both assessments, the multiple-choice questions had five options: A, B, C, D, and E. Questions were made after referring to the textbooks that students in both classes used. Questions used in both pretest and posttest assessment worksheets were standardized and were assessed by a team of professors teaching biology at BRCC.

#### **Science Vocabulary Familiarity Scale Survey (SVFS):**

Fagen (2003) based the science vocabulary familiarity scale (SVFS) survey in his study to measure the familiarity of the vocabulary terms to the content. A brief survey was prepared to assess students' background and familiarity with vocabulary used in teaching the cell biology chapter. Twelve terms were taken from the glossary section of the same textbook that students used in these two courses. Students were asked to rate their familiarity (f) with the terminology on a 1-5 scale (see Appendix H):

“1 = Totally unfamiliar

2 = Word is vaguely familiar

3 = Hazy understanding

4 = Okay understanding

5 = Confidence understanding” (p. 111, Fagen, 2003)

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Two words (“clastron” and “spooling”) were included in the survey to serve as controls as they did not have any definitions in the biological science discipline (p. 111, Fagen, 2003). Fagen suggested that if a student marked three as the option for these two words, then it suggested that “he or she was less likely to suggest a low familiarity at all” (p. 111). The initial science vocabulary familiarity scale (SVFS) was given before the pretest, and then the same survey was given after the completion of the posttest. Students were asked to put their names on the surveys so they could be matched with pretest-posttest at the end of the unit.

### **Demographics Survey**

At the beginning of conducting research, a one page demographic survey was also collected from the participant sample groups (see Appendix I). Statistical information was collected on gender, age, race/ethnicity, work status, prior coursework in science, student status (full-time or part-time), future career, and number of credits taken in the semester. Students were asked to put their name on the demographic surveys so they could be matched with their pretest-posttest, preSVFS, and postSVFS assessment scores at the end of the unit.

### **3.8 Data Collection Procedures**

Prior to beginning research, approval was first taken from the Research Review Committee (RRC) of Blue Ridge Community College (BRCC). Once approved by BRCC-RRC, approvals from Virginia Tech’s governing Internal Review Board (VT- IRB) was acquired by the principal investigator (Appendices J and K). During the third week of lab for the Spring 2018 semester, each participating professor, for the four classes to be researched, introduced the study to the participants by reading the recruitment letter that was made by the researcher (Appendix L). The recruitment letter was used in order to provide a consistent presentation of procedures to all potential participants and included an explanation of the study background,

purpose, and overview. In the letter, students were asked to participate in the study, and were assured that their participation was optional and would have no part in determining their semester grade. The professor then immediately distributed the consent forms (Appendix M) and students indicated their choice for participation. The demographic survey and the four assessments, in the form of pretest, posttest, preSVFS, and postSVFS, had no bearing on students' grade. For every lab class of 24 students, names were entered into a raffle drawing at the end of the activity to win a gift card to a fast-food restaurant for ten dollars. Eight raffle drawings were drawn for every lab section of the two participating courses (Biology 101 and Biology 141).

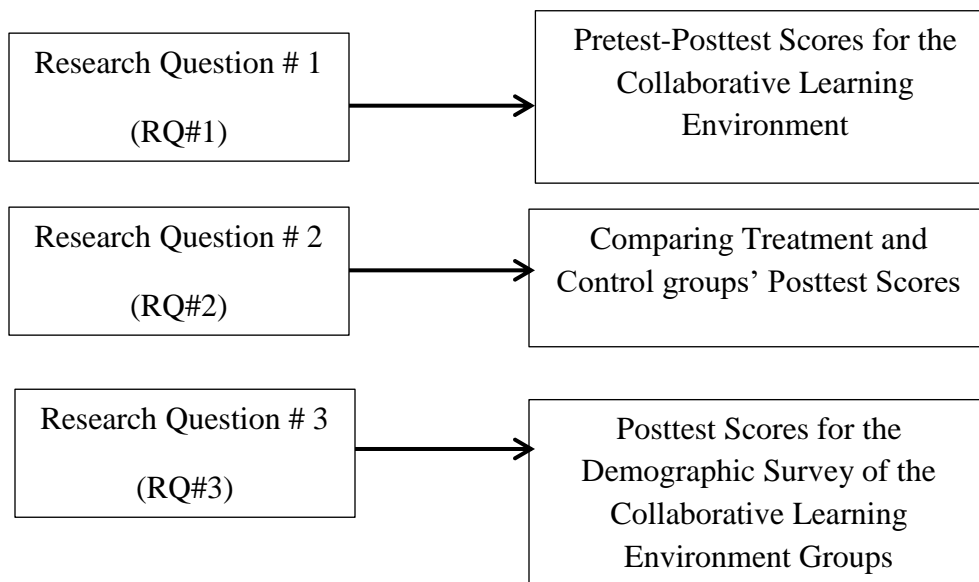
Of the eight lab sections that participated in this study, the researcher researched the four sections of Biology 141, and the two sections of Biology 101. Since the researcher was the instructor for the remaining two lab sections of Biology 101, to avoid conflict of interest, another instructor was requested to conduct research activity in these classes.

### **3.9 Data Analysis**

Pretest-posttest designs are widely used in research, primarily for the purpose of comparing groups and/or measuring change resulting from experimental treatments. In all these methods, the use of pretest scores helps to reduce error variance, thus producing more powerful tests than designs with no pretest data (Stevens, 1996). A paired sample t-test usually provides a more appropriate and informative analysis of data. The paired sample t-test, sometimes called the dependent sample t-test, is a statistical procedure used to determine whether the mean difference between two sets of observations is either zero (null hypothesis) or not equal to zero (alternate hypothesis). A paired t-test is used to compare two population means. It is also important to describe the internal and external validity of this research. Internal validity is the degree to which

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

the experimental treatment makes a difference or causes a change in the specific experimental settings. External validity is the degree to which the treatment effect can be generalized across populations and other similar settings (Isaac & Michael, 1981). The statistical tests can help answer some very important questions like- “how do students differ in posttest scores? Moreover, “how do groups, on average, differ in gains? (Fitzmaurice, Laird, & Ware, 2004). A summary of data analysis process used in this research study is shown in Figure 8.



*Figure 8.* Data Analysis Flowsheet used in this study

### **Descriptive Analysis on Gain Scores:**

The gain scores measures the change in assessment scores between the two groups (differences between pretest and posttest).  $\text{Gain Score} = \text{Posttest Scores} - \text{Pretest Scores}$ . It is important to measure and compare the differences in these two scores between the two groups (traditional and collaborative learning groups). Two common methods of analyzing data from a

two-group pretest-posttest research design are (a) two-sample *t* test on the difference score between pretest and posttest and (b) repeated-measures/split-plot analysis of variance. The analysis of gains, for example, focuses on the improvements from pretest to posttest for the whole groups, and compares those improvements between treatment and control groups.

For single-group tests that compare pretest to posttest, analysts have been left with three options: a *t*-test of gain scores, paired *t*-tests, and repeated measures ANOVA (Kanji, 1999). According to Winer (1971), repeated measures ANOVA is also equivalent to a *t*-test that compares gain scores between two independent groups, where the gain scores are the differences between pretest and posttest.

### **3.10 Role of Researcher**

In this quantitative study, the role of the researcher was to prepare, conduct, and administer the research in biology classrooms in a community college setting in compliance with the institutional review board (IRB). The role of the researcher in the experiment itself was non-existent, which means that the participants participated in the study independent of the researcher. The researcher teaches courses in general biology, and anatomy and physiology in the same community college setting in which the research was conducted. The researcher conducted research in six of the eight biology classes, and made sure that the integrity of the participants was respected. The researcher also made sure that all data, in the form of demographic surveys, pre and posttests, pre and postSVFS, and consent forms, were well stored in a locked place. The next role of researcher was to analyze the data in a controlled but non-biased way. The sole purpose of conducting this research was to attempt to answer research questions and apply the results, in future, to other similar research projects. The researcher also

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

made sure that the data obtained was reliable, credible, and dependable; that it, same results should be found if the study was to be repeated.

### **3.11 Summary**

This study utilized a quantitative data analysis design to explore answers to the three research questions posed. This research was designed to reveal to what extent changes in undergraduate student learning outcomes occurred in a collaborative learning environment in a biology classroom. It was conducted to address research need by providing evidence that undergraduate biology students who studied collaboratively scored significantly higher on measures of assessment (pretests versus posttests scores) than students who studied individually in a traditional classroom. This study used the quantitative approach for data collection and analysis using scores from assessment questionnaires. This study was a quasi-experimental, pretest-posttest, control group design. The sample consisted of students enrolled in general biology classrooms at Blue Ridge Community College (BRCC).

## CHAPTER FOUR

### RESULTS

#### **4.1 Introduction**

The purpose of this study is to examine the role or value, if any, that a collaborative learning environment has for a community college biology classroom setting. This dissertation is based on (a) exploring the effects of collaboration in a biology classroom in a community college, (b) explaining findings from an applied research study focused on the content taught in a science (biology) classroom using collaboration, and (c) offering suggestions on how other science and STEM faculty members in community colleges can create or enhance pedagogical tools and partnerships to better utilize the strengths of their disciplines.

This research was conducted in biology classes at the community college level, and it examined the differences between traditional learning versus collaborative learning in the conceptual understanding of a topic in cell biology. Structured data collection was aimed at determining:

- To what extent does a collaborative learning approach in the community-college classroom result in changes to students' biology science content knowledge?
- If there were identifiable differences seen in achievement for groups of students learning traditionally and groups of students learning collaboratively?
- What differential learning impacts are identifiable in a STEM educational environment employing collaborative learning?

The results of this study are presented in this chapter and are organized into four sections. The first section gives a description of participants within this study, and the next three sections address the three research questions posed. Each of these sections include a description of data

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

assessment and data analysis. This chapter concludes with a summary of the overall results. The methods of data collection and instruments used in the study have been discussed in Chapter 3.

### **4.2 Profile of Participants in the Study**

Study participants were self-selected into available general biology I (Biology 101) and Anatomy & Physiology I (Biology 141) courses for the Spring, 2018 semester. The college offered 10 classes in Biology 101 and 141, of which four were Biology 101 and the remaining were Biology 141 classes. Four classes participated in this study: two were Biology 101 and the other two were Biology 141, and these four classes had two lab sections each. Therefore, eight lab classes participated: four of which were part of a collaborative learning environment and the other four were a part of the traditional (T) learning environment (see Table 2). The remaining six classes could not participate because they were either a hybrid, online, or a single lab class. Participants were asked to self-report demographics and other educational details (Appendix I) using the demographics survey (as discussed in Chapter 3). They identified their prior college science courses taken within the last five years, current field of study, number of credits taken in the semester, and the highest level of education they expect to complete. In addition, participants were also asked to identify their work status.

For the 155 students that participated in the study, the frequency of the student distribution in the four classes is shown in Figure 9. Specifically, at the outset of the study ( $N = 155$ ), participants were almost equally distributed among Biology 101 ( $n = 78, 51\%$ ) and Biology 141 ( $n = 77, 49\%$ ). The frequency of student distribution in the two Biology classrooms is shown in Figure 10. In between the two classes (Biology 101 and 141), the total number of students that participated in the collaborative environment were 71, while the total number in the

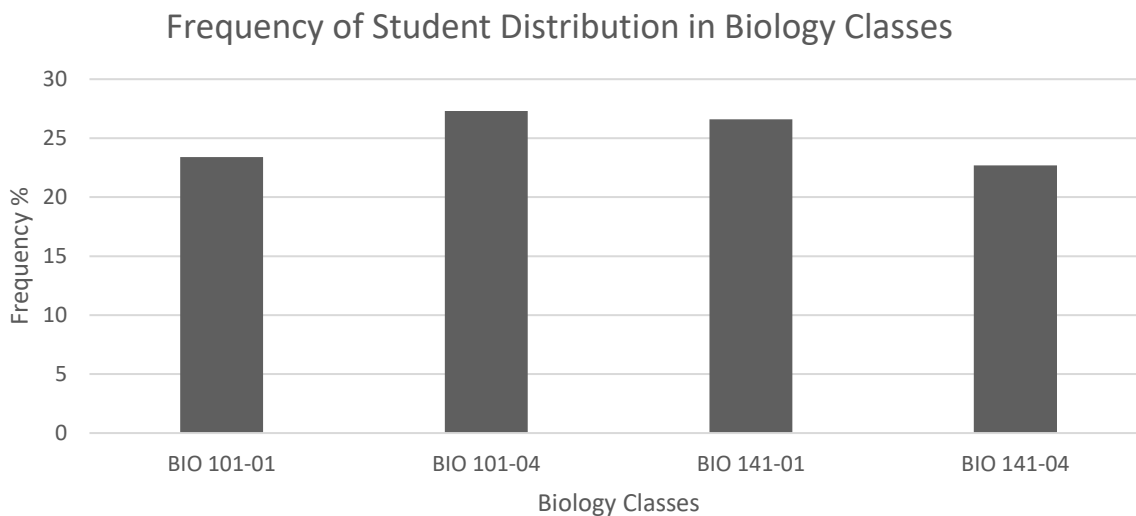
traditional learning environment were 84 (Figure 11). The students participating in the research were previously not informed of the environment in which they would be participating.

Table 2.

*Classes that Participated in the Research Study*

<i>Class</i>	<i>Professor</i>	<i>Learning Environment T or C</i>	<i>Number of Students N=155</i>
Bio 101-01	A	Traditional	20
		Collaborative	16
Bio 101-04	B	Traditional	20
		Collaborative	22
Bio 141-01	C	Traditional	26
		Collaborative	15
Bio 141-04	D	Traditional	19
		Collaborative	17

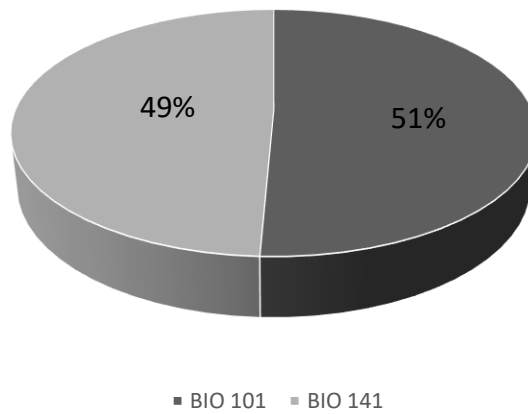
T= Traditional, C= Collaborative



*Figure 9. Frequency Distribution of Students of All Student Participants*

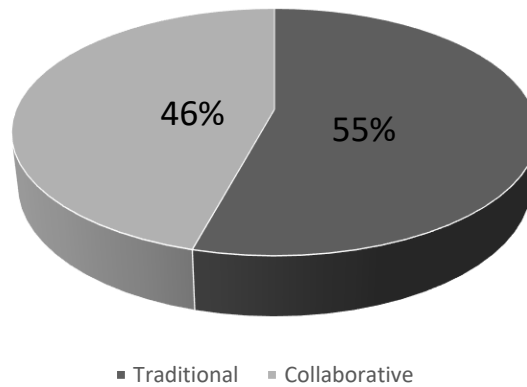
## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Student Distribution Based on Classroom



*Figure 10.* Frequency Distribution of Student Participants in Biology 101 and Biology 141

Student Distribution based on Learning Environment



*Figure 11.* Frequency Distribution of Student in two learning environments: Traditional and Collaborative

### **Student Demographics: Gender, Age, and Ethnicity**

In addition to the assessment scores, it is important to examine group equivalency in student demographics of each classroom section participating in the study. A summary of key sample demographics to include participants' gender, age, and ethnicity are in Tables 3 and 4.

Table 3.

*Summary of Community College Students' Demographics for Biology 101*

Demographics											
Class	N = 78	Gender			Age range		Ethnicity				
		Male	Female	NR	18-24	others	A	B	H/L	W	O
Bio 101-T	40	19	20	1	35	30	0	2	6	31	1
Bio 101-C	38	11	26	1	30	8	1	1	10	26	0

Note: T= Traditional and C= Collaborative. Under gender, NR= no response. Under Ethnicity, A= Asian, B= Black, H/L= Hispanic/Latino, W= White, and O= others

Table 4.

*Summary of Community College Students' Demographics for Biology 141*

Demographics											
Class	N = 77	Gender			Age range		Ethnicity				
		Male	Female	NR	18-24	others	A	B	H/L	W	O
Bio 141-T	44	11	33	0	32	12	1	3	3	35	2
Bio 141-C	33	9	24	0	22	10	0	2	8	20	2

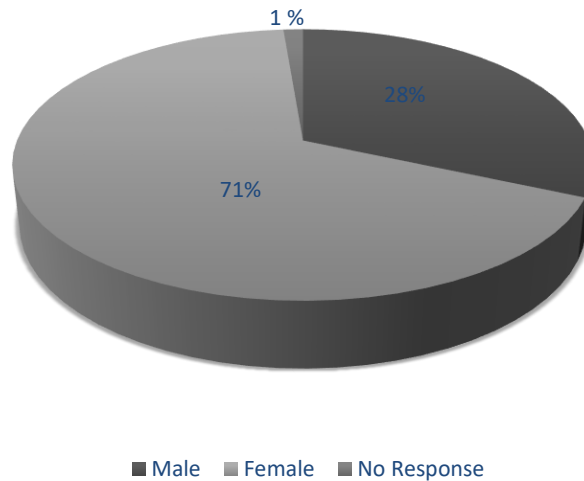
Note: T= Traditional and C= Collaborative. Under gender, NR= no response. Under Ethnicity, A= Asian, B= Black, H/L= Hispanic/Latino, W= White, and O= others

Specifically, at the outset of the study (N = 155), participants included 32% male students (n= 49), while 67% were female students (n= 104) (see Figure 12). Two participants did not respond to the question on gender and accounted for a little over 1% of the overall numbers. Both traditional and collaborative classrooms were consistent with the overall ratio of female students to be higher than their male counterpart. Traditional classrooms included 36% male (n=

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

30) and 64% female students (n= 53), while collaborative classrooms included 28% male (n= 19) and 71% female (n= 50) students.

### Male to Female Frequency in the Study



*Figure 12.* Frequency of Male and Female Students in Research Classes: Both Biology 101 and 141

The most represented age of college going students, which is classified as “traditional,” is between 18-24 years, which accounted for 77% (n= 119). The statistics of the other age groups were as follows: 25-34 years (n= 22), 35-44 years (n= 9), age < 18 years (n= 3), and there were no students greater than 45 years of age. These age groups made up 14%, 6%, and 2% respectively. Ethnically, the sample was 73% White/Caucasian (n = 112), 18% Hispanic/Latino (n=27), 5% African American (n = 8), 1% Asian (n = 2), 0.6% American Indian/Alaska native (n=1), and 3% classified themselves as others (n= 4). The results were consistent with the demographics of the community college population with respect to gender, age, and ethnicity (Chapter 3.4)

### **Student Demographics: Education background, Career, Work Status, and Student Status**

Questions were also asked about students' prior college science courses taken within the last five years, the students' current field of study, and number of credits taken in the semester, highest level of education they expect to complete, and work status. A summary of the above questions asked is depicted in Tables 5 and 6. Of the total 155 students, 82% students (n=127) had some form of prior experience in taking science courses in the past five years (see Appendix N). Of the major science courses, 23% students (n= 35) had previously taken Biology 101 course, 21.3% (n= 33) had previously taken Chemistry 101, 21% (n= 33) had taken Biology 141, and 7% (n= 10) had previously taken Physics 100. Of the other courses, eight students had previously taken Biology 102, eight students had taken Chemistry 102, and three students had taken Biology 142.

The most represented work status (see Appendix O) was the part-time group of students, who made up 64% of all students (n= 99), with full-time students representing 16% of all classes (n= 25). Unemployed students made up almost the same ratio as full-time students, with about 20% (n= 30). The demographic survey also captured the highest level of education expected by the students, and it was found that 33% of all students (n= 51) were pursuing to earn a Bachelor's degree, 28% (n= 44) were pursuing Masters. The other students: 13.5% (n= 21) were working towards their Associate, 11% (n= 17) were taking courses for continuing their education, 9% (n= 13) were aspiring to earn their doctorate degree, and the rest 6% (n= 5) were working towards earning their professional degree (see Appendix P). The overall group had 51% of students (n= 78) who were enrolled in 12 credits or more; 38% (n= 59) of them were enrolled in 6-11 credits, and the remaining 11% (n= 16) enrolled in less than six credits (see Appendix Q). Also, 57% students (n = 86) were enrolled in the Natural Science, and wanted to pursue into

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

healthcare fields like nursing, physiotherapy, and other allied fields. In the overall group, 39% (n = 39) students were enrolled in other interest courses or wanted to transfer to four-year colleges. The remaining 16% were interested in humanities and arts fields (n = 16). Of the total number of students (n= 150), two students who were interested in engineering fields, and seven were interested in social sciences, like psychology (see Appendix R).

Table 5.

*Summary of Community College Students' Demographics for Biology 101*

		Demographics																							
		Prior College Science Courses							Current Field of Study					Work Status			Credits			Highest Level of Education expected					
Class	n=78	Biology 101	Biology 102	Biology 141	Biology 142	Chemistry 101	Chemistry 102	Physics 100	NS	H/A	Engineering	Social Science	Other	Unemployed	Part-time	Full-time	Less than 6	6-11	12 or more	Associate	Bachelors	Masters	PhD	Professional	CE
101-T	40	6	1	3	0	8	0	2	15	3	0	6	16	7	27	6	1	10	29	7	16	10	4	0	3
101-C	38	10	0	7	1	7	4	2	9	7	2	0	20	8	24	6	4	14	19	4	11	11	5	0	5

Note: T= Traditional and C= Collaborative. Under demographics, NS= Natural Science, H/A= Humanities/Arts, and CE= Continuing Education.

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Table 6.

Summary of Community College Students' Demographics for *BIOLOGY 141*

		Demographics																							
Class	n=77	Prior College Science Courses							Current Field of Study					Work Status			Credits			Highest Level of Education expected					
		Biology 101	Biology 102	Biology 141	Biology 142	Chemistry 101	Chemistry 102	Physics 100	NS	H/A	Engineering	Social Science	Other	Unemployed	Part-time	Full-time	Less than 6	6-11	12 or more	Associate	Bachelors	Masters	PhD	Professional	CE
141-T	44	12	4	10	2	11	2	4	7	3	0	0	29	7	28	9	9	20	15	8	13	11	1	3	8
141-C	33	13	3	13	0	7	2	2	7	2	0	1	21	8	20	4	2	15	15	2	11	12	3	2	1

Note: T= Traditional and C= Collaborative. Under demographics, NS= Natural Science, H/A= Humanities/Arts, and CE= Continuing Education.

### 4.3 Research Question #1

The first research question sought to explore the potential impact of collaboration on students' science content knowledge in biology classrooms. Two assessments, in the form of pretest and posttest, were used to assess their learning gains.

**RQ1:** To what extent does a collaborative learning approach in the community-college classroom result in changes to students' biological science content knowledge?

**RQ1-  $H_0$ :** A collaborative learning approach in the community college classroom does not result in increased student biological science content knowledge.

**RQ1-  $H_A$ :** A collaborative learning approach in the community college classroom results in increased student biological science content knowledge.

#### **Analytical Approach:**

The difference in the mean posttest assessment score and pretest assessment score was used to see if a collaborative learning approach in the community-college classroom result in changes to students' biological science content knowledge. The paired t-test was utilized to compare the means of the pretest and the posttest, and a paired sample correlation was conducted to determine any significance. The study design for this test involves measuring each class twice: pretest and the posttest. The paired comparison t-test was used to test if the means of the pretest and the posttest of the two measures differed significantly.

The results of the pretest and posttest are shown in Table 7. For the collaborative learning environment for both classes ( $n=71$ ), the mean score for the pretest was 7.06 ( $SD = 2.139$ ,  $p < .05$ ) and the mean score for posttest was 8.96 ( $p < .05$ ). There was a significant difference for the collaborative learning environment,  $t(70) = 6.54$ ,  $p < .05$ , with the students receiving a higher score on the posttests as compared to pretests. The mean difference between the overall pretest

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

and posttest scores for both Biology 101 and 141 classes was about two points ( $M = 1.90$ ,  $SD = 2.433$ ), with a strong positive correlation between the two scores of  $r(70) = .445$ ,  $p < .001$ .

Table 7.

### *Pretest and Posttest Assessment Scores for Collaborative Learning Environment*

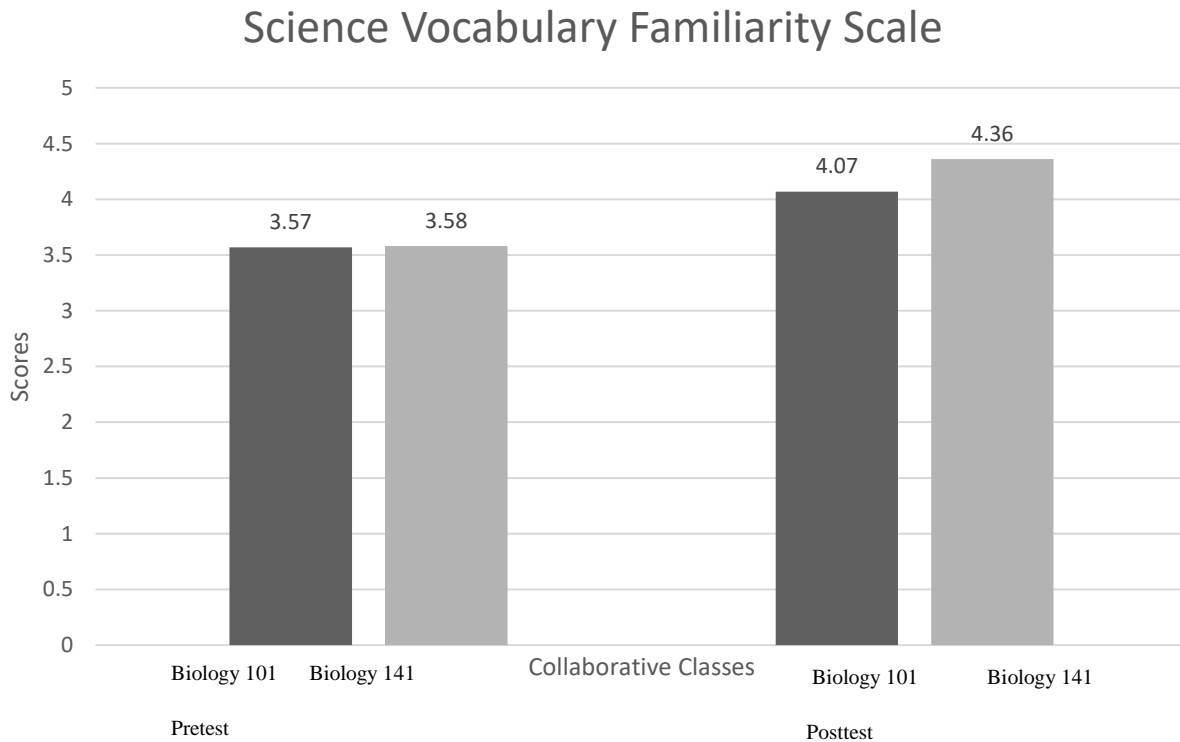
Class (C) N= 71	Total number of Students (N)	Prof.	Mean Pretest Score	Mean Posttest Score	Mean Scores (Pretest) Average	Mean Scores (Posttest) Average	SD (Pre)	SD (Post)	*Sig. (2 tail)
Biology 101	38	EC	7	8.38	7.23	8.76	2.44	2.30	.001
		HP	7.45	9.14					
Biology 141	33	EP	6.93	9.87	6.82	9.17	1.71	2.64	.000
		FD	6.71	8.47					
Both Classes	71				7.06	8.96	2.139	2.452	.000

\* $P < .05$ , C= collaborative learning environment, SD = standard deviation, Sig. = Significance

For the collaborative learning environment in Biology 101, the mean was higher for the posttest scores as compared to pretest scores ( $M = 1.553$ ,  $SD = 2.617$ ). There was a significance difference in scores seen between the pretests and posttests,  $t(37) = 3.657$ ,  $p = .001$ , with posttest scores being higher than pretest scores. For the Biology 141 collaborative learning class, the mean score difference between the posttest and pretest was more than two points higher ( $M = 2.313$ ,  $SD = 2.162$ ). There was a significant difference in scores seen between the pretest and posttest assessment scores,  $t(32) = 6.051$ ,  $p < .001$ , with posttest scores being higher than pretest scores.

### Supplemental Information for RQ1:

Supplemental information was collected from the students in the collaborative learning environment in the form of preSVFS (Science Vocabulary Familiarity Scale) and post SVFS to examine the familiarity of the students to the important terms of cell biology. For more information on the instrument, refer to Section 3.7 in Chapter 3. It was found that the mean of the post SVFS ( $M = 4.215$ ) for the collaborative environment classes was higher than the preSVFS mean score ( $M = 3.575$ ). Looking at both the classes separately (see Figure 13), Biology 101 and Biology 141 had the same preSVFS score ( $M = 3.58$ ), but the mean of the postSVFS score was higher for Biology 141 as compared to Biology 101 mean (see Figure 13). Pre and post SVFS scores for Bio 101 and 141 is shown in Figures 14 and 15.



*Figure 13.* Science Vocabulary Familiarity Scale for Collaborative Learning Environments

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

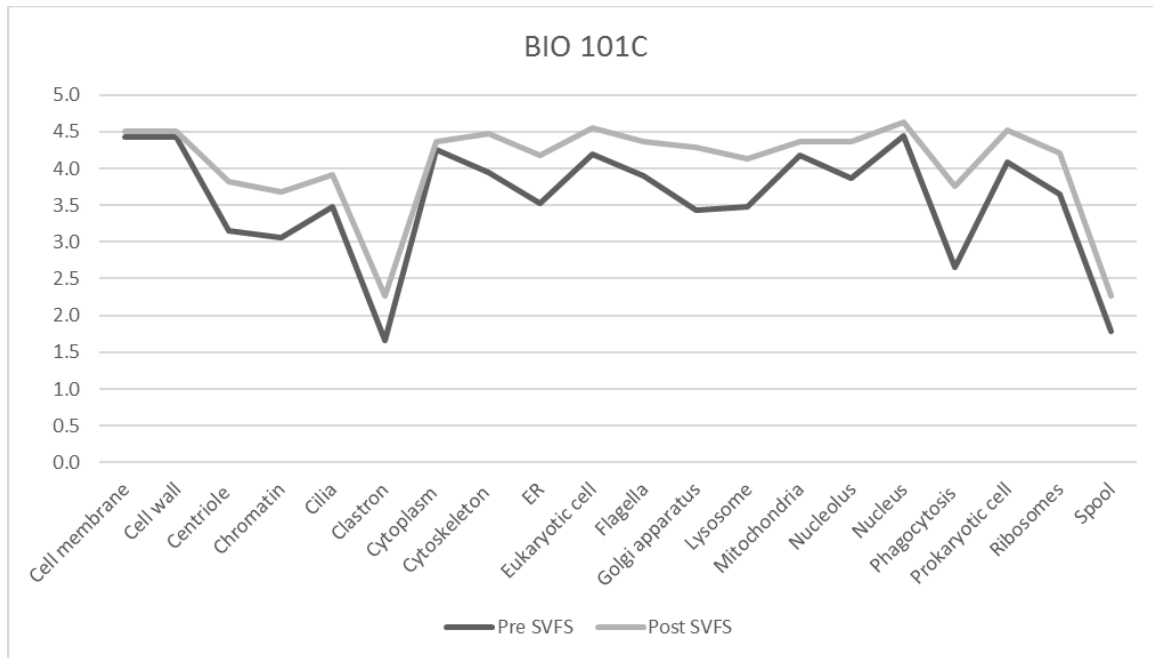


Figure 14. Pre and Post Science Vocabulary Familiarity Scale for Biology 101: Collaborative

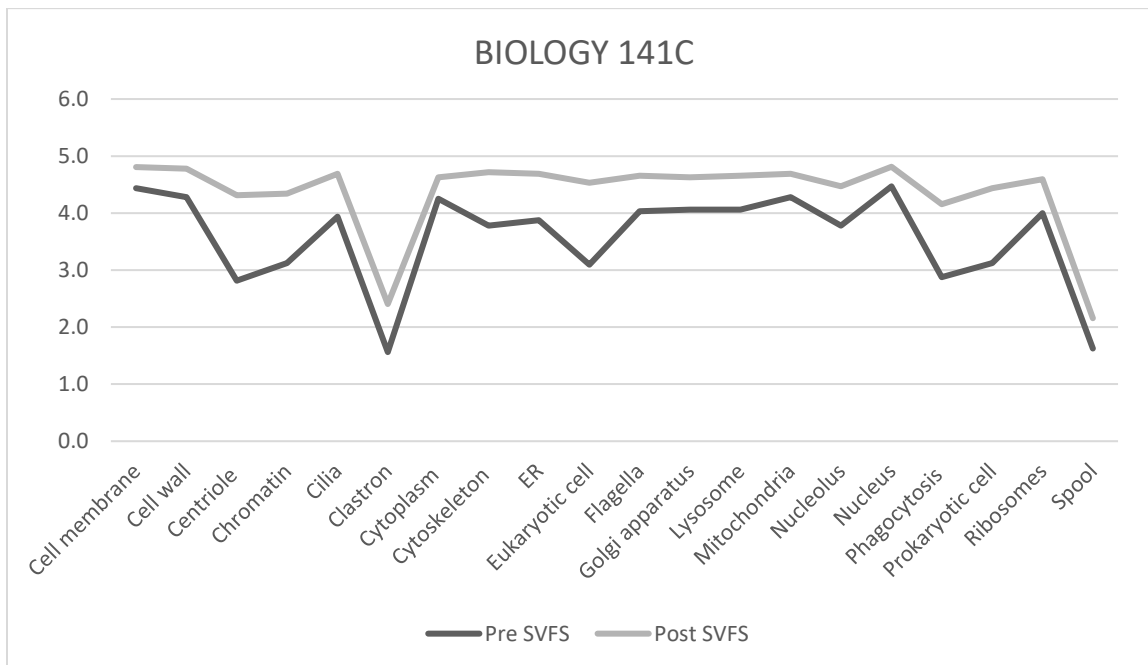


Figure 15. Pre and Post Science Vocabulary Familiarity Scale for Biology 141: Collaborative

#### 4.4 Research Question #2

**RQ2:** Are there identifiable differences in achievement for groups of students learning traditionally and groups of students learning collaboratively?

**RQ2-  $H_0$ :** There are no identifiable differences in achievement for groups of students learning traditionally versus groups of students learning collaboratively

**RQ2-  $H_A$ :** There are identifiable differences in achievement for groups of students learning traditionally versus groups of students learning collaboratively

#### **Analytical Approach:**

Two learning environments were studied in this project, traditional and collaborative environments, to answer the research questions. The posttest scores in each learning environment was used to find answers to this research question. The Independent sample paired t-test was utilized to compare the mean scores of the posttest, and a paired sample correlation was conducted to determine any significance. The results of the posttest scores of the two learning environments is shown in Table 8. This procedure calculates the difference between the observed means in two independent samples. A significance value (P-value) and 95% Confidence Interval (CI) of the difference is reported. The P-value is the probability of obtaining the observed difference between the samples if the null hypothesis were true. For the collaborative learning environment for both classes, the mean was higher for the posttest scores ( $M = 8.27$ ,  $SD = 2.559$ ) as compared to the posttest scores of the traditional learning environment ( $M = 8.97$ ,  $SD = 2.452$ ). There was no significance difference in posttest assessment scores seen between the two learning environments,  $t(153) = 1.727$ ,  $p = .0862$ .

For the Biology 141 class, the mean posttest score for the collaborative learning environment was 9.17 ( $SD = 2.6429$ ), as compared to the traditional learning environment, whose posttest score was 8.54 ( $SD = 2.517$ ). The mean difference between the posttest scores

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

between the two environments was 0.525. There was no significance difference seen in mean posttest scores between the two learning environments in the Biology 141 classes,  $t(75) = .883$ ,  $p > .05$  (as shown in Figure 16).

For the Biology 101 classes, the mean posttest score for the collaborative learning environment was 8.76 (SD = 2.300), as compared to the traditional learning environment, whose posttest score was 8.00 (SD = 2.481). The mean difference between the posttest scores between the two environments was 0.816. There was no significance difference seen in mean posttest scores between the two learning environments in the Biology 101 classes,  $t(76) = 1.504$ ,  $p > .05$  (as shown in Figure 16).

Table 8.

### *Posttest Achievement Scores for Traditional and Collaborative Learning Environments*

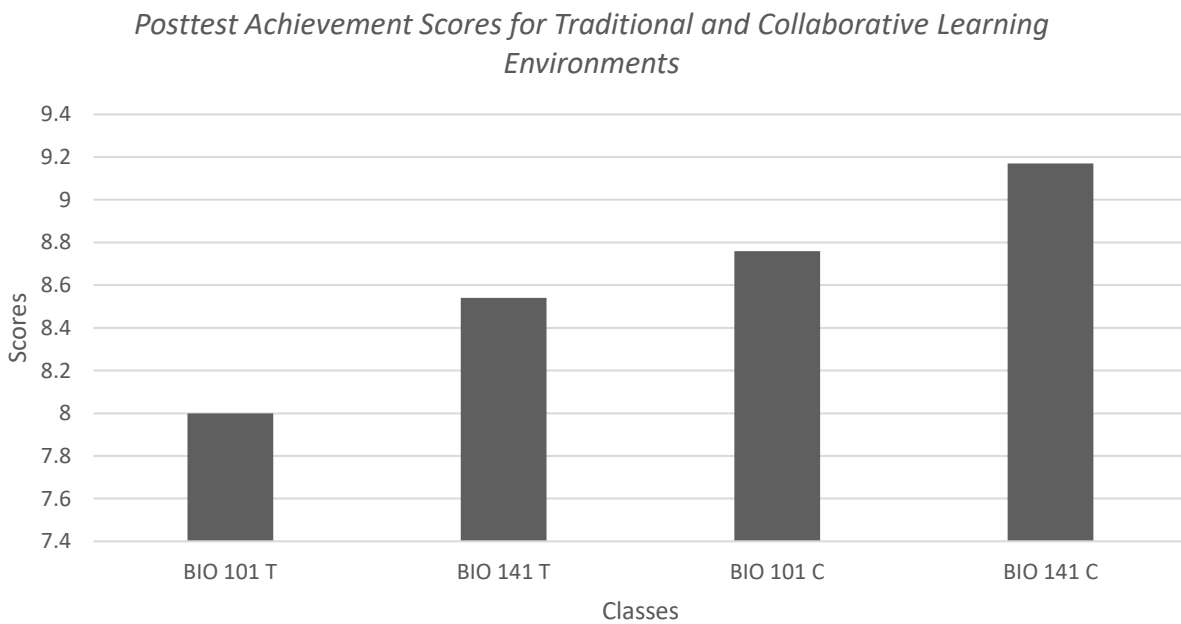
N= 155 Class	Posttest Score	Mean Posttest Scores	SD	T value	df	Sig. (2 tailed)
Biology 101 T	8.00	8.27	2.559			
Biology 141 T	8.54			1.727	153	.0862
Biology 101 C	8.76	8.97	2.452			
Biology 141 C	9.17					

SD = Standard Deviation, T = Traditional, C = Collaborative, df = degrees of freedom, sig = significance values

### **Supplemental Information for RQ2:**

Supplemental information was collected from the students in both traditional and collaborative learning environments in the form of preSVFS (Science Vocabulary Familiarity Scale) and post SVFS to examine the familiarity of the students to the important terms of cell

biology. It was found that the mean of the postSVFS for the traditional Biology 101 classes ( $M = 4.26$ ) was higher than its mean of preSVFS ( $M = 3.54$ ). Similarly, mean of the postSVFS for the collaborative Biology 101 classes ( $M = 4.07$ ) was higher than the mean of preSVFS ( $M = 3.57$ ). In addition, the mean of postSVFS ( $M = 4.43$ ) for the traditional Biology 141 classes was higher than the preSVFS mean score ( $M = 3.6$ ), and for the collaborative Biology 141 classes, mean of postSVFS ( $M = 4.36$ ) was higher than the preSVFS mean score ( $M = 3.58$ ). The mean PreSVFS and PostSVFS scores in both Biology 101 and 141 classes for both traditional and collaborative learning environments is shown in Figure 17. This Figure also shows the preSVFS and postSVFS of all the twenty terms used in the vocabulary assessment of the students in the two learning environments.



*Figure 16. Mean Posttest Scores for all Classes and in Both Environments*

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

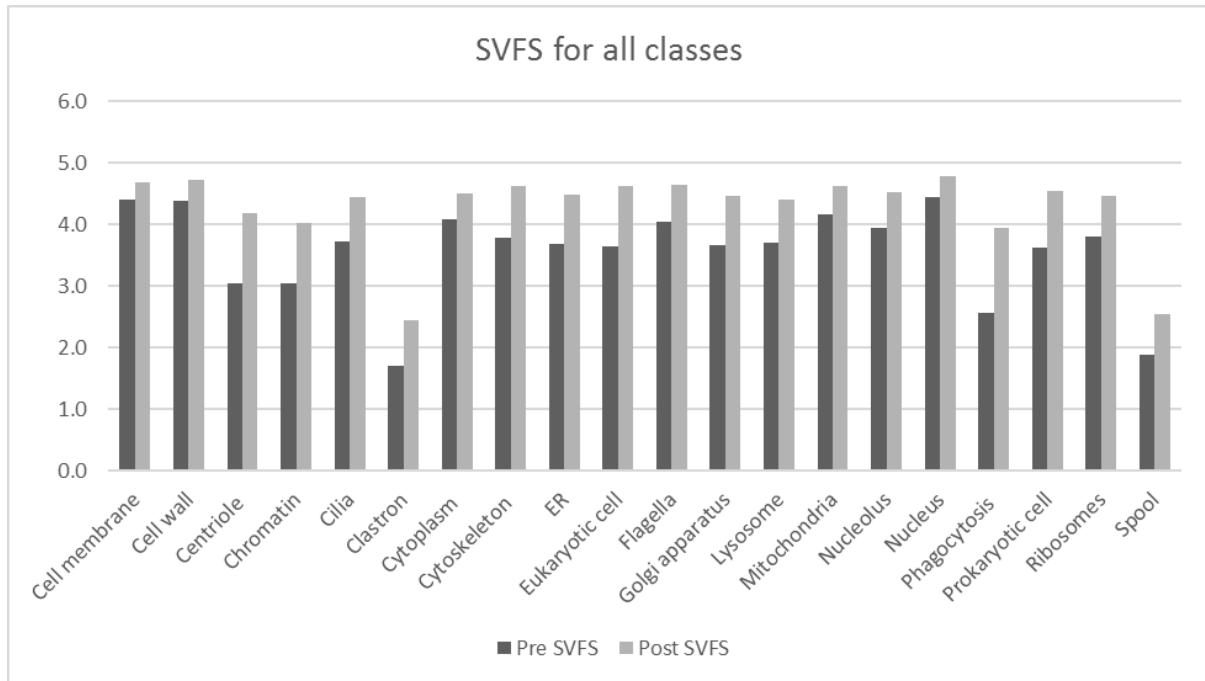


Figure 17. Mean PreSVFS and PostSVFS for both Biology 101 and 141: Traditional and Collaborative

### 4.5 Research Question #3

**RQ3:** What differential learning impacts are identifiable in a STEM educational environment employing collaborative learning?

**RQ3-  $H_0$ :** There are no differential learning impacts identified in a STEM educational environment employing collaborative learning.

**RQ3-  $H_A$ :** There are differential learning impacts identified in a STEM educational environment employing collaborative learning.

#### Analytical Approach:

In order to answer this research question, it is important to examine some of the major groups under student demographics and compare the posttest scores for each of these groups in a collaborative learning environment classroom.

**Age:** Age was categorized into six categories. Of these six groups, college students of “traditional” age (18-24 years) were classified as one group, and “other” nontraditional age group included the remaining five categories. The statistical analysis for the “traditional” college students (N = 52, M = 8.88, SD = 2.549) was done, and it was found that the mean posttest assessment score was higher than the “other” nontraditional age category (N = 18, M = 9.17, SD = 2.203). However, there was no significant difference seen between the posttest scores of “traditional” college age students and the “other” nontraditional age students  $t(68) = .418, p > .05$  (see Table 9).

Table 9.

*Group Statistics: Age and Posttest Scores in a Collaborative Learning Environment*

Student Type		N	Mean	
POST	Traditional age	52	8.88	
	Non-traditional	18	9.17	

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
								Lower	Upper
POST	Equal variances assumed	.896	.347	-.418	68	.677	-.282	-1.628	1.064

**Work Status:** Work status was categorized into three groups: unemployed, part time, and full time. Data was analyzed for only the collaborative learning group environment using independent paired sample t- test. Comparing the unemployed and the part time categories (Figure 18), it was found that the mean posttest scores for the unemployed group (M = 9.00) was almost similar to the posttest score for the part time group (M = 8.86). The mean of the posttest scores for the unemployed participants in the group was not significantly different from the part

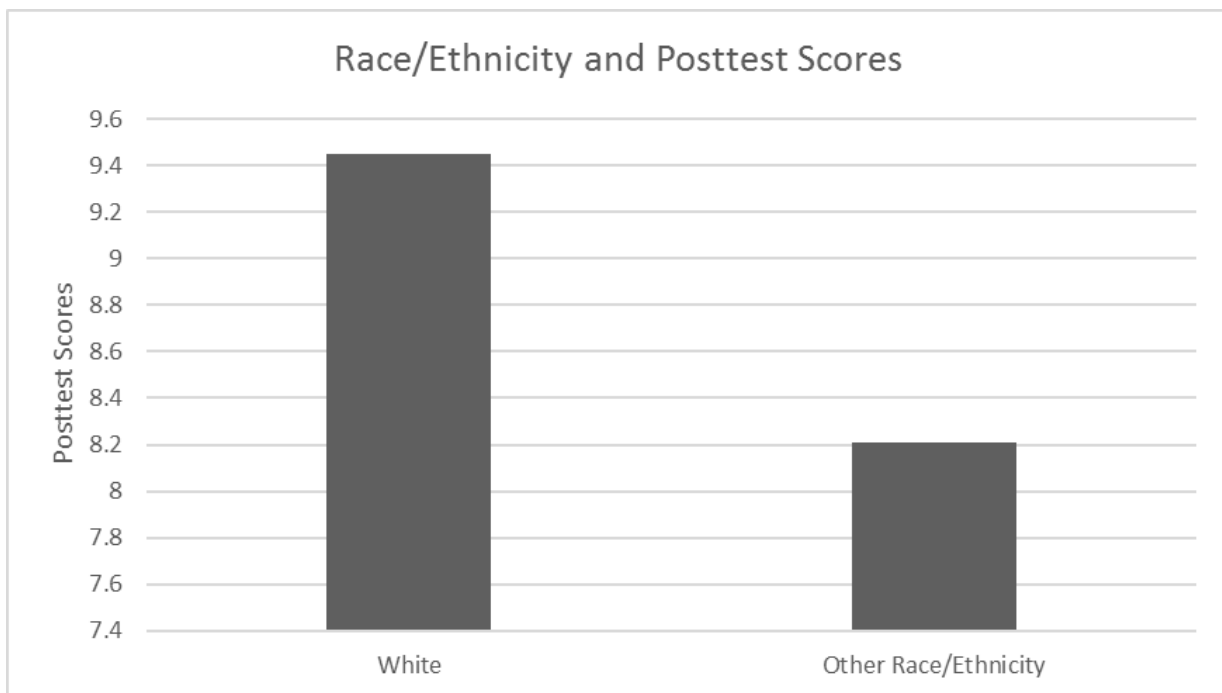
## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

time group. The t-test yielded a value ( $t = .197, p > 0.05$ ), which was not statistically significant (Appendix S). Hence, it was concluded that posttest score differences among collaborative learning groups were not significant. In comparing the unemployed and full time categories, it was found that the mean posttest scores for the unemployed group ( $M = 9.00$ ) was slightly lower than the posttest score for the full time group ( $M = 9.30$ ). The mean of the posttest scores for the unemployed participants in the group was not significantly different from the full time group. The t-test yielded a value ( $t = .288, p > 0.05$ ), which was not statistically significant. Hence, it was concluded that posttest score differences among collaborative learning groups were not significant. Comparing part time and full time categories, it was found that the mean posttest scores for the part time group ( $M = 8.86$ ) were lower than the posttest score for the full time group ( $M = 9.30$ ). The mean of the posttest scores for the full time participants in the group was not significantly different from the part time group. The t-test yielded a value ( $t = .488, p > 0.05$ ), which was not statistically significant. Hence, it was concluded that posttest assessment score differences among collaborative learning groups were not significant.



*Figure 18.* Group Statistics: Work Status and Posttest Scores in a Collaborative Learning Environment

**Race and Ethnicity:** The sample was categorized into two groups: white and “others” (Asian, Black/African American, Hispanic/Latinos, and others). In the collaborative learning environment, there were 46 white participants and 24 were grouped under “others.” The mean of the posttest scores ( $M = 9.45$ ) for the white participants in the group was significantly different from the “other” group ( $M = 8.21$ ). The t-test yielded a value  $t(68) = 2.045$ ,  $p < 0.05$ , which was statistically significant (Figure 19). Hence, it was concluded that posttest score differences among collaborative learning groups were significant in the race/ethnicity category.

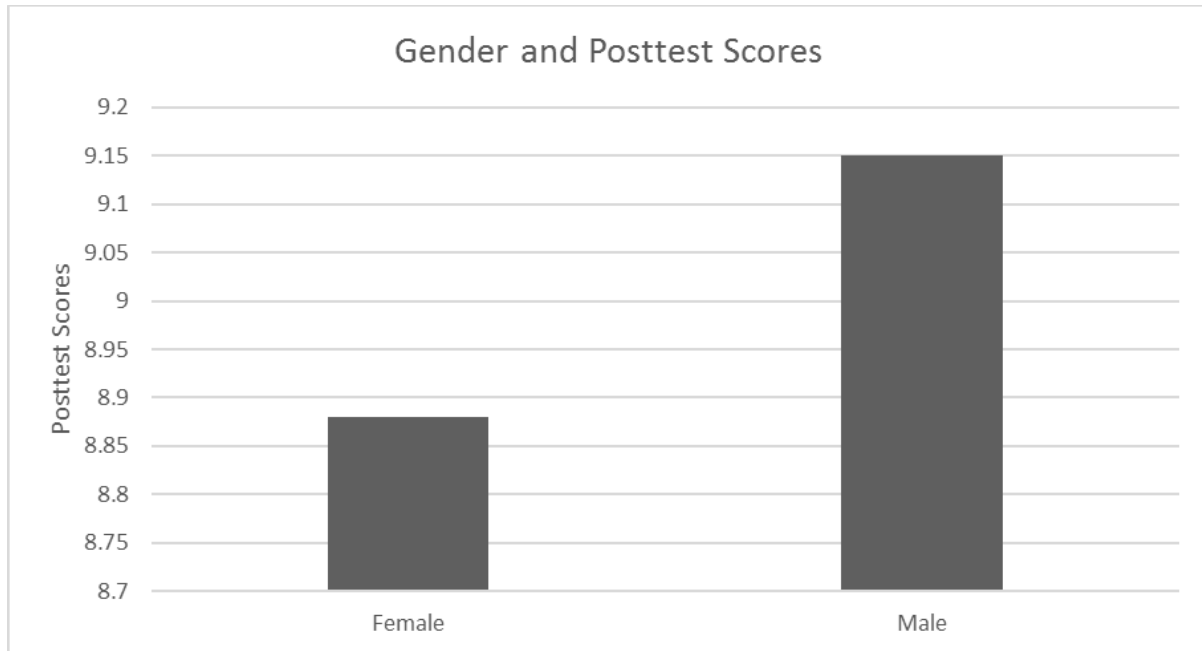


*Figure 19. Group Statistics: Race/Ethnicity and Posttest Scores in a Collaborative Learning Environment*

**Gender:** This question was not categorized, and students were provided with no options. Participants had to write in their answer. Of the seventy demographic surveys collected from the collaborative learning environment, statistics were as follows: females ( $N = 50$ ,  $M = 8.88$ ), male ( $N = 20$ ,  $M = 9.15$ ), and no response ( $N = 1$ ). The mean of the posttest scores ( $M = 8.88$ ) for the

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

female participants in the group was not significantly different from the male participants ( $M = 9.15$ ). The t-test yielded a value  $t(68) = .414$ ,  $p > 0.05$ , which was statistically not significant (see Figure 20). Hence, it was concluded that posttest score differences among collaborative learning groups were not significant in the gender category (see Appendix T).



*Figure 20.* Group Statistics: Gender and Posttest Scores in a Collaborative Learning Environment

### 4.6 Summary

This chapter describes the purpose and design of this study related to the data and its analyses. This study examined 155 students in a biology classroom at a community college to study collaborative versus traditional learning environments. In the first section of this chapter, the participants of this study were described with summaries of demographic data and descriptions of their current education and educational background. Then, the next three sections analyzed the data for the three research questions posed. Quantitative research analysis was

presented in the form of descriptive statistics to address all the research questions. The results from data assessment section for the three research questions led the researcher to accept or reject the hypotheses. The descriptive analysis for the first research question revealed that there was a significant difference seen in a collaborative learning approach in the community college classroom that resulted in increased student biological science content knowledge,  $t(70) = 6.54$ ,  $p < .05$ , with the students receiving a higher score on the posttests as compared to pretests (see Appendix U). The descriptive analysis for the second research question revealed that there are no identifiable differences in achievement for groups of students learning traditionally versus groups of students learning collaboratively  $t(153) = 1.727$ ,  $p = .0862$ . The descriptive analysis for the third research question revealed that there was a significant difference seen between the race and posttest score in a collaborative learning environment; whereas no significant difference was seen between age and posttest score, work status and posttest score, and gender and posttest score.

Chapter Five summarizes this study and discusses the results, implications, and suggestions for further research. The last chapter concludes with a final data analysis of all the research questions posed.

CHAPTER FIVE

DISCUSSIONS AND CONCLUSIONS

**5.1 Introduction**

This research was designed to reveal the extent of changes in undergraduate student learning outcomes in a collaborative learning environment, and it was conducted in biology classes at a community college level. This study examined the differences between traditional learning and collaborative learning in the conceptual understanding of a topic in cell biology. This chapter presents the main conclusions related to the findings of this study. The researcher completed data collection in the form of reviewing and scoring participants' pretest and posttest assessments. Additionally, the researcher also examined the pre and postSVFS (Science Vocabulary Familiarity Scale), and demographic surveys, and studied their relationship with the assessment scores. The results were used to summarize the current findings to improve classroom learning of community college students in higher education. There were three research questions guiding this study:

RQ1: To what extent does a collaborative learning approach in the community-college classroom result in changes to students' biology science content knowledge?

RQ2: Are there identifiable differences in achievement for groups of students learning traditionally and groups of students learning collaboratively?

RQ3: What differential learning impacts are identifiable in a STEM educational environment employing collaborative learning?

This chapter summarizes the study and its findings, offers discussion and conclusions about the study results. Limitations of the study's results, implications, and suggestions for further research are presented in this chapter.

## 5.2 Summary of Study

The purpose of this study was to explore the learning benefits of collaboration in a community college STEM classroom. Collaboration has been promoted in the K-12 education at an extensive scale. There has been a lot of research done and books written that introduce, describe, and encourage collaboration in schools. In spite of so many recommendations by researchers and administrators, collaboration and collaborative learning has mostly been researched in K-12 education, especially at the primary and secondary levels. There was very little evidence of the benefits of collaboration and collaborative learning at the community college level. The research presented in this study explored the learning benefits of collaboration, and found that undergraduate students in a biology science course who studied collaboratively, scored higher on measures of assessment (pretests versus posttests) than students who studied individually in a traditional classroom setting in a biology classroom at a community college. Though the difference was not statistically significant, it could be argued that the percentage of learning gains was higher in collaborative environment than the traditional learning environment. It was also found that the collaborative learning approach resulted in changes to students' understanding of biological science content.

## 5.3 Summary of Findings

The first research question sought to explore the potential impact of collaboration on students' science content knowledge in biology classrooms. Two assessments, in the form of pretest and posttest, were used to assess their learning gains.

***RQ1:*** To what extent does a collaborative learning approach in the community-college classroom result in changes to students' biology science content knowledge?

The null hypothesis was rejected as a significant difference was seen in between the pretest and posttest scores of students in a collaborative learning environment. Hence, a

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

collaborative learning approach in the community college classroom results in increased student biology science content knowledge.

**RQ2:** Are there identifiable differences in achievement for groups of students learning traditionally and groups of students learning collaboratively?

The null hypothesis was accepted, as there was not a significant difference seen in the pretest and posttest scores of students learning traditionally versus students learning collaboratively. Hence, there are no identifiable differences in achievement for groups of students learning traditionally versus groups of students learning collaboratively

**RQ3:** What differential learning impacts are identifiable in a STEM educational environment employing collaborative learning?

In the third research question, four major categories that were studied in the collaborative learning environment: age, work status, race and ethnicity, and gender. In reference to age, it was found that there was no significant difference seen in the posttest scores of “traditional” college age students and the “other” age students. In regards to work status, it was found that there was no significant difference seen in the posttest scores of the full time, part time, and unemployed students. In reference to race and ethnicity, it was found that there was a significant difference seen in the posttest scores of the white students and the other race students. In studying gender, it was found that there was no significant difference seen in the posttest scores of the male students and the female students. Hence, for the third research question it was concluded that posttest score differences among collaborative learning groups were significant only in the race/ethnicity category.

For the other categories not analyzed, results found that most of the students were enrolled in twelve or more credits in the Spring 2018 semester; some students had taken a prior

college science course (depending on whether they were enrolled in Biology 101 or Biology 142). Most of the students enrolled in Biology 101 and 141 wanted to enter into healthcare professions. In addition, most students were seeking either bachelors or masters as their highest level of education for future. PUT STATS

## **5.4 Discussions of Results**

### **Research Question #1**

Research question one was concerned with exploring the potential impact of collaboration on students' understanding of science content in biology classrooms. The mean posttest scores were higher for both Biology 101 and Biology 141 collaborative classes. However, the posttest mean score was higher for the higher-level Biology class (Biology 141) as compared to the general biology class (Biology 101). One reason for this could be that the Biology 141 students were more experienced as compared to Biology 101 students. Second, anatomy and physiology is a higher-level course, and is taken by students to enter into nursing or health allied fields. Third, some Biology 141 students may have taken a course in Biology 101, but a Biology 101 student may not have necessarily taken a Biology 141 course.

After assessing the supplemental information that was collected in the form of preSVFS and post SVFS, it was found that, the mean of postSVFS was higher than the mean of preSVFS. This suggested that students claimed that they were familiar with the vocabulary words that were needed to comprehend the cell biology chapter. In addition, it was interesting to note that the Biology 141 students scored a higher mean than the Biology 101 students. There could be three reasons for the difference in assessment scores and SVFS between the two biology classes. One, the Biology 101 students may not have a better understanding of the terms in cell biology and hence could not associate these terms to pre and post test questions. Two, students may think that their understanding has increased more than it actually has. If we compare students' familiarity

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

scale and their assessment scores, we would be able to conclude that students' overconfidence could be a factor where their perceived understanding exceeds their actual understanding.

Looking at just the pretest or posttest, there is a question about how the grader's scale for familiarity compares with the student's assessment results. Therefore, for Biology 101 collaborative learning environment students, it could be concluded that students think that their understanding has increased more than it actually has as compared to students in Biology 141 classes. Hence, this could have accounted for the difference in posttest scores seen in between the two biology classes.

Two control words ("Spooling" and "Clastron") were placed in the familiarity scale that did not have any definitions in context to cell biology. Fagen suggested that if a student marks three as the option for these two words, then it suggests that "he or she was less likely to suggest a low familiarity at all" (p. 111). It was found that the mean scores for both the words was lower than three, which suggests that the students did read and mark their answers correctly. It was analyzed from the pre and postSVFS scores that there were some terms in cell biology that the students were very familiar with (cell membrane, cell wall, nucleus, and cytoplasm), while there were some terms that the students struggled with (phagocytosis, lysosomes, chromatin, centriole, eukaryotic cells). The survey shows that the majority of students began in biology class with significant deficiencies in their understanding of cell biology terminology. Moreover, while there was improvement by the end of the treatment intervention, gaps in understanding can remain even after instruction, and hence this could have accounted for low scores on the assessment posttest. Some students may have believed that they understood more than they actually did.

With all the learning benefits and achievement gains that collaborative learning environments provide, it is important to incorporate collaborative learning environments in

classrooms in higher education. P-21 framework for 21<sup>st</sup> century learning includes the 4Cs, which are summarized as skills that are needed for students to be successful in college, careers, and life. These 4Cs are creativity, communication, collaboration, and critical thinking. Of these, collaboration is mentioned as an important educational outcome and a key skill. This guide suggests that students learn best when they are provided collaborative learning environments; student achievements are higher when they are engaged with others in their learning environments. Students collaborate by working in teams, learn content by identifying problems and finding solutions. This cannot only help build content knowledge but can also develop critical thinking and creativity. Collaboration can actually help develop the other three Cs

### **Research Question #2**

The two learning environments, collaborative and traditional, were studied in this research question to answer: “Are there identifiable differences in achievement for groups of students learning traditionally and groups of students learning collaboratively?” The posttest scores in both learning environments was used to find answers to this research question. For the collaborative learning environment for both classes, the mean was higher for the posttest scores as compared to the posttest scores of the traditional learning environment. Even though, there was no significance difference in achievement seen between the two learning environments, it could be argued that the mean posttest scores for the collaborative learning environments were higher. One plausible explanation may be that the intervention time for collaboration in classrooms was not sufficient to show statistical improvements in students’ achievement scores. Second, this study only covered a part of one unit of the twelve units that are taught over the course of the whole semester. It is plausible that if students were given more exposure to collaborative learning environments, it may have led to significant difference between the two

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

learning environments. One week is not enough time for students to get used to a new pedagogical approach to learning.

Third, the sample size of participants for this study was 155, but an increased sample size may have increased sample power. Increasing sample power could increase the probability of significant results. Mazur et al. (2008) studied collaboration and peer instruction in physics and mathematics classrooms, used a similar sample size as this study, and still yielded significant results. One could argue that Physics concepts are more concrete in nature as compared to biology, which is more subjective than mathematics and physics. The amount of terminology that is needed in order to fully understand concepts in biology could be like learning a new language, and hence students learning in a biology collaborative environment may need more time to get used to learning. The mean posttest score for the collaborative learning environment was higher as compared to the traditional score, and hence learning in collaboration with others could offer promising results if implemented over the course of the whole semester. Students need time and practice to get into the mode of learning in a collaborative learning environment, and just giving them a week to work may not be sufficient to show learning gains. Students may need time to get to know their collaborating partners, to learn the correct techniques for collaboration, and practice. Sousa (2006) suggests that in order to see results of collaboration, instructors should incorporate this learning environment into their classrooms every day. This can help students to get into the practice of working in groups, and hence incorporates a learning benefit to all student members.

Gain scores (Appendix V) were calculated for both the learning environments, and it was found that the gains for the collaborative learning environment for the Biology 141 class was much higher than for Biology 101 class (Appendix W). For Biology 141, gain for collaborative

class was 35% as compared to 21% in Biology 101. This suggests that the higher-level class may have more experience in working in collaboration as compared to the general biology class. Most of the Biology 101 students were new to the college environment as compared to the Biology 141 students, and hence it was found that their gain was lower in collaborative environment (21% gain) as compared to the traditional environment (29% gain).

In addition, there may be some sociocultural reasons for some students not able to collaborate in their learning environments. Reasons could include lack of trust in one another, personality differences between the strong willed and weak students, lack of communication skills and low confidence levels for the ESL (English as a Foreign Language) students. Some higher achieving students may think that explaining concepts to others in a collaborative group could be a waste of time. Lastly, it is plausible that some students did not take the assignments seriously because an outside instructor conducted the research rather than their own instructor. In addition, no points were given for the pre and posttests and for pre and postSVFS.

### **Research Question #3**

The purpose of this question was to find the answer to “What differential learning impacts are identifiable in a STEM educational environment employing collaborative learning?” In order to discuss this research question, it is important to examine some of the major groups under student demographics and compare the posttest scores for each of these groups in a collaborative learning environment classroom.

### **Student Participants’ Demographics**

**Age:** Community colleges play a very important role to help establish a bridge for STEM students to enter four-year colleges, thus helping to provide labor forces in growing STEM careers. There is an increasing number of high school students who are now opting to first enroll

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

in community colleges over four-year institutions (AACC, 2014; Hoffman, Strarobin, Laanan & Rivera, 2010). “This is evidenced by increasing associates degree enrollment, which accounted for 49.8% of total higher education enrollment increases from 2000 to 2011, in contrast to enrollment in baccalaureate education, which accounted for 6.8% of the total increase in enrollment” (NSB, 2014, as cited in Gess, 2015). In Chapter 1.3, a reference was made to the growing number of nontraditional student population at the community college level. However, at the community college that was researched, it was found that the “traditional” college going age was the 18-24 years (N = 119), which accounted for 77% of the total student population. The nontraditional students (adult learners) accounted for only 20% (N = 31) of the total sample population. These numbers were in line with the student demographics for the entire population of Blue Ridge Community College (BRCC). The question that arises is “why are the students in community colleges getting younger and younger?”

We discussed in Chapter One the reasons for increase in adult learner population in higher education, especially in community colleges. The younger “traditional” students are opting to enroll in local community colleges, rather than going straight to four-year institutions. In the past, four-year universities seemed to offer better practical profession preparation than their two-year counterparts. However, as prices for universities continue to rise and community colleges expanding their fields of study, the fields of higher education appears to be changing drastically. Today, community college enrollment is increasing very rapidly across the country, while four-year institutions have seen a decrease in student population within the past few years. The open-enrollment policies of community colleges and their low tuition undoubtedly are attracting students and families of the middle to lower income groups. Studying at community colleges offers flexible schedules to students who have families and must work full time during

their college experience. Open admission policies at community colleges allow students who did not perform as well in high school the opportunity to pursue a higher education. These students also have the ability to transfer credits to another institution if they desire to improve or further their education in the future. Another reason for the increased percentage of young student population is that most community colleges offers dual enrollment to high school students in its district.

In addition, there are some students who are not sure of their major, and do not want to invest their time and money into courses at the university level that may not interest them later. Hence, they prefer to take courses at community colleges without having to invest a lot of money. Some students prefer to work alongside education, and hence they enroll themselves as part-time students at community colleges, where flexible schedules are available.

It was also interesting to note that the posttest scores for the nontraditional students was higher than the posttest scores for traditional students. These nontraditional students are experienced and come with different skills and abilities, vary in personal motivation and objectives. They generally work full time and have less time on campus, so they make use of the class timing for learning the best they can. As mentioned in Chapter 2, nontraditional students are persistent, self-directed and committed. They are motivated, are ready to learn, and hence do better on any task that is in front of them.

**Work Status and Number of Credits:** This study has found that sample students at BRCC work full-time jobs, and are taking 12 credits or more in a single semester. These students work full-time jobs because of family demands and monetary needs. They are young and need to work full time to support themselves and their education, and pay the costs of attending college. In order to be considered a full-time student, BRCC requires that students take at least 12 credits

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

per semester, while part-time students usually take between 6-8 credits per semester. American Association of Community Colleges (2014) finds that, in general, students who work full time and take a full load of 12 credits or more are less likely to graduate as compared to the other students. In addition, full-time students spend more time on campus and have better access to support services, including academic advisers. Moreover, these students have more opportunities to collaborate with other students and to interact with full-time faculty members. Quantitative studies consistently show that retention rates are higher for students who work a modest number of hours per week (part-time) than they are for students who do not work at all or those who work full-time. As per the statistics from *American Association of University Professors*, nearly one in ten traditional-aged, full-time undergraduate student is employed at least thirty-five hours per week. Contrary to the common belief that community college students are more likely to be employed than students at four-year institutions, the number of working undergraduates by the number of hours was similar at public two-year, public four-year, and private four-year institutions (2010). Young “traditional” students think of work to be their fundamental responsibility. It can be argued that some “traditional” students may use employment as a way to explore career options. These students may not have time to study, and hence learning in collaboration could be beneficial to their learning. Working full time or part time and studying full-time or part-time while enrolled in community college comes with its unique strengths and weaknesses. Making a choice between the two (work status and student status) comes down to a combination of personal choices and factors, including work schedule, long-term goals, support from family, and professional aspirations (see Appendix X for relationship between work status and mean posttest score).

**Race/ Ethnicity and Gender:** It is well documented that community colleges serve a large proportion of minority, first-generation, low-income, and adult students. In fact, it will be right to say that the population of community colleges reflect the geographical areas they serve. The higher education enrollment rates among white, black, and Hispanic students are similar. According to a study by the National Center for Education Statistics (NCES), in 2014 the rate of college enrollment directly out of high school was 68% for white students, 63% for black students and 62% for Hispanic students. In this study, it was found that, most students were white, 18% of all participants were Hispanic/Latinos, and eight percent of participants were Black/African American. As per research, Asian and White (first-time full-time) students are much more likely to be enrolled at public four-year institutions than at community colleges, while black and Hispanic first-time full-time students are represented majorly in the public two-year and for-profit sectors (Jaggars & Jenkins, 2015). Community colleges serve a diverse range of students in terms of age, race/ethnicity, and socioeconomic background, providing an important pathway to education for many who would not attend college otherwise. The participants' demographic of this study matched with the population of Blue Ridge Community College. The overall population of BRCC represents students who are 32% full-time and 68% part-time; 42% male students and 58% are female. Of these students, 79% are White, 9% are Hispanic/Latino, 5% are Black, 2% are Asian, and 5% belonged to other races. Of the total enrolled, 74% students are age 24 and under while 26% are 25 years and older.

Therefore, the questions arises that why the “non-white” students get a lower posttest score as compared to white students. First, these “nonwhite” students may have English as their second language, and hence may lack communication skills to interact in a collaborative learning environment. This could then result in lack of confidence in interacting with others, and

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

eventually may result in lack of academic motivation, which could finally result in a lower posttest score.

In the gender category, the question arises that why is the percentage of women in community colleges increasing? Female participants in the sample researched was found to be three times the number of male students. According to the NCES (2014) report, over the past 25 years, the total enrollment of adults in higher education institutions increased for Whites, Blacks, and Hispanics. Within each racial/ethnic group, female enrollment increased more than male enrollment, although the rates of increase varied by race/ethnicity. The fastest rate of growth for women students was seen for the Hispanics group. Tsapogas (2004) writes that females who are in STEM careers have attended a community college at some point of their lives, and it has been recognized that community colleges play a very important role in training women to enter STEM fields. Studies also report that more and more women are now returning to community colleges to continue with their education. Community colleges have played an important role for women education. In 2010, women made up 57 percent of the students at these institutions. Currently, more than 4 million women attend community colleges. These women have families to support and may have limited financial resources, and so for these reasons, they are attracted to the “flexible schedules, low cost, and open-door admissions of community colleges” (Rose & Hill, 2013, p. 2). More jobs are now created for women to create a gender balance in various companies, and studies report that more and more women are now returning to community colleges to continue with their education to fill up these jobs. Community colleges offer various program to their female students to help them with their education. Childcare facilities, increased scholarship programs, and increased enrollment of female students are a few factors that may have led to increased female enrollments in community colleges. Since this research was

conducted in a biology-based classroom, and most of the students will enter into medical and health allied fields, these programs have increased number of female students in them.

**Prior College Science Courses and Current Field of Study:** Of the 155 students that participated in the study, 82% of students had taken at least one prior college science course in the past five years. Of all the science courses that are offered at BRCC, it was found that Biology 101, Biology 141, and Chemistry 101 are the top three science courses that students have taken in the past five years. This completely aligns with the current field of study, as these three courses are required prerequisites for natural science or other courses like nursing and other healthcare professions. 83% percent of the participating students wanted to enter natural sciences or healthcare professions like nursing, dental hygiene, or physical therapist. These programs are selective with limited enrollment and are very competitive. Students who do not do well in the prerequisite course the first time end up taking the courses again to earn a better grade. Of the remaining participants, a few students had taken a course in general physics, and these students were taking general biology as one of the prerequisite to fulfill their science credits. Community colleges offer students the opportunity to save money, prepare for transfer to a four-year college, get ready for a career, try out college and take advantage of a flexible schedule. According to the American Association of Community Colleges (AAAS, 2015), 44 percent of all undergraduate college students are enrolled at a community college.

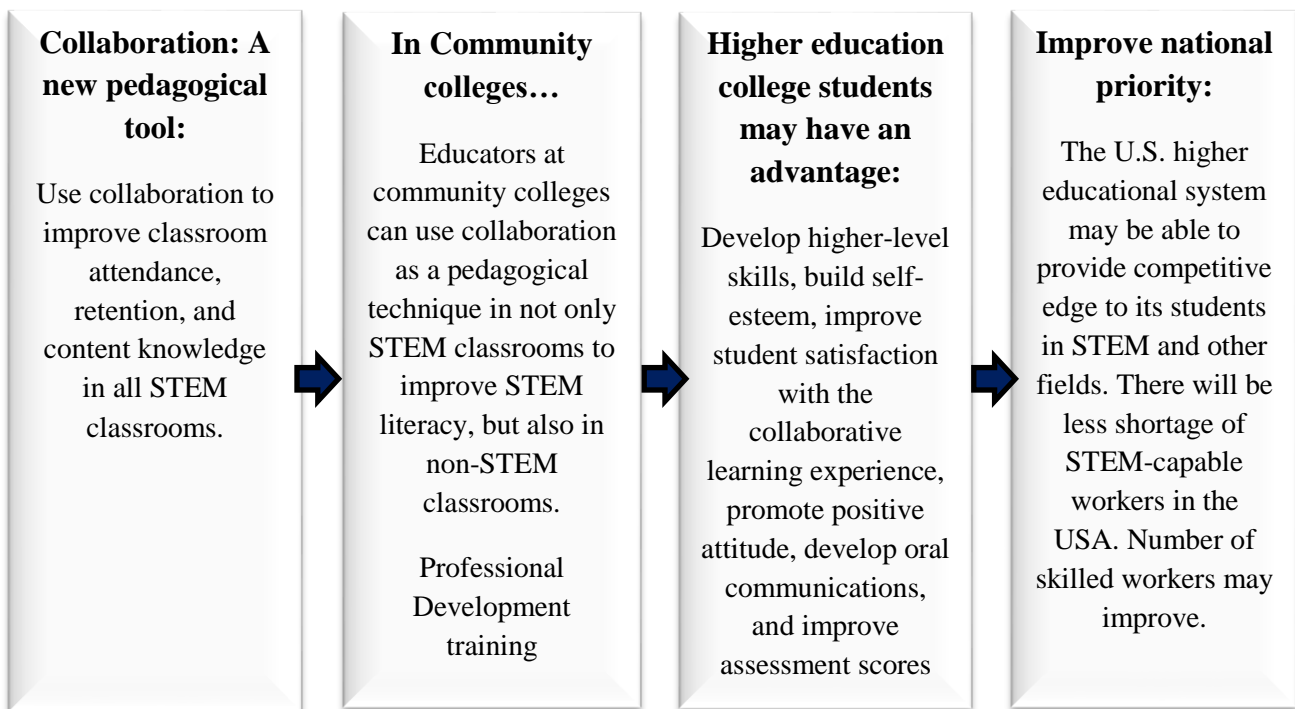
**Highest Level of Education desired:** Fifty one percent of participants were enrolled in twelve or more credits, and the remaining were enrolled in less than twelve credits during the semester. This suggests that the students have high aspirations and are earning towards their future career or goal. More than 50% of the participants want to earn either a masters or a bachelor's degree, and since these degrees are not offered at community colleges, it is most likely that these

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

students will transfer into four-year colleges. An associate degree is an undergraduate degree that typically takes two years to complete being a full time student, but some students may take more than 12 credits in a semester, and finish it a semester or two before the scheduled time. Many participants aspired to enter into the nursing and other health-related fields. Hence, it can be summarized that students of all ages and income backgrounds attend community colleges.

### 5.5 Implications of Study

The implications for the study come from the results and discussions of the study, and has been summarized in the following illustration (see Figure 21).



*Figure 21: Summary of Implications of the Study*

#### **Collaboration: The Right Pedagogical Tool:**

The results of this study have direct implications for the STEM educator within biological sciences, and in future for the other fields of integrative STEM education. Learning science content through inquiry requires a science pedagogy that places emphasis on student led

instruction. Improved understandings of using collaboration in community college classrooms can help in “developing understanding on a deeper level that enables to the student to link the new information to prior knowledge, and organize and assimilate the new information” (NRC, 1999, p. 9). Collaboration is increasingly mentioned as an important pedagogical technique in various levels of education and most models of 21<sup>st</sup> century skills include collaboration as a key skill. According to Ormond (2012), students learn through cognitive engagement. Students who are engaged will learn more effectively than those who are not. Collaborative learning activities allow learners to think in a way that the content information stays with them for a longer time. The results from this study finds collaborative learning environment to be an effective tool to use in classrooms. Collaboration enables STEM disciplines to increase opportunities for knowledge sharing and exchange, thereby increasing knowledge and competence. Researchers have found that students who work in collaborative environments retain information much longer and deeper as compared to students who work individually in traditional classrooms. In addition, it has been researched that students who studied in an active and collaborative environment scored better in cognition and psychological activities as compared to students taught in traditional classrooms. Cognitively and socially, collaboration has been found to improve self-esteem and self-confidence. Researchers argue that disengagement in classrooms is more harmful to our country’s future than social problems involving youth. Disengagement results in underachieving students and this can lead to many other national issues. So in order to prevent this from happening, student engagement must be the top priority of all educators, administrators, parents, and researchers.

### **Professional Development for Professors and Instructors in Community Colleges:**

Improving student success in higher education is a national priority and it is important to

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

highlight community colleges as one of the main resources to improve representation in STEM education. Evidence suggests that students learning gains are higher when they are working in a collaborative and engaged learning environment, and it becomes important to train community college professors in this pedagogical approach. There is a continuous need for ongoing opportunities for professional development in an era of rapid and continuous change in higher education. Most of the STEM faculty of community colleges spend 16% more time in lecturing and significantly less time in incorporating new pedagogical techniques to improve content knowledge in classrooms. Role of instructor has been thoroughly researched in collaborative learning environments in classrooms, but the criteria for implementing collaboration in classrooms is not much researched, and must be thoroughly planned and implemented by the instructor. Osterholt & Barratt (2012) discuss the three guiding principles for implementing collaborative learning in classrooms. One, the instructor should have knowledge on collaborative-based learning in classrooms. Two, the instructor should prepare activities in a way that induces critical thinking opportunities for students working in collaborative groups. Three, the instructor should be present during the collaborative exercises and must be available to provide any guidance to students if necessary.

Professional development and training is required to increase the proficiency of classroom instruction, to improve student achievement, and address the social needs of community college students. Time should be built in the instructor's teaching schedules for professional development opportunities in implementing collaboration in classrooms.

### **Improve National Priority in STEM Education:**

Significant importance has been placed on STEM education to encourage students to enter into careers related to science, technology, engineering, and mathematics. The United

States education system is looking ways to provide a positive student-learning environment to improve student achievement, critical and rational thinking, analysis, and synthesis. In order to improve STEM literacy and STEM readiness, it is important to focus research efforts at the community college. STEM literacy does not mean that the students will have content knowledge in all four silos of STEM (Toulmin & Meghan, 2007); rather they should be able to integrate skills, processes, and concepts from each of the four disciplines and extend it towards its application. With the growing number of undergraduate students at the community colleges in STEM fields, it is important to retain these students by keeping them engaged in their learning fields. So in order to improve STEM skills in students, policy makers have called for the implementation of programs that can help improve inquiry-based scientific research methods in community college classrooms. Policy makers and educational leaders are trying to find various factors that can improve academic and cognitive outcome and help progress STEM literacy (Bybee, 2013). Collaboration provides competitive edge to its students in STEM fields. Increased number of STEM capable students graduating from the United States colleges and universities may help solve the national problem of shortage of STEM workers.

### **5.6 Suggestions for Future Research**

The findings of this study indicate that there is need for more research on the implementation of collaborative learning environments in community college classrooms. This study has the potential to be implemented not only in other STEM disciplines but also in non-STEM disciplines. A STEM-literate student should be able to think critically and make rational judgments by managing, analyzing, and synthesizing from multiple sources of information (Partnership for 21st Century Skills, 2011). Collaborative learning should start in elementary school classrooms, and should be adopted all levels of education and education communities.

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

These 4Cs are creativity, communication, collaboration, and critical thinking. Of these, collaboration is mentioned as an important educational outcome and a key skill. This guide suggests that students learn best when they are provided collaborative learning environments; student achievements are higher when they are engaged with others in their learning environments. Students collaborate by working in teams; learn content by identifying problems and finding solutions. This can not only help build content knowledge but can also develop critical thinking and creativity. Collaboration can actually help develop the other three Cs. This pedagogical approach should then be adopted all the way into two-year and four-year institutions. It will also be interesting to see if this collaborative teaching and learning could be implemented in all community colleges and universities across the nation, and if the results obtained would be the same across the board. If this technique is introduced early on in education, then it can help students develop the skills they need to succeed in doing group activities, such as using team-building exercises or introducing self-reflection techniques. In addition to looking at STEM disciplines, since critical thinking and problem solving is one of the major focuses in STEM integration, future research should also explore students' problem solving skills and abilities when implementing a STEM integration lesson in any other non-STEM classroom as well.

It would be worthwhile to study a larger sample size to see if there is a significant difference in the posttest assessment scores between the collaborative and traditional learning environments. Peer learning is also a student-centered approach that helps students learn to engage in-group activities, perform better academically, persist longer, feel better about the educational experience and have enhanced self-esteem (Landis, 2000).

Another central and important issue for further study is to examine the legislation and expectations for using collaboration as an effective pedagogical tool in K–16 education setting from a national and statewide policy level. This could help to create a framework for collaborative learning that can guide educators, researchers, and policymakers to examine and evaluate the outcomes of using this pedagogical approach.

Lastly, it would be interesting to study the merger of collaboration with design-based learning (DBL) or project-based learning (PBL) in STEM classrooms. With this approach, students would have the opportunity to engage collaboratively in a problem, and work to resolve it through construction of a design-based artifact or by problem solving.

Changes should be implemented not only in classrooms, higher education-community colleges, at the state level, but also at the national level. In classrooms, curriculum and instruction should be evaluated for inclusion of collaborative learning, opportunities for collaboration should be embedded, and assessment of collaboration as a major student outcome should be incorporated. In higher education, especially in community colleges, collaboration should be made as a required skill to have and develop common vision and plan to incorporate it as a necessary skill for success. Professional development should be offered to all instructional faculty and educators. At the state level, collaboration should be promoted as an important student outcome for success and should be implemented across the higher education schools and colleges. In short, collaboration should be promoted as an important skill to increase 21<sup>st</sup> century learning across all levels of educations in the United States.

## **5.7 Conclusion**

Significant importance has been placed on STEM education to encourage students to enter into careers related to science, technology, engineering, and mathematics. United States

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

education system is looking ways to provide a positive student-learning environment to improve student achievement, critical and rational thinking, analysis, and synthesis. United States does not have a very good standing in international math and science assessment tests. Research indicates that U.S. students continue to rank around the middle, and behind many other advanced industrial nations. To help US do better in STEM disciplines, policymakers, researchers, and educators should look at ways for improving classroom experience for students in K-16 education.

P21's Framework for 21st Century Learning offers 4Cs, of which collaboration is mentioned as an important pedagogical technique, an educational outcome, and a key skill in various levels of education. This guide suggests that students learn best when they are provided collaborative learning environments; student achievements are higher when they are engaged with others in their learning environments. Students collaborate by working in teams; learn content by identifying problems and finding solutions. This can not only help build content knowledge, but can also develop critical thinking and creativity. Collaboration can actually help develop the other 4Cs. By implementing this unique pedagogical mode of instruction, in the form of collaboration in biology classrooms, improved achievement and representation can be seen, thus improving STEM literacy across the nation. Although further work is required to gain a more complete understanding of implementing collaborative learning environments, our findings indicate that collaboration was an effective means to improve students' learning outcomes in a biology-based classroom at the community college level.

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## **Appendix A**

### **Biology Classes Spring 2018 Schedule**

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

**ORACLE** **SIS PRODUCTION**

Favorites Main Menu > Self Service > Faculty Center > My Schedule > Class Search

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10 class section(s) found

**▼ BIO 101 - General Biology I**

Class	Section	Days & Times	Room	Instructor	Meeting Dates	Status
<a href="#">11546</a>	<a href="#">01-LEC</a> <a href="#">Regular</a>	MoWe 8:00AM - 9:15AM	J117-General Classroom	Ellen Crabtree	01/08/2018 - 05/07/2018	●
<a href="#">11547</a>	<a href="#">02L-LAB</a> <a href="#">Regular</a>	Mo 9:30AM - 12:15PM	J105-Biology Laboratory	Ellen Crabtree	01/08/2018 - 05/07/2018	●
<a href="#">11548</a>	<a href="#">03L-LAB</a> <a href="#">Regular</a>	We 9:00AM - 11:45AM	J105-Biology Laboratory	Ellen Crabtree	01/08/2018 - 05/07/2018	●
<a href="#">11549</a>	<a href="#">04-LEC</a> <a href="#">Regular</a>	MoWe 11:00AM - 12:15PM	J117-General Classroom	Harpreet Panesar	01/08/2018 - 05/07/2018	●
<a href="#">11550</a>	<a href="#">05L-LAB</a> <a href="#">Regular</a>	Mo 1:00PM - 3:45PM	J105-Biology Laboratory	Harpreet Panesar	01/08/2018 - 05/07/2018	●
<a href="#">11551</a>	<a href="#">06L-LAB</a> <a href="#">Regular</a>	We 1:00PM - 3:45PM	J105-Biology Laboratory	Harpreet Panesar	01/08/2018 - 05/07/2018	●
<a href="#">11586</a>	<a href="#">07-LEC</a> <a href="#">Regular</a>	MoWe 5:15PM - 6:30PM	J117-General Classroom	S Staff	01/08/2018 - 05/07/2018	●
<a href="#">11587</a>	<a href="#">08L-LAB</a> <a href="#">Regular</a>	Mo 6:45PM - 9:30PM	J105-Biology Laboratory	S Staff	01/08/2018 - 05/07/2018	●
<a href="#">11552</a>	<a href="#">V01-LEC</a> <a href="#">Regular</a>	TBA	TBA	Michael Cast	01/08/2018 - 05/07/2018	●
<a href="#">11553</a>	<a href="#">V02L-LAB</a> <a href="#">Regular</a>	TBA	TBA	Michael Cast	01/08/2018 - 05/07/2018	●

[NEW SEARCH](#) [MODIFY SEARCH](#)

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  Closed 
  Wait List

BIO 141 sections for 2018 Spring

1-12 of 12

Section	Session	Status			
<a href="#">01-LEC (11559)</a>	1	<input type="checkbox"/>			
Days	Start	End	Room	Instructor	Dates
MoWe	9:30AM	10:45AM	J130-General Classroom	Faison Dana	01/08/2018 - 05/07/2018


Section	Session	Status			
<a href="#">02L-LAB (11560)</a>	1	<input type="checkbox"/>			
Days	Start	End	Room	Instructor	Dates
MoWe	11:00AM	12:15PM	J125-Biology Lab	Faison Dana	01/08/2018 - 05/07/2018

Section	Session	Status			
<a href="#">03L-LAB (11561)</a>	1	<input type="checkbox"/>			
Days	Start	End	Room	Instructor	Dates
MoWe	12:30PM	1:45PM	J125-Biology Lab	Faison Dana	01/08/2018 - 05/07/2018

Section	Session	Status			
<a href="#">04-LEC (11574)</a>	1	<input type="checkbox"/>			
Days	Start	End	Room	Instructor	Dates
TuTh	11:00AM	12:15PM	J130-General Classroom	EmmaRose Phillips	01/08/2018 - 05/07/2018

Section	Session	Status			
<a href="#">05L-LAB (11575)</a>	1	<input type="checkbox"/>			
Days	Start	End	Room	Instructor	Dates
TuTh	12:30PM	1:45PM	J125-Biology Lab	EmmaRose Phillips	01/08/2018 - 05/07/2018

Section	Session	Status			
<a href="#">06L-LAB (11578)</a>	1	<input type="checkbox"/>			
Days	Start	End	Room	Instructor	Dates
TuTh	2:00PM	3:15PM	J125-Biology Lab	EmmaRose Phillips	01/08/2018 - 05/07/2018


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 [Faculty Center](#) > 
 [My Schedule](#) > 
 [Class Search](#) > 
 [Browse Course Catal](#)

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Section				Session	Status
<a href="#">07-LEC (11562)</a>				1	<input type="checkbox"/>
Days	Start	End	Room	Instructor	Dates
TuTh	5:30PM	6:45PM	J130-General Classroom	Pamela Monger	01/08/2018 - 05/07/2018

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Section				Session	Status
<a href="#">08L-LAB (11563)</a>				1	<input type="checkbox"/>
Days	Start	End	Room	Instructor	Dates
TuTh	7:00PM	8:15PM	J125-Biology Lab	Pamela Monger	01/08/2018 - 05/07/2018

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Section				Session	Status
<a href="#">10L-LAB (44826)</a>				1	<input type="checkbox"/>
Days	Start	End	Room	Instructor	Dates
TuTh	11:00AM	12:15PM	J125-Biology Lab	Faison Dana	01/08/2018 - 05/07/2018

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Section				Session	Status
<a href="#">V01-LEC (44823)</a>				1	<input type="checkbox"/>
Days	Start	End	Room	Instructor	Dates
TBA	TBA		TBA	Faison Dana	01/08/2018 - 05/07/2018

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Section				Session	Status
<a href="#">V03-LEC (11589)</a>				1	<input type="checkbox"/>
Days	Start	End	Room	Instructor	Dates
TBA	TBA		TBA	Pamela Monger	01/08/2018 - 05/07/2018

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Section				Session	Status
<a href="#">V04L-LAB (11590)</a>				1	<input type="checkbox"/>
Days	Start	End	Room	Instructor	Dates
TBA	TBA		TBA	Pamela Monger	01/08/2018 - 05/07/2018

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## **Appendix B**

### **Prerequisite Requirements for BIOLOGY 101 and BIOLOGY 141**

 [GO](#)

[Home](#) > [Academics](#) > [Course Descriptions](#)

## Course Descriptions

### Biology

#### **BIO 101–102 (4 CR) (4 CR)** **General Biology I–II**

Must be taken in sequence

Prerequisite: Readiness to enroll in ENG 111 plus completion of MTE 1-3 OR placement in MTE 4 or higher. Completion of high school chemistry or CHM 101 is strongly encouraged.

Explores fundamental characteristics of living matter from the molecular level to the ecological community with emphasis on general biological principles. Introduces the diversity of living organisms, their structure, function, and evolution. Lecture 3 hours. Recitation and laboratory 3 hours. Total 6 hours per week.

#### **BIO 141–142 (4 CR) (4 CR)** **Human Anatomy and Physiology I–II**

Must be taken in sequence

Integrates anatomy and physiology of cells, tissues, organs, and systems of the human body. Integrates concepts of chemistry, physics, and pathology. Lecture 3 hours. Laboratory 2-3 hours. Total 5-6 hours per week.

[Programs & Majors](#)

[Catalog](#)

[Course Descriptions](#)

[Distance Learning](#)

[Academic Calendar](#)

[Academic Support](#)

[Academic Expectations](#)

[Honors Program](#)

[Graduation](#)

[Contact](#)

## **Appendix C**

### **Class Schedules for BIOLOGY 101 and 141**

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

**Biology 101 Schedule  
Spring 2018 Semester  
Lab Room J 105**

Number	Week	Lab	Quiz/Assignment
1	Jan 8-12	Safety & Measurement	Introductions and in-lab assignment 1
2	Jan 15-19	No Labs- Martin Luther King	
3	Jan 22-26	Scientific Method / Pill Bug Lab	Quiz 1 on lab 1
4	Jan 29-Feb 2	Chemistry and Biogologychemistry	Quiz 2 on lab 2
5	Feb 5-9	Microscope & Cell Structure	Quiz 3 on lab 3
6	Feb 12-16	<b>Lab Exam 1</b>	
7	Feb 19-23	Osmosis & Enzymes	
8	Feb 26-Mar 2	Photosynthesis	Quiz 4 on lab 7
9	Mar 5-9	<b>No Labs- Spring Break</b>	
10	Mar 12-16	Cell Respiration	Quiz 5 on lab 8
11	Mar 19-23	<b>Lab Exam 2</b>	
12	Mar 26-30	Genetics	
13	Apr 2-6	Replication/ Transcription-Translation & Monster Lab	Quiz 6 on lab 12 In-lab assignment 2
14	Apr 9-13	Electrophoresis & Microarray	Quiz 7 on lab 13
15	Apr 16-20	Evolution online lab/ Evolution Lab	Quiz 8 on lab 14 In-lab assignment 3
16	Apr 23-27	<b>Lab Exam 3</b>	

\*\*All quizzes will be given in the first 15 minutes of lab period and is worth 15 points, for a total of 120 points

\*\*Three in-class assignments are worth 10 points each, for a total of 30 points

\*\*All exams are worth 50 points for a total of 150 points

\*\*There will be no make up for lab exams or quizzes- they have to be taken on the day scheduled

## Schedule for Human Anatomy & Physiology BIOLOGY-141, Spring 2018

### Lecture Room in D109

### Room J106

Day	Lecture Schedule	Laboratory Schedule
MON	Introduction to Human Anatomy and Physiology (1.1-1.8)	Lab Overview and Scientific Method
WED	Introduction to Human Anatomy and Physiology (1.1-1.8) <b>Quiz 1 on Ch 1</b>	Lab 1: Introduction to Human Anatomy
MON	<b>MLK DAY- WE ARE OFF</b>	
WED	Chemical Basis of Life (2.1-2.2) <b>Quiz 2 on Chapter 2</b>	Lab 2: Chemical Bonding and Solubility
MON	Chemical Basis of Life (2.3)	Lab 3: Microscope Use
WED	<b>Lecture Exam 1</b>	<b>Lab Exam 1</b>
MON	Cells (3.1-3.3) <b>Quiz 3 on Chapter 3</b>	Lab 4: Cell
WED	Cells (3.4-3.7)	Lab 5: Membrane Transport
MON	Cellular Metabolism (4.1-4.5) <b>Quiz 4 on Chapter 4</b>	Lab 6: Organic Molecules
WED	Cellular Metabolism (4.5-4.7)	Lab 7: DNA Replication and Mitosis
MON	<b>Lecture Exam 2</b>	<b>Lab Exam 2</b>

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

WED	Tissues (5.1-5.2) <b>Quiz 5 on Chapter 5</b>	Lab 8: Epithelial Tissue
MON	Tissues (5.3-5.6)	Lab 9: Connective Tissue
WED	Integumentary System (6.1-6.4) <b>Quiz 6 on Chapter 6</b>	Lab 10: Muscle Tissue and Nervous Tissue
MON	Integumentary System (6.5-6.6)	Lab 11: Integumentary System
WED	<b>Lecture Exam 3</b>	<b>Lab Exam 3</b>
MON	<b>Spring Break</b>	
WED	<b>Spring Break</b>	
MON	Skeletal System (7.1-7.3, 7.7-7.10) <b>Quiz 7 on Chapter 7</b>	Lab 12: Skeletal Organization – skull, vertebrae, ribs, sternum

*\*The instructor reserves the right to make changes to the schedule or course assignments. It is the student's responsibility to keep up with any changes to the schedule or coursework as notified in class, through the course BlackBoard website, or through email.*

*\* The Make-up Quizzes can be used to replace two low quiz grades*

## **Appendix D**

### **Guided Course Objectives for Cell Biology in Collaborative Learning Environment**

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

Names of Collaborating Members: \_\_\_\_\_ Class: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ Date: \_\_\_\_\_  
\_\_\_\_\_

**Given to you:** You are given MODELS of different cell models (bacteria, animal, and plant), PowerPoint notes, and chapter notes for reference. You may use any resources available for this activity.

### **Concept Objective 1: Types of cells: Eukaryotic and Prokaryotic Cells**

*You have 15 minutes* to look up these concepts. Please work together in groups to learn the following. Please ask me if your group needs any clarification or has any questions.

- Major differences between the prokaryotic and eukaryotic cells?
- Examples of eukaryotic cells and prokaryotic cells
- Structural differences between plant cells and animal cells.
- Structures that are common to all cells (eukaryotic and prokaryotic)

### **Concept Objectives 2: cell membrane, phagocytosis, and chromatin**

*You have 15 minutes* to look up these concepts. Please work together in groups to learn the following. Please ask me if your group needs any clarification or has any questions.

- Location and function of cell membrane
- Composition of cell membrane (what is it made up of)
- What is phagocytosis? (process and examples of cell)
- What is chromatin?
- Chromatin: location, structure, and function

### **Concept Objectives 3; organelles of the cells**

*You have 15 minutes* to look up these concepts. Please work together in groups to discuss the following. Please ask me if your group needs any clarification or has any questions.

#### ❖ **Know the location and functions of the following structures in a cell:**

- ❖ Golgi apparatus
- ❖ Mitochondria
- ❖ Centriole
- ❖ Endoplasmic reticulum
- ❖ Nucleus
- ❖ Lysosome
- ❖ Ribosomes
- ❖ Nucleolus
- ❖ Cilia
- ❖ Flagella
- ❖ Cytoskeleton

## **Appendix E**

### **Cell Biology: Student Learning Objective**

**LEARNING OBJECTIVES**

**CHAPTER 4: CELL STRUCTURE**

*4.1 Cell Theory*

- 1. Discuss the cell theory.*
- 2. Describe the factors that limit cell size.*
- 3. Categorize structural and functional similarities in cells.*

*4.2 Prokaryotic Cells*

- 1. Describe the organization of prokaryotic cells.*
- 2. Distinguish between bacterial and archaeal cell types.*

*4.3 Eukaryotic Cells*

- 1. Compare the organization of eukaryotic and prokaryotic cells.*
- 2. Discuss the role of the nucleus in eukaryotic cells.*
- 3. Describe the role of ribosomes in protein synthesis.*

*4.4 The Endomembrane System*

- 1. Identify the different parts of the endomembrane system.*
- 2. Contrast the different functions of internal membranes and compartments.*
- 3. Evaluate the importance of each step in the protein-processing pathway.*

*4.5 Mitochondria and Chloroplasts: Cellular Generators*

- 1. Describe the structure of mitochondria and chloroplasts.*
- 2. Compare the function of mitochondria and chloroplasts.*
- 3. Explain the probable origin of mitochondria and chloroplasts.*

*4.6 The Cytoskeleton*

- 1. Contrast the structure and function of different fibers in the cytoskeleton.*
- 2. Illustrate the role of microtubules in intracellular transport.*

*4.7 Extracellular Structures and Cell Movement*

- 1. Describe how cells move.*
- 2. Identify the different cytoskeletal elements involved in cell movement.*
- 3. Classify the elements of extracellular matrix in animal cells.*

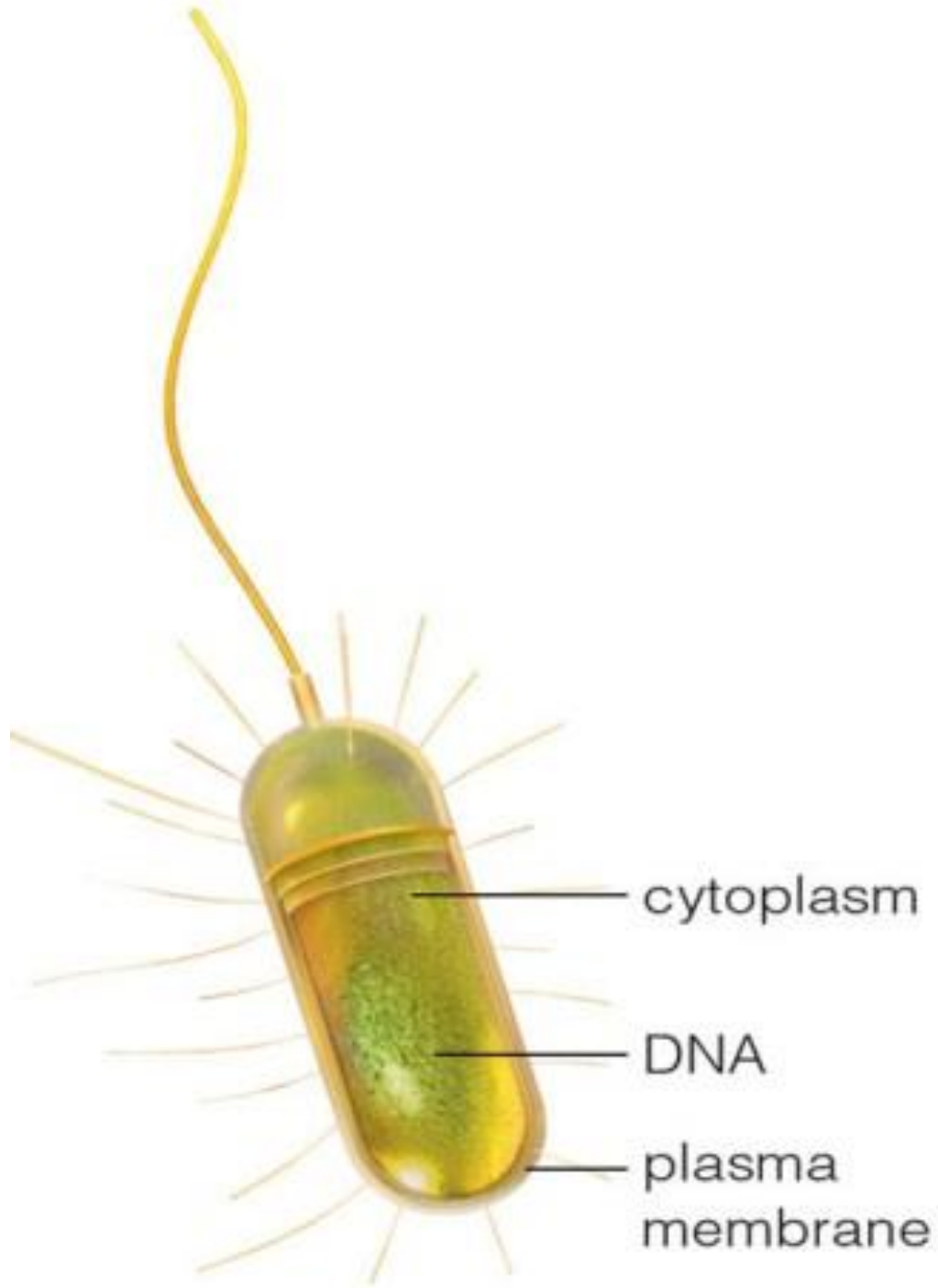
*4.8 Cell-to-Cell Interactions*

- 1. Differentiate between types of cell junctions.*
- 2. Describe the roles of surface proteins.*

## **Appendix F**

### **PowerPoint Slides for Chapter Four and Pictures of Models: Collaborative Learning**







CELLS

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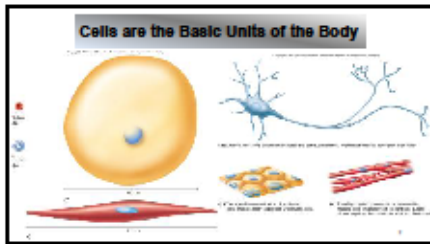
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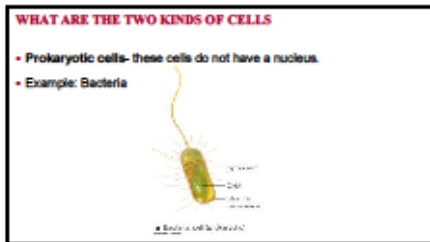
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**Appendix G**

**Pretest and Posttest Assessment Worksheet**

## Pre-Assessment Worksheet

Name: \_\_\_\_\_

Class: \_\_\_\_\_

### **Pick circle one best option for each question:**

1. Which is the outermost structure of plant cells?
  - a. Cell membrane
  - b. Cell wall
  - c. Cytoplasm
  - d. Nucleus
  - e. Clastron
  
2. \_\_\_\_\_ is the fluid portion of the cell.
  - a. Clastron
  - b. Centriole
  - c. Chromatin
  - d. Cytoplasm
  - e. Lysosomes
  
3. The cell membrane is composed of two major types of molecules:
  - a. Lipids and carbohydrates
  - b. Lipids and proteins
  - c. Proteins and carbohydrates
  - d. Carbohydrates and water
  - e. Water and proteins
  
4. Prokaryotic cells include:
  - a. Bacteria
  - b. Viruses
  - c. Plants
  - d. Fungi
  - e. Animals
  
5. Which of the following provide a supporting framework for the cell?
  - a. Cilia
  - b. Flagella
  - c. Spool
  - d. Ribosomes
  - e. Cytoskeleton
  
6. In a cell, \_\_\_\_\_ resembles like a stack of pancakes
  - a. Cilia
  - b. Golgi
  - c. Flagella

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

- d. Chromatin
  - e. Endoplasmic reticulum
7. Phagocytosis is an outward extension of the:
- a. Lysosome
  - b. Cell wall
  - c. Cytoskeleton
  - d. Cell membrane
  - e. Nucleolus
8. All prokaryotic cells have which of the following:
- a. Golgi
  - b. Nucleus
  - c. Mitochondria
  - d. Ribosomes
  - e. Endoplasmic reticulum
9. The function of nucleolus is:
- a. To make energy
  - b. To make water and nutrients
  - c. To control the functions of the cell
  - d. To make ribosomes
  - e. To help in cell reproduction
10. Which of the following set is an examples of eukaryotic cells:
- a. Plants and bacteria
  - b. Animals and virus
  - c. Plants and animals
  - d. Virus and bacteria
  - e. Fungi and bacteria
11. This structure/process helps a cell to divide during mitosis:
- a. Spool
  - b. Centriole
  - c. Nucleus
  - d. Phagocytosis
  - e. Cell wall
12. Which of the following is the key structure that helps in removing wastes from the cell?
- a. Centriole
  - b. Lysosomes
  - c. Mitochondria
  - d. Golgi
  - e. Endoplasmic reticulum

## Post-Assessment Worksheet

Name: \_\_\_\_\_

Class: \_\_\_\_\_

### **Pick circle one best option for each question:**

1. Which of the following structures are found in a plant cell?
  - f. cell membrane, cell wall, and centriole,
  - g. cell wall, chloroplast, and cilia
  - h. chloroplast, cell wall, and cell membrane
  - i. centriole, chloroplast, and cilia
  - j. cell wall, cilia, and centriole
  
2. Which of the following structures will you not find inside the cytoplasm of an animal cell?
  - f. Golgi
  - g. Centriole
  - h. Mitochondria
  - i. Flagella
  - j. Nucleus
  
3. The cell membrane is composed of two major types of molecules:
  - f. sugars and phospholipids
  - g. phospholipids and proteins
  - h. proteins and sugars
  - i. carbohydrates and lipids
  - j. cholesterol and sugars
  
4. Prokaryotic cells do not have \_\_\_\_\_ and includes the \_\_\_\_\_ cell:
  - f. nucleus; bacteria
  - g. cell wall; viruses
  - h. nucleus; virus
  - i. cell wall; bacteria
  - j. nucleus; plant
  
5. Which of the following provide a supporting framework for the cell?
  - f. Cilia
  - g. Flagella
  - h. Ribosomes
  - i. Cytoskeleton
  - j. Centriole
  
6. The organelle that collects, assembles, and packages proteins is the \_\_\_\_\_ and it resembles like a stack of pancakes
  - f. Cilia
  - g. Golgi

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

- h. Flagella
  - i. Chromatin
  - j. Endoplasmic reticulum
7. Phagocytosis is an outward extension of the \_\_\_\_\_, and the main function of this process is to \_\_\_\_\_
- f. cell membrane; maintain shape of cell
  - g. cell wall; engulf substances
  - h. cytoskeleton; protect against harmful substances
  - i. cell membrane; engulf substances
  - j. cell wall; maintain shape of cell
8. All prokaryotic cells have which of the following:
- f. golgi and cytoplasm
  - g. nucleus and cell membrane
  - h. ribosomes and endoplasmic reticulum
  - i. cell membrane and lysosomes
  - j. cytoplasm and cell membrane
9. \_\_\_\_\_ is a membrane structure found in the nucleus, and is responsible for:
- f. lysosome; making energy
  - g. mitochondria; transporting water and nutrients
  - h. nucleolus; making ribosomes
  - i. golgi; cell division
  - j. endoplasmic reticulum; making proteins
10. Which of the following set is an examples of eukaryotic cells:
- f. plants and bacteria
  - g. animals and virus
  - h. plants and animals
  - i. virus and bacteria
  - j. fungi and bacteria
11. This structure/process helps a cell to divide during mitosis:
- f. Spool
  - g. Centriole
  - h. Nucleus
  - i. Phagocytosis
  - j. Cell wall
12. Which of the following is the key structure that helps in removing wastes from the cell?
- f. Centriole
  - g. Lysosomes
  - h. Mitochondria
  - i. Golgi
  - j. Endoplasmic reticulum

**Appendix H**  
**PreSVFS and PostSVFS**  
**(Science Vocabulary Familiarity Scale)**

# STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

## BIO 101/141

Name: \_\_\_\_\_

### Beginning of Activity Survey

This survey is designed to collect information on your previous experience in biology. You can help the teaching staff gain a better sense of your preparation and experience by completing this survey.

Your responses on this survey will have no bearing on your grade. However, you will positively affect your own experience in the course by responding thoughtfully and honestly.

Thanks for your feedback!

### Science Vocabulary Familiarity Scale

The following table contains vocabulary taken from the glossary in the back of the text and represents some of the important terms in biology. For each word, indicate your familiarity with the term in the context of biology (several have non-scientific meaning as well) on a 1-5 scale as shown. Remember that we do not expect or assume you to know all - or even any - of these terms prior to the course.

How well do you know these terms in context of biology?	Totally unfamiliar	Word is vaguely familiar	Hazy understanding	Okay understanding	Confident understanding
Cell membrane	1	2	3	4	5
Cell wall	1	2	3	4	5
Centriole	1	2	3	4	5
Chromatin	1	2	3	4	5
Cilia	1	2	3	4	5
Clastron	1	2	3	4	5
Cytoplasm	1	2	3	4	5
Cytoskeleton	1	2	3	4	5
Endoplasmic reticulum	1	2	3	4	5
Eukaryotic cell	1	2	3	4	5
Flagella	1	2	3	4	5
Golgi apparatus	1	2	3	4	5
Lysosome	1	2	3	4	5
Mitochondria	1	2	3	4	5
Nucleolus	1	2	3	4	5
Nucleus	1	2	3	4	5
Phagocytosis	1	2	3	4	5
Prokaryotic cell	1	2	3	4	5
Ribosomes	1	2	3	4	5
Spool	1	2	3	4	5

## BIO 101/141

Name: \_\_\_\_\_

### End of Activity Survey

This survey will help to measure the effectiveness of the course in helping you to learn introductory level to cell biology. You can help the teaching staff to best meet your needs by responding to this survey thoughtfully and honestly.

Your responses on this survey will have no bearing on your grade. This will help to measure the course, not your performance in it. Thanks for your feedback! The following table contains vocabulary taken from the glossary in the back of the text and represents some of the important terms in this chapter. For each word, indicate your familiarity with the term in the context of biology (several have non-scientific meaning as well) on a 1-5 scale as shown.

### Science Vocabulary Familiarity Scale

How well do you know these terms in context of biology?	Totally unfamiliar	Word is vaguely familiar	Hazy understanding	Okay understanding	Confident understanding
Cell membrane	1	2	3	4	5
Cell wall	1	2	3	4	5
Centriole	1	2	3	4	5
Chromatin	1	2	3	4	5
Cilia	1	2	3	4	5
Clastron	1	2	3	4	5
Cytoplasm	1	2	3	4	5
Cytoskeleton	1	2	3	4	5
Endoplasmic reticulum	1	2	3	4	5
Eukaryotic cell	1	2	3	4	5
Flagella	1	2	3	4	5
Golgi apparatus	1	2	3	4	5
Lysosome	1	2	3	4	5
Mitochondria	1	2	3	4	5
Nucleolus	1	2	3	4	5
Nucleus	1	2	3	4	5
Phagocytosis	1	2	3	4	5
Prokaryotic cell	1	2	3	4	5
Ribosomes	1	2	3	4	5
Spool	1	2	3	4	5

**Appendix I**

**Demographic Survey**

**Demographic Survey: THANK YOU SO MUCH FOR COMPLETING THIS SURVEY!**

All information on this survey will be kept confidential.

Identification Name: \_\_\_\_\_

Class: \_\_\_\_\_

**For each of the following, check ONE that best describes you:**

1. Prior COLLEGE science courses taken within the last 5 years (mark all that apply):

- \_\_\_\_\_ Introduction to Biology I (BIO 101)
- \_\_\_\_\_ Introduction to Biology II (BIO 102)
- \_\_\_\_\_ Anatomy and Physiology I (BIO 141)
- \_\_\_\_\_ Anatomy and Physiology II (BIO 142)
- \_\_\_\_\_ College Chemistry I (CHM 101)
- \_\_\_\_\_ College Chemistry II (CHM 102)
- \_\_\_\_\_ College Physics I (PHY 100)

2. Current field of study: \_\_\_\_\_ Natural Science  
\_\_\_\_\_ Humanities and Arts  
\_\_\_\_\_ Engineering  
\_\_\_\_\_ Social Science  
\_\_\_\_\_ other (please specify) \_\_\_\_\_

3. Gender: \_\_\_\_\_

4. Age (years): \_\_\_\_\_ less than 18  
\_\_\_\_\_ 18-24  
\_\_\_\_\_ 25-34  
\_\_\_\_\_ 35-44  
\_\_\_\_\_ 45-54  
\_\_\_\_\_ 55 and over

5. Race/Ethnicity: \_\_\_\_\_ American Indian or Alaska Native  
\_\_\_\_\_ Asian  
\_\_\_\_\_ Black or African American  
\_\_\_\_\_ Hispanic or Latino  
\_\_\_\_\_ Native Hawaiian or Other Pacific Islander  
\_\_\_\_\_ White Caucasian  
\_\_\_\_\_ Others (Please specify) \_\_\_\_\_  
\_\_\_\_\_ Prefer not to answer

6. Work Status: \_\_\_\_\_ Not applicable  
\_\_\_\_\_ Part-time

**Please Turn Page Over**

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

\_\_\_\_\_ Full-time

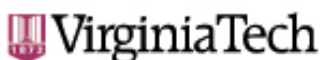
7. Number of credits taken this semester: \_\_\_\_\_ less than 6  
\_\_\_\_\_ 6-11  
\_\_\_\_\_ 12 or more

8. Highest level of education you expect to complete:

\_\_\_\_\_ Associate degree  
\_\_\_\_\_ Bachelor's degree  
\_\_\_\_\_ Master's degree  
\_\_\_\_\_ Doctoral degree  
\_\_\_\_\_ Professional degree (please specify) \_\_\_\_\_  
\_\_\_\_\_ Continuing Educatio

**Appendix J**

**Institutional Review Board Approval Letter: Virginia Polytechnic and State University**



Office of Research Compliance  
Institutional Review Board  
North End Center, Suite 4120, Virginia Tech  
300 Turner Street NW  
Blacksburg, Virginia 24061  
540/231-4606 Fax 540/231-0969  
email [irb@vt.edu](mailto:irb@vt.edu)  
website <http://www.irb.vt.edu>

**MEMORANDUM**

**DATE:** January 19, 2018  
**TO:** Jeremy V Ernst, Harpreet Kaur Panesar, Jennifer M Bondy, Bradley Bowen, Thomas O Williams Jr  
**FROM:** Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)  
**PROTOCOL TITLE:** COLLABORATION AND ITS LEARNING BENEFITS IN A COMMUNITY COLLEGE STEM EDUCATION CLASSROOM  
**IRB NUMBER:** 17-1154

Effective January 19, 2018, the Virginia Tech Institutional Review Board (IRB) approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at: <http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

**PROTOCOL INFORMATION:**

Approved As: Expedited, under 45 CFR 46.110 category(ies) 5,7  
Protocol Approval Date: January 19, 2018  
Protocol Expiration Date: January 18, 2019  
Continuing Review Due Date\*: January 4, 2019

\*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

**FEDERALLY FUNDED RESEARCH REQUIREMENTS:**

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

**Appendix K**

**Approval from Research Review Committee- Blue Ridge Community College**

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

RRC Summary Form

Date submitted to OIRE: 11/30/17

Date reviewed by RRC: 12/7/17

After review, the RRC finds that the submitted project x does not meet federal guidelines. (If the submitted project does not meet the federal guidelines please outline reasons below)

Additional concerns/comments: our concerns have been addressed by Ms. Panesar's followup work (attached). Some edits will be forwarded to her consent form and demographic survey (also attached).

The RRC x recommends not does not recommend the approval of this project.

Susan O'Grady  
RRC Chairperson

12/12/17  
Date

The Vice President ✓ recommends not does not recommend the approval of this project.

AJ Murphy  
Vice President of Instruction and Student Services

12/12/17  
Date

Date investigator informed of final action: 12/13/17

Protocol Number: 18-2 Panesar

**Appendix L**  
**Recruitment Letter**

**Recruitment Letter**

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

My name is Harpreet Panesar and I am an Assistant Professor at the Blue Ridge Community College, as well as a doctoral candidate of Integrative STEM Education at Virginia Polytechnic University. I am inviting you to take part in a research study for my dissertation. The research study is entitled ‘Collaboration and Its Learning Benefits in a Community College STEM Education Classroom’. The purpose of this study is to reveal the extent of results seen in classrooms employing a collaborative learning environment. It will also examine the differences seen between traditional and collaborative learning in the conceptual understanding of an important Biology process.

Students, this activity will not take more than one lab period. This activity is a part of the class syllabus and follows the student-learning outcome, so please attend as usual. I will be conducting this activity in your classroom. This activity follows your course objectives, student-learning outcome, and course schedule. At the beginning of class, I will review the consent form with all of you, and those who choose to participate will be able to sign the form at that time. In the beginning of the research activity, students who choose to participate will fill demographic survey, a vocabulary, and a pre assessment worksheet, which should take no more than 20 minutes. Then all students will do the class activity for about 45 minutes, and then after the class activity, students who choose to participate will do a post vocabulary worksheet and a post assessment, which should not take more than 10 minutes. Worksheets, surveys, and assessments will not be graded for points.

All participants’ names will be placed in a raffle drawing for a ten-dollar gift card towards a fast-food restaurant. There will be one drawing at the end of the activity, and you have a chance of 1 in 24 to win a gift card.

Your answers will remain strictly confidential and will NOT affect your grade in this course. Your identity and personal information, and surveys shared during this research activity will remain confidential at all times.

This research study has minimal risks for any potential participants involved. The survey questions are noninvasive and are designed to provide me insight into the student demographics in BRCC Biology classrooms. By participating in this research, you will not only be learning your course content as per your schedule, but will also be contributing to a project that will deepen our understanding of using collaboration in classrooms, and hence will contribute towards developing ways of improving classroom instruction in Biology classrooms.

I hope that you will be able to participate in this study. For more information, please contact me at (540) 523-0070 or email me at [hkp253@vt.edu](mailto:hkp253@vt.edu) or [panesarh@brcc.edu](mailto:panesarh@brcc.edu)

Sincerely,  
Harpreet Panesar

### Appendix M

## **Consent Forms**

**VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY**

# STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

## **Informed Consent for Participants In Research Projects Involving Human Subjects**

### **Title of Project: Collaboration and Its Learning Benefits in a Community College STEM Education Classroom**

**Investigator:** \_\_\_Harpreet Panesar\_\_\_ hkp253@vt.edu; [panesarh@brcc.edu](mailto:panesarh@brcc.edu)

**Principal Investigator:** \_\_\_Dr. Jeremy Ernst\_\_\_ jvernst@vt.edu

You are being asked to take part in this research project. Your participation in this project is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of this research is to gain a better understanding of a certain topic or issue. In this consent form, you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form, it is your right to ask the investigator for clarification or more information. If at any time you have questions about your participation, do not hesitate to contact the investigator named above.

#### **I. Purpose of this Research Project:**

In order to improve STEM literacy and STEM readiness, it is important to focus research efforts at the community college. With the growing number of undergraduate students at community colleges in STEM fields, it is important to retain these students by keeping them engaged in their learning fields. There has been growing evidence for the employment of a collaborative learning pedagogical approach in K-12 STEM classrooms as a means to improve student engagement, persistence, critical thinking, motivation, STEM literacy, and knowledge transfer. However, there is hardly any research in regard to using collaborative techniques in a Biology based STEM classroom at the community college level. This research is designed to reveal the extent of changes in undergraduate student learning outcomes in a collaborative learning environment. This study is the doctoral dissertation of the investigator and the results of the study will be published.

#### **II. Procedures:**

A guest lecturer will be in class to conduct this activity. This activity is a part of the class syllabus and follows the student-learning outcome, so please attend as usual. If you agree to participate, you will be filling out a demographic survey, vocabulary worksheet, and a preassessment worksheet at the beginning of the class period. This should not take more than 20 minutes of the class period. There will be a class activity for about 45 minutes, and then you will be given two worksheets to reassess your knowledge, which will not take more than 10 minutes. Your answers will remain strictly confidential. All surveys, worksheets, and assessments are non-graded, and will not be posted in your gradebook.

#### **III. Risks:**

This research will be conducted in a Biology classroom at the Blue Ridge Community College campus. It will be conducted in an educational setting to assess effectiveness of instructional pedagogies and strategies. There are no known foreseeable risks to students in this study.

#### **IV. Benefits:**

By participating in this research, you will not only be learning your course content as per your course objectives and class schedule, but will also be contributing to a project that will deepen our understanding of using collaboration in classrooms, and hence will contribute towards developing ways of improving classroom instruction in Biology classrooms.

#### **V. Participation:**

No promise or guarantee of benefits has been made to encourage you to participate.

Participation in this research study is completely voluntary. You are free to decline to participate, to end participation at any time for any reason, or to refuse to answer any individual questions on any survey, tests, or science vocabulary familiarity scale without penalty. This survey has no effect on your grade in this course. If you choose not to be involved in the study it will have no bearing on your grade.

#### **VI. Extent of Anonymity and Confidentiality:**

All your responses will be held in confidence at all times. The information in the survey and worksheets will be kept confidential to the full extent of law. Data will be stored securely and measures will be taken to protect the security of data. No reference will be made in oral or written reports, which could link you to the project. After the data is collected and the project is over, all surveys and worksheets will be destroyed. To protect your identity and confidentiality during the semester, you will be asked to put coded identifiers on each of the worksheets and surveys so that your identity and your contribution to the data can be hidden. The researcher will only be using the coded identifiers to connect the study documents from before the activity to the study documents completed after the research activity

"At no time will the researchers release identifiable results of the study to anyone other than individuals working on the project without your written consent".

"The Virginia Tech (VT) Institutional Review Board (IRB) may view the study's data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research."

#### **VII. Compensation:**

Your name will be entered into a raffle drawing at the end of the activity to win a gift card to a fast-food restaurant in the amount of ten dollars. There will be five drawings in the amount of ten dollars each. Your chances of winning a raffle prize will be at most one in twenty-four students.

#### **VIII. Freedom to Withdraw:**

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

It is important for you to know that you are free to withdraw from this study at any time without penalty. You are free not to answer any questions that you choose or respond to what is being asked of you without penalty.

Please note that there may be circumstances under which the investigator may determine that a subject should not continue as a subject.

Should you withdraw or otherwise discontinue participation, you will be compensated for the portion of the project completed in accordance with the Compensation section of this document.”

### **IX. Questions or Concerns:**

Should you have any questions about this study, you may contact the researcher, Harpreet Panesar, at [panesarh@brcc.edu](mailto:panesarh@brcc.edu) or [hkp253@vt.edu](mailto:hkp253@vt.edu), or at (540) 523-0070.

If you have questions about your rights as a participant, you may contact the Virginia Tech Institutional Review Board at [irb@vt.edu](mailto:irb@vt.edu) or (540) 231-3732.

### **X. Subject's Consent:**

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

Participant's signature: \_\_\_\_\_ Date: \_\_\_\_\_

Participant's name: \_\_\_\_\_

Investigator's signature: \_\_\_\_\_ Date: \_\_\_\_\_

# VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

## Informed Consent for Participants In Research Projects Involving Human Subjects

**Title of Project: Collaboration and Its Learning Benefits in a Community College STEM Education Classroom**

**Investigator:** \_\_\_\_Harpreet Panesar\_\_\_\_ hkp253@vt.edu; [panesarh@brcc.edu](mailto:panesarh@brcc.edu)

**Principal Investigator:** \_\_\_Dr. Jeremy Ernst\_\_\_ jvernst@vt.edu

You are being asked to take part in this research project. Your participation in this project is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of this research is to gain a better understanding of a certain topic or issue. In this consent form, you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form, it is your right to ask the investigator for clarification or more information. If at any time you have questions about your participation, do not hesitate to contact the investigator named above.

### **I. Purpose of this Research Project:**

In order to improve STEM literacy and STEM readiness, it is important to focus research efforts at the community college. With the growing number of undergraduate students at community colleges in STEM fields, it is important to retain these students by keeping them engaged in their learning fields. There has been growing evidence for the employment of a collaborative learning pedagogical approach in K-12 STEM classrooms as a means to improve student engagement, persistence, critical thinking, motivation, STEM literacy, and knowledge transfer. However, there is hardly any research in regard to using collaborative techniques in a Biology based STEM classroom at the community college level. This research is designed to reveal the extent of changes in undergraduate student learning outcomes in a collaborative learning environment. This study is the doctoral dissertation of the investigator and the results of the study will be published.

### **II. Procedures:**

The researcher will be in class to conduct this activity. This activity is a part of the class syllabus and follows the student-learning outcome, so please attend as usual. If you agree to participate, you will be filling out a demographic survey, vocabulary worksheet, and a pre-assessment worksheet at the beginning of the class period. This should not take more than 20 minutes of the class period. There will be a class activity for about 45 minutes, and then you will be given two worksheets to reassess your knowledge, which will not take more than 10 minutes. Your answers will remain strictly confidential. All surveys, worksheets, and assessments are nongraded, and will not be posted in your gradebook.

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

### **III. Risks:**

This research will be conducted in a Biology classroom at the Blue Ridge Community College campus. It will be conducted in an educational setting to assess effectiveness of instructional pedagogies and strategies. There are no known foreseeable risks to students in this study.

### **IV. Benefits:**

By participating in this research, you will not only be learning your course content as per your course objectives and class schedule, but will also be contributing to a project that will deepen our understanding of using collaboration in classrooms, and hence will contribute towards developing ways of improving classroom instruction in Biology classrooms.

### **V. Participation:**

No promise or guarantee of benefits has been made to encourage you to participate.

Participation in this research study is completely voluntary. You are free to decline to participate, to end participation at any time for any reason, or to refuse to answer any individual questions on any survey, tests, or science vocabulary familiarity scale without penalty. This survey has no effect on your grade in this course. If you choose not to be involved in the study it will have no bearing on your grade.

### **VI. Extent of Anonymity and Confidentiality:**

All your responses will be held in confidence at all times. The information in the survey and worksheets will be kept confidential to the full extent of law. Data will be stored securely and measures will be taken to protect the security of data. No reference will be made in oral or written reports, which could link you to the project. After the data is collected and the project is over, all surveys and worksheets will be destroyed. To protect your identity and confidentiality during the semester, you will be asked to put coded identifiers on each of the worksheets and surveys so that your identity and your contribution to the data can be hidden. The researcher will only be using the coded identifiers to connect the study documents from before the activity to the study documents completed after the research activity

"At no time will the researchers release identifiable results of the study to anyone other than individuals working on the project without your written consent".

"The Virginia Tech (VT) Institutional Review Board (IRB) may view the study's data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research."

### **VII. Compensation:**

Your name will be entered into a raffle drawing at the end of the activity to win a gift card to a fast-food restaurant in the amount of ten dollars. There will be five drawings in the amount of ten dollars each. Your chances of winning a raffle prize will be at most one in twenty-four students.

### **VIII. Freedom to Withdraw:**

It is important for you to know that you are free to withdraw from this study at any time without penalty. You are free not to answer any questions that you choose or respond to what is being asked of you without penalty.

Please note that there may be circumstances under which the investigator may determine that a subject should not continue as a subject.

Should you withdraw or otherwise discontinue participation, you will be compensated for the portion of the project completed in accordance with the Compensation section of this document.

**IX. Questions or Concerns:**

Should you have any questions about this study, you may contact the researcher, Harpreet Panesar, at [panesarh@brcc.edu](mailto:panesarh@brcc.edu) or [hkp253@vt.edu](mailto:hkp253@vt.edu), or at (540) 523-0070.

If you have questions about your rights as a participant, you may contact the Virginia Tech Institutional Review Board at [irb@vt.edu](mailto:irb@vt.edu) or (540) 231-3732.

**X. Subject's Consent:**

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

Participant's signature: \_\_\_\_\_ Date: \_\_\_\_\_

Participant's name: \_\_\_\_\_

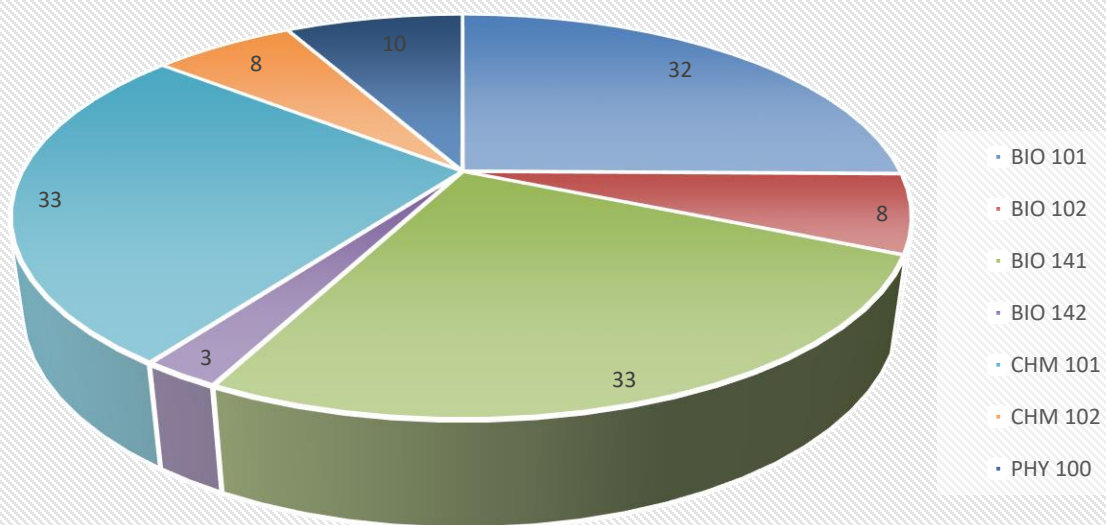
Investigator's signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Appendix N**

**Pie Chart: Participants: Prior Science Coursework taken**

## STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

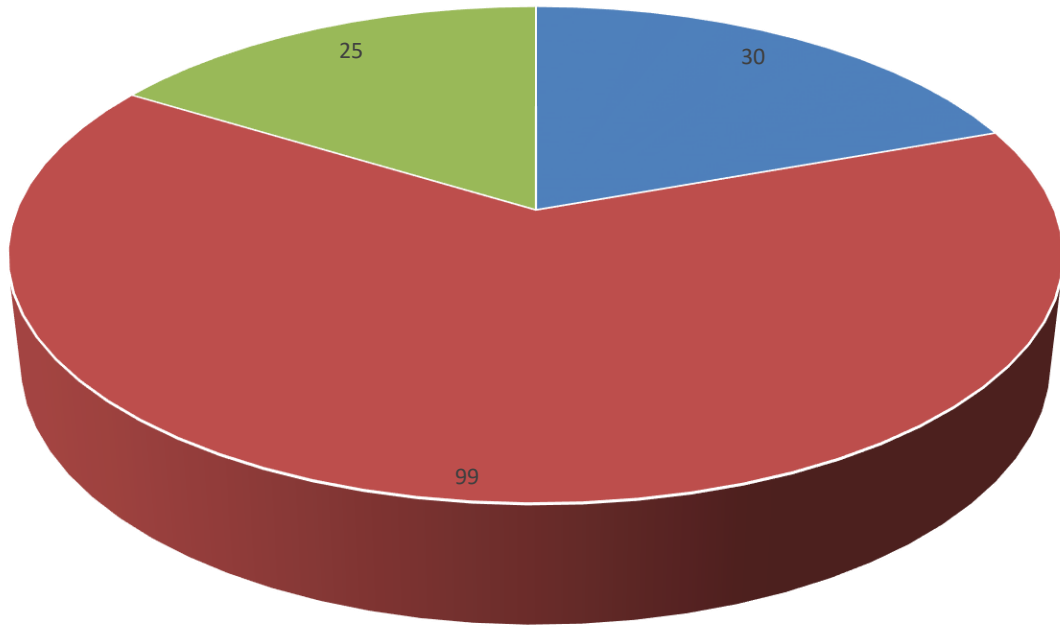
## Prior College Science Courses Taken



**Appendix O**

**Pie Chart: Participants: Work Status**

Student Participants': Work Status

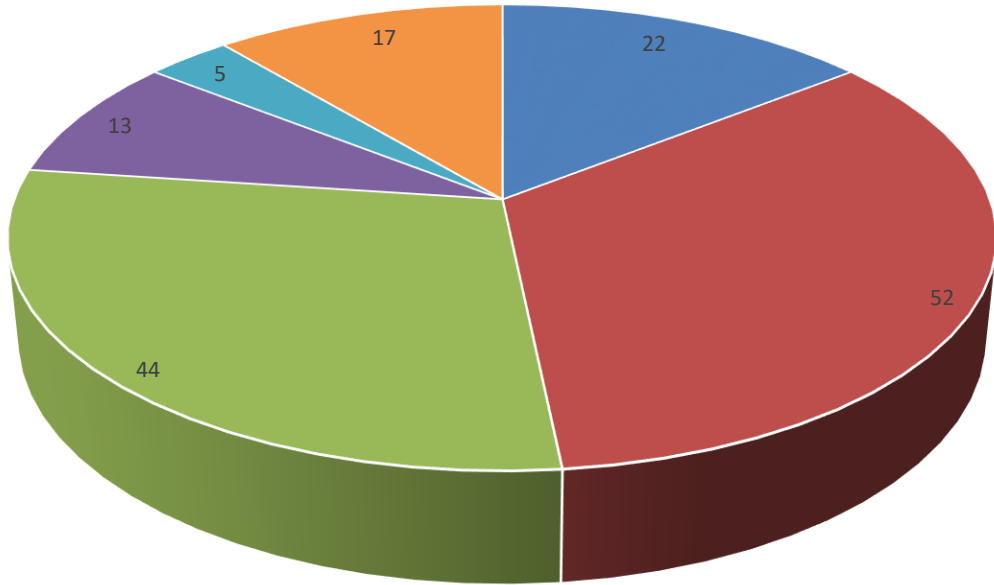


■ Unemployed ■ PT ■ FT

**Appendix P**

**Pie Chart: Participants: Highest Level of Education to Pursue**

### Highest Degree to Earn

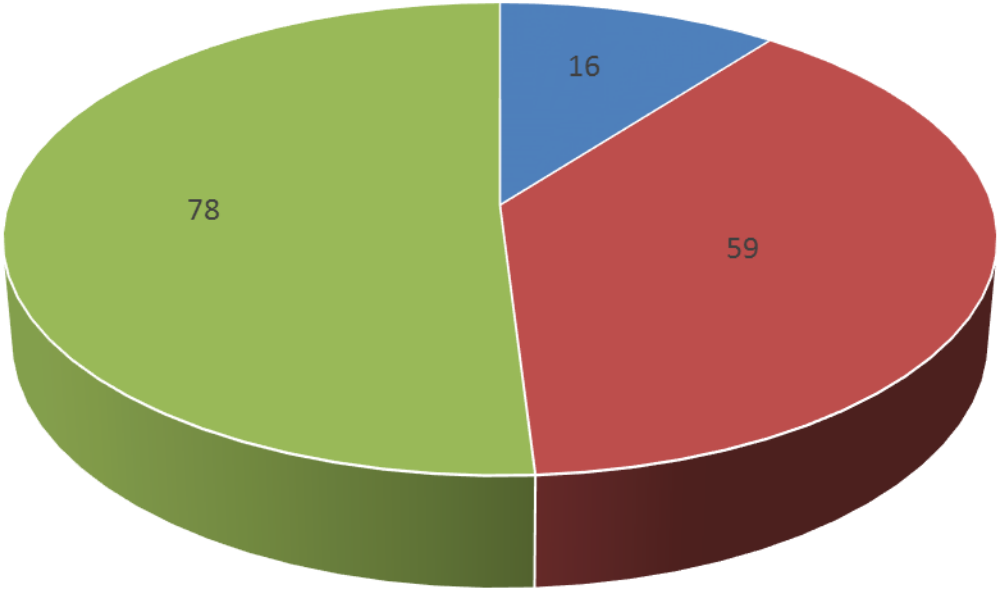


■ Associate ■ Bachelors ■ Masters ■ PhD ■ Prof Deg ■ CE

**Appendix Q**

**Number of Credits taken by Students in Collaborative Learning Environment**

Number of Credits

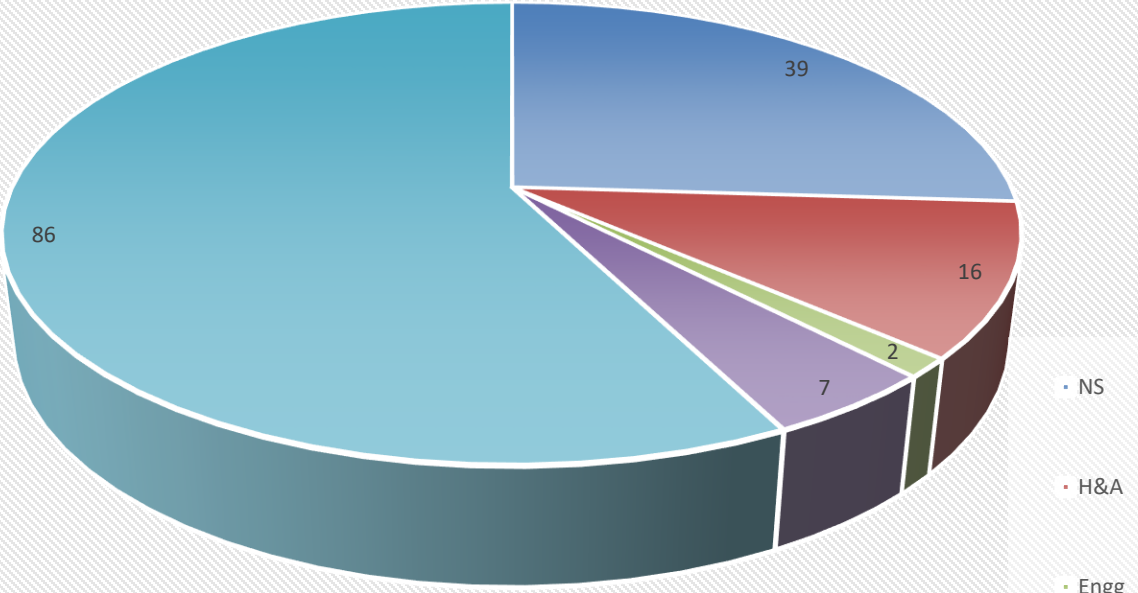


■ <6   ■ 6 - 11   ■ >=12

**Appendix R**

**Pie Chart: Participants: Current Field of Study**

# Current Field of Study



**Appendix S**

**SPSS Results for Work Status:**

**Part time versus Unemployed**

**Full time versus Unemployed**

**Part time versus Full time**

## T-Test

### Group Statistics

	STATUS	N	Mean	Std. Deviation	Std. Error Mean
POST	unemployed	16	9.00	2.221	.555
	part time	44	8.86	2.427	.366

### Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
POST	Equal variances assumed	.269	.606	.197	58	.845	.136	.693	-1.252	1.524
	Equal variances not assumed			.205	28.944	.839	.136	.665	-1.224	1.496

## T-Test

### Group Statistics

	STATUS	N	Mean	Std. Deviation	Std. Error Mean
POST	unemployed	16	9.00	2.221	.555
	full time	10	9.30	3.093	.978

### Independent Samples Test

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
POST	Equal variances assumed	1.395	.249	-	24	.776	-.300	1.041	-2.449	1.849
	Equal variances not assumed			-14.813		.793	-.300	1.125	-2.700	2.100

**T-Test**

*Group Statistics*

	STATUS	N	Mean	Std. Deviation	Std. Error Mean
POST	part time	44	8.86	2.427	.366
	full time	10	9.30	3.093	.978

*Independent Samples Test*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper

---

POST Equal	.916	.343	-	52	.628	-.436	.895	-2.232	1.359
variances			.488						
assumed									
Equal			- 11.646		.684	-.436	1.044	-2.719	1.847
variances			.418						
not									
assumed									

---

**Appendix T**

**SPSS Results for Gender: Male and Female**

### T-Test T-Test Research Question 3: Gender

#### Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
POST	Female	50	8.88	2.387	.338
	Male	20	9.15	2.661	.595

#### Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
POST	Equal variances assumed	.492	.486	-.414	68	.680	-.270	.653	-1.572	1.032
	Equal variances not assumed			-31.920		.696	-.270	.684	-1.664	1.124

**Appendix U**

**SPSS Results for Collaborative Learning Environments**

## T-Test for BIO 101 Collaborative

### Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	V24	7.26	38	2.446	.397
	V46	8.82	38	2.300	.373

### Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	V24 & V46	38	.393	.015

### Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	V24 - V46	-1.553	2.617	.425	-2.413	-.692	-3.657	.001	

## T-Test for BIO 141 Collaborative

### Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	V24	6.81	32	1.712	.303
	V46	9.13	32	2.649	.468

### Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	V24 & V46	32	.581	.000

### Paired Samples Test

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	V24 - V46	-2.313	2.162	.382	-3.092	-1.533	-6.051	31	.000

**T-Test BIO Collaborative ALL**

*Paired Samples Statistics*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	V24	7.06	70	2.139	.256
	V46	8.96	70	2.452	.293

*Paired Samples Correlations*

		N	Correlation	Sig.
Pair 1	V24 & V46	70	.445	.000

*Paired Samples Test*

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	V24 - V46	1.900	2.433	.291	-2.480	-1.320	-6.535	69	.000

**Frequencies**

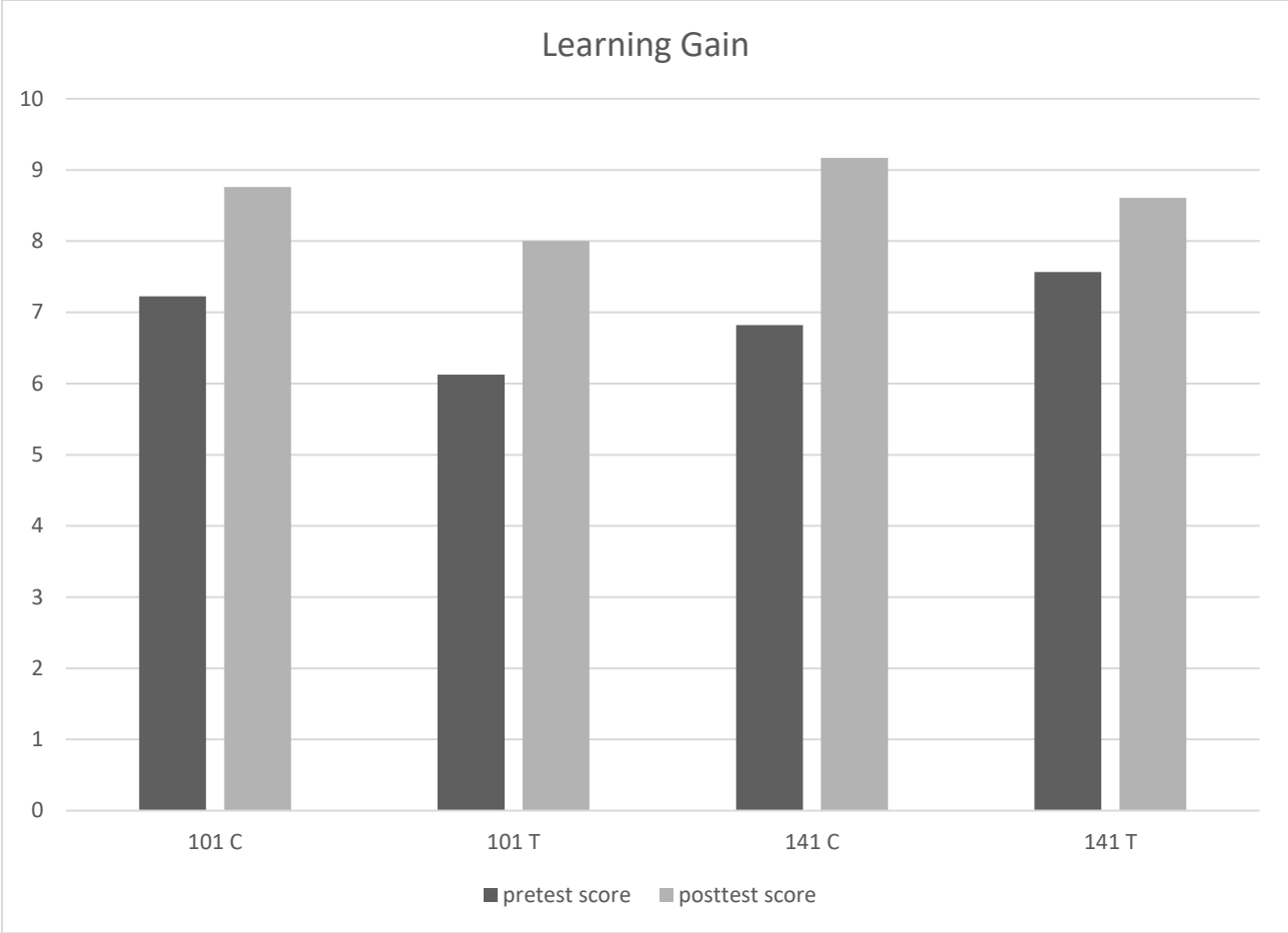
*Statistics*

		V1	V2
N	Valid	154	154
	Missing	0	0

## Appendix V

### Chart for Gains in Scores between Traditional and Collaborative Learners

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS



## **Appendix W**

### **Pretest and Posttest Scores and Gain Scores Comparison between Traditional and Collaborative Environments**

STUDY OF COLLABORATION AND ITS LEARNING BENEFITS

	PRE	POST	
BIO 101 T	6.0	8.3	<p><b>Bio 101 gain in CLE = 21% as compared to 29% in TLE</b></p> <p><b>Bio 141 gain in CLE = 34.5% as compared to 14% in TLE</b></p>
BIO 101 T	6.35	7.7	
BIO 101 C	7.0	8.38	
BIO 101 C	7.45	9.14	
BIO 141 T	7.63	8.68	
BIO 141 T	7.5	8.54	
BIO 141 C	6.93	9.87	
BIO 141 C	6.71	8.47	

TLE = Traditional Learning Environment; CLE = Collaborative Learning Environment

## **Appendix X**

### **Work Status: Work Status and Mean Posttest Score**

# STUDY OF COLLABORATION AND ITS LEARNING BENEFITS



