PROMOTING EQUITABLE LEARNING THROUGH COLLABORATIVE WORK IN LARGE-ENROLLMENT CLASSROOMS

by

YUNJEONG CHANG

(Under the Direction of MICHAEL HANNAFIN)

ABSTRACT

Post-secondary education goals include cultivating independent learners who become lifelong contributors to society and a scientifically literate citizenry. Most universities offer required Science, Technology, Engineering, and Mathematics (STEM) courses at the undergraduate level and often delivers in large-enrollment (e.g. over 100) formats. In a large-classrooms, diverse learning needs and student preferences need to be accommodated, but solutions for large enrollment courses have proven elusive. Group work has been widely used to support students learning in large enrollment classrooms. However, collaborative work may inadvertently reify misconceptions among students with limited background knowledge and experience while encouraging rote learning. In particular, chronic underachievers have reported limited understanding of (or skill in) collaborative learning.

This dissertation reported design-based research to promote equitable learning through collaborative work in large-enrollment classrooms. This research was conducted in large-enrollment introductory biology courses for non-science majors. Academically different learners registered the courses and collaborative learning was used to achieve course objectives; promoting general scientific literacy skills. Considering goals and challenges of learning in
higher education, the studies examines optimal learning environments for underperforming students.

The first manuscript (Chapter 2) analyzes and synthesizes research, theory and practice related to underperforming students in postsecondary settings, and identifying research needed to support both underperforming college students and their instructors. In Chapter 3, a mixed method study examines how individual and group inquiry-based activities influence achievement among academically diverse students. The results indicated that some group-based activities positively influenced the achievement of higher achievers but no group activities improved lower achievers’ individual achievement. The study detailed in Chapter 4 examines group methods designed to benefit the academic performance of all participants equitable across achievement levels. The study mainly examines circumstances and methods where group work benefits performance across achievement levels. The mixed method study indicated that lower performing groups were more likely to benefit when they included higher achievers and/or received additional instructor guidance and positive interdependence and promotive interaction were not consistently associated with improved learning. The dissertation concludes with implications of the program of inquiry and future research directions in Chapter 5.

INDEX WORDS: group work, collaborative learning, lower achievers, large classrooms, equitable learning
PROMOTING EQUITABLE LEARNING THROUGH COLLABORATIVE WORK
IN LARGE-ENROLLMENT CLASSROOMS

by

YUNJEONG CHANG

BA, Sungshin Women’s University, South Korea, 2004

MA, Korea University, South Korea, 2007

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial
Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2015
PROMOTING EQUITABLE LEARNING THROUGH COLLABORATIVE WORK IN LARGE-ENROLLMENT CLASSROOMS

by

YUNJEONG CHANG

Major Professor: Michael Hannafin
Committee: Lloyd Rieber
Marguerite Brickman
Jori Hall

Electronic Version Approved:

Julie Coffield
Interim Dean of the Graduate School
The University of Georgia
May 2015
DEDICATION

This dissertation is dedicated to my family, especially to my parents. Your support, encouragement, and belief in me gave me the strength to persevere and complete this journey.
ACKNOWLEDGEMENTS

This dissertation would not have been possible without the support and assistance of many people. Foremost, my sincerest appreciation goes to my advisor, Dr. Michael Hannafin, for his continuous support and insightful mentoring throughout my doctoral studies. He guided me to become a well-rounded educator and a scholar, spending a great deal of his time in reading my work and offering ideas and encouragement. I also thank him for being such an important role model as a mentor, and for so patiently guiding me every step of the way during my doctoral studies.

I would like to thank my committee members: Dr. Marguerite (Peggy) Brickman, who allowed me to conduct my research in her classes with constant support and guidance, Dr. Jori Hall, who inspired me to use mixed methods and to become a successful young scholar, and Dr. Lloyd Rieber, who so generously provided insightful feedback and support for my research and career building.

Additionally, I would like to acknowledge all the excellent learning opportunities I have had in Learning, Design, and Technology program at the University of Georgia. With the support and friendship of the members in this academic community, I would have been able to my academic credentials. I particularly appreciate Ms. Gretchen Thomas, my teaching supervisor, for her brilliant ideas and encouragement for excellent teaching. I give special thanks to Dr. Gregory Clinton, who generously offered me opportunities to assist and contribute to the Instructional Design and Development program. I also would like to acknowledge all the friends and colleagues in the United States and Korea who have always encouraged me.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>x</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>1 INTRODUCTION AND LITERATURE REVIEW</td>
<td>1</td>
</tr>
<tr>
<td>Structure of the dissertation</td>
<td>5</td>
</tr>
<tr>
<td>References</td>
<td>7</td>
</tr>
<tr>
<td>2 STUDENT-CENTERED LEARNING AND UNDERPERFORMING COLLEGE STUDENTS</td>
<td>10</td>
</tr>
<tr>
<td>Abstract</td>
<td>11</td>
</tr>
<tr>
<td>The Underperforming Student</td>
<td>13</td>
</tr>
<tr>
<td>The Challenges of College Learning Environments</td>
<td>15</td>
</tr>
<tr>
<td>Addressing the Needs of College Students</td>
<td>17</td>
</tr>
<tr>
<td>Instructional Support</td>
<td>26</td>
</tr>
<tr>
<td>Scaffolding via technology</td>
<td>29</td>
</tr>
<tr>
<td>Implications</td>
<td>31</td>
</tr>
<tr>
<td>References</td>
<td>35</td>
</tr>
</tbody>
</table>
3  INDIVIDUAL AND GROUP INQUIRY IN COLLEGE SCIENCE CLASSROOMS: WHO BENEFITS? .................................................................................................................. 45
   Abstract ............................................................................................................. 46
   Methods .............................................................................................................. 51
   Results and Discussion .................................................................................... 59
   General Discussion and Implications ................................................................ 66
   Limitations ......................................................................................................... 74
   Conclusions ....................................................................................................... 75
   References ......................................................................................................... 76

4  SCAFFOLDING COLLABORATIVE WORK IN A LARGE-ENROLLEMENT CLASSROOM FOR UNDERPERFORMING COLLEGE STUDENTS ............... 83
   Abstract ............................................................................................................. 84
   Introduction ....................................................................................................... 85
   Methods ............................................................................................................. 91
   Results and Discussion .................................................................................... 107
   General Discussion and Implications ............................................................... 117
   Limitations ....................................................................................................... 121
   References ....................................................................................................... 123

5  CONCLUSION .................................................................................................... 130
   Implications for Program of Inquiry ............................................................... 132
   References ....................................................................................................... 134

APPENDICES

   A  Get to Know Each Other & Be Ready ............................................................ 137
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Inquiry-based Activities</td>
<td>54</td>
</tr>
<tr>
<td>3.2</td>
<td>Measures per Research Questions</td>
<td>57</td>
</tr>
<tr>
<td>3.3</td>
<td>Interviewee Profiles</td>
<td>60</td>
</tr>
<tr>
<td>3.4</td>
<td>Regression results for all independent variables</td>
<td>60</td>
</tr>
<tr>
<td>3.5</td>
<td>Regression results for significant variables</td>
<td>64</td>
</tr>
<tr>
<td>4.1</td>
<td>Scientific thinking process, problems, and scaffolds</td>
<td>97</td>
</tr>
<tr>
<td>4.2</td>
<td>Examples of Instructional Scaffolding</td>
<td>100</td>
</tr>
<tr>
<td>4.3</td>
<td>Names, foci, process, and outcome of group-based activities and individual based activities</td>
<td>101</td>
</tr>
<tr>
<td>4.4</td>
<td>Measures per Research Questions</td>
<td>103</td>
</tr>
<tr>
<td>4.5</td>
<td>Descriptive Statistics, Mean score, standard deviation of higher and lower achievers by overall group performance. N presents number of students included in higher and lower performing groups</td>
<td>107</td>
</tr>
<tr>
<td>4.6</td>
<td>Multivariate Tests results of solo and group tests scores</td>
<td>108</td>
</tr>
<tr>
<td>4.7</td>
<td>Tests of Between-Subjects Effects</td>
<td>108</td>
</tr>
<tr>
<td>4.8</td>
<td>Estimated marginal means for the interaction of group performance and individual performance</td>
<td>109</td>
</tr>
<tr>
<td>4.9</td>
<td>Interviewee Profiles. H=Higher performer, L=Lower performer, HG=Higher performing Group, LG=Lower performing Group</td>
<td>110</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Operational Definition of Underperforming Students</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>Common learning problems of underperforming college students</td>
<td>21</td>
</tr>
<tr>
<td>3.1</td>
<td>Overview and flow of semester-long course</td>
<td>59</td>
</tr>
<tr>
<td>4.1</td>
<td>Hypothesis of the research</td>
<td>90</td>
</tr>
<tr>
<td>4.2</td>
<td>Procedure of the study</td>
<td>92</td>
</tr>
<tr>
<td>4.3</td>
<td>Overview and flow of semester-long course</td>
<td>106</td>
</tr>
<tr>
<td>4.4</td>
<td>Performance differences in solo test and group test</td>
<td>109</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

Prior to entering college, teaching and learning are typically mediated externally via high school curriculum standards with direct instruction to prepare for college admission. Studies reveal critical differences in academic performances. Students enter college with varied background knowledge and competencies. As a result, cognitive development varies individually according to varying motivation for the content to be learned (Paris & Byrnes, 1989); previously successful high school students often encounter unexpected failure upon entering college (Perry, Hladkyj, Pekrun, & Pelletier, 2001). We cannot assume that all students respond similarly to, or benefit equally from, any single instructional method. College students need to not only acquire and transfer new knowledge and skill but also to interpret, understand, and apply information to address shifting expectations. Students need to actively determine their individual learning needs as well as to adapt to the rigors of college life. Yet, only half of incoming bachelor’s degree-seeking students completed their degrees within 4 years (Snyder & Dillow, 2011) suggesting many are ill-prepared for college-level coursework.

A key post-secondary education goal is to cultivate independent learners who become lifelong contributors to society (National Research Council, 2003). Underperforming students often struggle due to differences between K-12 and college curriculum and expectations. Pre-service teachers, for example, develop teaching philosophies from coursework such as foundations of education, psychology, and sociology. In contrast, college students are often assumed to be capable, self-regulated learners who are motivated to learn from college lectures.
Rather than being guided by instructors, many students are presumed to establish and monitor progress toward individual learning goals, to organize and structure requisite knowledge and skills across diverse materials, and to apply and solve problems using knowledge and skills emphasized in course assignments and exams.

Another crucial higher education goal is to cultivate a scientifically literate citizenry (National Research Council, 2003). Scientific literacy for all students has become a core requirement for undergraduate general education (Meinwald & Hildebrand, 2010). For example, developing higher-order skills, including critical thinking, problem solving, and scientific reasoning are the foci of college-level teaching and learning (National Research Council, 2003). The skills are needed across domains but especially critical in science, technology, engineering, and mathematics (STEM). Indeed, most universities offer required STEM courses at the undergraduate level. Introductory STEM courses are often delivered in large-enrollment (e.g. over 100) formats to challenge undergraduate students to apply scientific understanding to everyday lives.

In a large-classroom setting, didactic instructional methods have been widely used to address requisite knowledge and skills. Yet, several limitations have been documented. Diverse learning needs and student preferences need to be accommodated, but solutions for large enrollment courses have proven elusive. Group work has been widely used to support students’ thinking in both small and large enrollment classroom. Collaborations involving peer-discussion and peer-assessment have supported students’ understanding of requisite knowledge and skills and in large enrollment courses (Johnson & Johnson, 1998; Nicol & Boyle, 2003).

For college science instructors, integrated peer-collaborative activities often challenge students’ understanding through in-depth peer inquiries. Inquiry-based active learning
encourages students to engage critical thinking inherent in the sciences (Handelsman et al., 2007). Inquiry-based methods include case-based learning, problem-based learning, group or peer discussion, formative quizzes, and writing (e.g., evidence-based argumentation, explaining phenomena) within college science classrooms. Increased individual involvement in inquiry-based activities is assumed to provide opportunities to contrast differing conceptual understanding.

However, collaborative work may inadvertently reify misconceptions among students with limited background knowledge and experience while encouraging rote learning. College students report difficulty due to limited background, skills, and lack of support from instructors. Johnson & Johnson (2009) noted that peer collaborations often promote shallow online participation due to insufficient instructor guidance. Since students are often inefficient or incapable of independently optimizing their learning, multiple studies document the need for increased support to encourage higher-level thinking skills. Without such support, students fail to evolve personal theories or explanations, and retain initial misconceptions (de Jong & Van Joolingen, 1998; Hannafin & Land, 1997; Nicaise & Crane, 1999).

College students, especially chronic underperformers, have reported limited understanding of (or skill in) collaborative learning; therefore, they tend to resist training to refine collaborative skill, believing it is unnecessary. Higher performers, in contrast, may perceive collaborative activities with underperformers as a hindrance to their own learning (Armstrong et al., 2007; Choi et al., 2005; Johnson, 2007). Both underperformers and higher performers, therefore, need well-structured support to promote positive interdependence, individual accountability, promotive interaction, appropriate social skills, and group processing (Johnson & Johnson, 2009).
According to collaborative learning advocates, fairness, motivation to compete, positive group work perceptions, and positive relationships among group member should enhance learning (Tjosvold, Johnson, Johnson, & Sun, 2003). Yet, previous studies indicated that under competition situations, individuals demonstrated self-worth protection, self-handicapping behaviors, and defensive pessimism (Johnson & Johnson, 1989). Social loafing (Latane, Williams, & Harkins, 1979) or free riding (Kerr & Bruun, 1983) effects have been documented involving students with varied achievement and prior knowledge levels.

To examine the effectiveness of collaborative learning, previous studies have placed attention on providing general guidelines for collaborative learning in college classrooms. It is necessary to conduct theory-based study of the effectiveness of suggested guidelines. In addition, previous studies placed less attention on effectiveness across diverse performance levels. The number of underperforming students in college is increasing, and the rate of college dropouts is increasing as well (Desruisseaux, 1998).

The extent to which group work influences the quality of underperformers’ collaboration and understanding has yet to be documented. Theoretically, every member will benefit proportionally from group work; however, evidence indicates that underperformers often fail to benefit from group work when working with both homogeneous as well as heterogeneous groups. The goals and effectiveness of group work vary according to subject domain; little research has focused on group effects associated across domains.

Research is needed to examine group interactions and effects across diverse domains such as STEM, social studies, and humanities to assess the influence on underperformers’ performance. College education aims to promote flexible domain knowledge and skills. To address diverse knowledge and skills, group work has been widely applied to promote
collaborative knowledge construction. Art and architecture, in contrast, primarily focus on individually developed unique outcome. Research is needed to promote interdependence among all group members to ensure comparable benefits.

**Structure of the dissertation**

This dissertation encompasses three articles submitted or to be submitted manuscripts. The following table summarizes each chapter in the dissertation.

<table>
<thead>
<tr>
<th>Chapters</th>
<th>Category</th>
<th>Title</th>
<th>Methodology</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch 1</td>
<td>Introduction and Literature</td>
<td>Introduction and Literature Review</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ch 2</td>
<td>Theoretical framework</td>
<td>Student-centered Learning and Underperforming College Students</td>
<td>Conceptual</td>
<td>Defining underperforming college students</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Framework</td>
<td></td>
</tr>
<tr>
<td>Ch 3</td>
<td>Pilot Study</td>
<td>Individual and group inquiry in college science classrooms: Who benefits?</td>
<td>Mixed Methods</td>
<td>The effectiveness of group activities</td>
</tr>
<tr>
<td>Ch 4</td>
<td>Main study</td>
<td>Scaffolding Collaborative Work in a Large-enrollment Classroom for Underperforming College Students</td>
<td>Mixed Methods</td>
<td>The effectiveness of scaffolding with group activities</td>
</tr>
<tr>
<td>Ch 5</td>
<td>Implication and Conclusion</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first manuscript (Chapter 2), *Student-centered Learning and Underperforming College Students*, delineates a conceptual framework for addressing the needs of underperforming college students. Based on the literature review, underperforming students are defined as those who possess the capability and background to succeed in college but fail to succeed in specific subject areas. Next, the paper describes the challenges of college learning environments for individual learners and how to address those needs via classroom instruction.
and group learning. Finally, the paper discusses how to design student-centered college learning environments for varied learners.

The second paper (Chapter 3), *Individual and group inquiry in college science classrooms: Who benefits?* examines the effectiveness of group-based inquiry activities on academic achievements of varied learners in large college science classrooms. Following a year of field-based observation, the study reported the effectiveness of group learning in large classrooms. Based on the operational definition of underperforming students, this paper reports the extent to which group-based and individual activities predicted higher and lower performers’ science learning performance. Then, the study examined differences in the extent to which group activities influenced both content knowledge and higher-order thinking skills between higher and lower performers. The results indicated that some group-based activities positively influenced the achievement of higher performers but no group activities improved lower performers’ learning achievement. This design research study gathered and analyzed evidence that proved critical to the methodology and analyses in the final study contained in the dissertation.

Chapter 4, *Scaffolding Collaborative Work in a Large-enrollment Classroom for Underperforming College Students*, presents evidence for the effectiveness of scaffolding group-based activities on students in varied prior knowledge and skill. Based on the results presented in Chapter 3, instructional scaffolds were developed and applied in the same college science context to promote equity of learning across learners. This study examined the influence of a scaffolding framework on support two key processes: 1) acquisition of content knowledge; and 2) the ability to analyze information for scientific inquiry. The purpose of the study was to examine the influence of peer collaborative support on underperforming biology students’ content knowledge and scientific literacy. Study results indicated that scaffolding enhanced some
students’ participation but did not significantly improve learning achievement among low performers.

Finally, Chapter 5 summarizes key ideas and implications from the three manuscripts. As design-based research, further research should follow to refine scaffolding with group activities to benefit both higher and lower performers’ learning achievements.

References


National Research Council (2003). *Evaluating and improving undergraduate teaching in science, technology, engineering, and mathematics*. Committee on Recognizing,


CHAPTER 2

STUDENT-CENTERED LEARNING AND UNDERPERFORMING COLLEGE STUDENTS¹

¹ Chang, Y. and Hannafin M. Submitted to Learning and Individual Differences, 2/02/15
ABSTRACT

Prior to entering college, teaching and learning opportunities are largely externally mediated via direct instruction and curriculum standards. Often, previously successful students have encountered unexpected failures upon entering college due to lack of requisite independent, self-regulated learning skills. Whereas instructors often assume students to be capable adults capable of learning independently, multiple studies document persistent problems and the need for additional support. In this paper, we analyze and synthesize research, theory and practices related to underperforming students in postsecondary settings, and identify research needed to support both underperforming college students and their instructors. We describe problems encountered by underperforming college students and propose shifts to support both instructors and students. Finally, we propose a research agenda to design college learning environment for underperforming students and instructors.

*Key words*: college learning environment, college teaching, underperforming students
The number of underperforming students in college is increasing, and the rate of college dropouts is increasing as well (Desruisseaux, 1998). According to recent National Center for Educational Statistics from 1996-2003, roughly half of incoming bachelor’s degree-seeking students completed their degrees within 4 years (Snyder & Dillow, 2011). Prior to entering college, teaching and learning were mediated externally via high school curriculum standards and direct instruction for those standards to prepare for college admission. Many previously successful high school students encounter unexpected failure upon entering college (Perry, Hladkyj, Pekrun, & Pelletier, 2001).

Often these students struggle to adapt to shifts from externally-manage learning systems in K12 schools to autonomously managed, flexible management required during post-secondary settings (Zimmerman, 2001). Whereas instructors may assume that students are capable independent learners, many lack requisite independent learning skills. Multiple studies document the need for instructional support to encourage students to develop higher level thinking skills, since current college students are deficient in independently optimizing their learning (Hadwin & Winne, 2001). Some college students report a lack of perceived learning ability and support from instructors. Students, for example, often fail to evolve personal theories or explanations, often retaining initial misconceptions (de Jong & Van Joolingen, 1998; Gyllenhaal & Perry, 1998; Hannafin & Land, 1997; Nicaise & Crane, 1999). Often, they fail to think reflectively and metacognitively during inquiry (Atkins & Blissett, 1993; Hill & Hannafin, 1997; Wallace & Kupperman, 1997); Many also fail to develop coherent explanations and produce primitive, often superficial artifacts devoid of related evidence (Land & Greene, 2000; Nicaise & Crane, 1999).
Since a key learning goal for college education is to cultivate independent and lifelong learners, college curriculum often requires students to develop not only specific knowledge and skills but also in-depth higher-order thinking skills (National Research Council, 2010). The importance of higher-order thinking, such as critical thinking, problem solving, and scientific reasoning, have become renewed foci for college-level teaching and learning (National Research Council, 2003). To realize this goal, however, important adjustments are needed among both college students and instructors. The purposes of this paper are: 1) to analyze and synthesize existing research, theory and practice related to underperforming students in postsecondary settings; and 2) to identify the need for research to support both underperforming college students and their instructors. We first describe evidence of problems encountered by underperforming college students then, propose shifts to support both instructors and students. Finally, we propose a research agenda to design college learning environment for underperforming students and instructors.

The Underperforming Student

As illustrated in Figure 2.1, underperformers have been described as low-achievers as compared with typical achiever students. Based on test performances, students who perform in the upper half or quartile among their peers (i.e., 75th percentile or above 50th percentile) have been defined as high achievers whereas who got the lower half or quartile (i.e., below 50th or 25th percentile) were defined as low-achievers (Baker, Gersten, & Lee, 2002; Eiselen & Geyser, 2006; Hong et al, 2000). Underperformers are often misjudged as having learning disabilities or being at risk students. Learning disabled students refer to a heterogeneous group that may include neurological disorders that affect the brain’s ability to receive process, store, respond and communicate information (American Psychology Association, 2000; Cortiella, Candace and
Horowitz, Sheldon H, 2014). However, many academic problems reported among underperforming students are similar to those reported by students with learning disabilities (Fuchs et al., 1997). Similarly, at-risk students include academically disadvantaged students whose academic difficulties have been associated with individual circumstances such as a low socioeconomic status, ethnic minority, parents with limited education or chronic unemployment, or poor or broken families (Heisserer & Parette, 2002; Kauffman, 1992). The learning problems reported among at-risk students are consistent with the broader spectrum of underperforming students.

**Figure 2.1. Operational Definition of Underperforming Students**

In this paper, we define underperforming students as those who possess the capability and background to succeed in college but fail to succeed in specific subject areas. Many, including individuals with learning disabilities are underrepresented in the postsecondary student population compared to the K-12 student and general populations (Gregg, 2007; United States Department of Education, 2005). Many students of average or above-average intelligence
struggle to acquire basic college level knowledge and skills, impacting performance in school, home, the community and the workplace.

**The Challenges of College Learning Environments**

College learning environments are often quite different from K-12 education settings in terms of class size, learning goals, curriculum structure, and instructional support. K-12 curriculum is designed to promote self-regulated learning with the direct support of teachers. K-12 students naturally and necessarily are directly guided as to what is considered important. Explicit stated learning objectives, textbook-oriented course materials and related assignments, and summative evaluations, however, may hinder K-12 learners’ independence and self-regulation skills.

A key post-secondary education goal is to cultivate independent learners who become lifelong contributors to society (National Research Council, 2003). Underperforming students often struggle due to differences between K-12 and college curriculum and expectations. Pre-service teachers, for example, develop teaching philosophies from coursework such as foundations of education, psychology, and sociology. In contrast, in college students are often assumed to be capable, self-regulated learners who are motivated to learn from college lectures. Rather than being guided by instructors, college students are assumed to establish and monitor progress on individual learning goals, to organize and structure required knowledge and skills across diverse materials, and to apply and solve problems using knowledge and skills emphasized in course assignments and exams.

Another crucial higher education goal is to cultivate a scientifically literate citizenry (National Research Council, 2003). Thus, students who previously benefitted from highly structured, teacher-directed instruction may lack self-regulated learning strategies when required
to structure and manage learning in college settings. In addition, college classes are often larger than typical K-12 classes. For instance, required STEM introductory courses are offered in large-enrollment settings including 100+ students (Hartfield, 2010). College level science, technology, engineering, and mathematics (STEM) emphasize the development of higher order thinking skills, yet students with limited prior exposure and opportunities to apply and refine these skills are disadvantaged. Recently, educators have attempted to advance individual learning in large-enrollment settings report limited success. Carbone & Greenberg (1998) report that the intensity and exchanges between students and teachers generally decreases as class size increases suggesting sustained passivity among students.

Whereas domain expertise is widely acknowledged as critical among college- instructors, few receive formal preparation or support to address the evolving learning needs of adult students (Merriam, 2001). Few university professors receive systematic preparation for teaching, but rather derive androgical beliefs and knowledge through trial-and-error in their work, reflection on student feedback, and self-evaluation; that is, university professors “learn from having observed their own teachers while they were students” (Hativa, Barak, & Simhi, 2001, p.700).

Various technologies have been applied to post-secondary education settings; technology has been lauded to promote higher order thinking skills such as critical thinking skills, problem solving skills, and reasoning skills, affording the potential to foster learning about complex systems (Azevedo, Cromley, & Seibert, 2004). Technology-enhanced scaffolding extends the "process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts” (Wood, Bruner, & Ross, 1976, p.90). Advances in technology and the learning sciences have made “on-the-fly” individualization of curricula
possible in practical, cost-effective ways; many technologies provide built in supports, scaffolds, and challenges to support understanding, navigating, and engaging learning environments (Rose & Wasson, 2008). However, simply using technology may not benefit diverse students equitably (Chang & Hannafin, submitted). According to a study involving 922 students across 51 undergraduate and graduate courses, no significant differences were detected between student computer use and course satisfaction (Lowerison, Sclater, Schmid, & Abrami, 2004).

**Addressing the Needs of College Students**

**Individual Differences**

Studies reveal critical differences in academic performances. Students enter college with varied background knowledge depth and competencies. As a result, cognitive development varies individually according to varying motivation for the content to be learned (Paris & Byrnes, 1989). We cannot assume that all students will respond similarly to, or benefit equally from, any single instructional method. College students need to not only acquire and transfer new knowledge and skill but also to interpret, understand, and apply that information. Students need to be actively involved in determining individual learning needs.

Contemporary college preparation requires active self-regulated learning (SRL) processing, metacognitive knowledge and skills, personal motivation to understand, retrievable memories, and advanced reasoning (Schunk, & Zimmerman, 2007; Zimmerman, 2001). Effective learners evolve an awareness of what they know and do not know as they assess and adapt learning processes. Students who are autonomously, metacognitively, motivationally, and behaviorally participate actively in self-regulated learning processes (Zimmerman, 2001; Zimmerman, 2006). Metacognitive knowledge, learner’s awareness of learning process and
abilities, is critical to identifying relevant information, separating relevant from irrelevant information, and monitoring strategies (Hill & Hannafin, 1997).

Prior knowledge and experience mediate the ability to assess and evaluate information as well as to detect inconsistencies and contradictions. Gagne emphasize the association of existing knowledge with new knowledge in *Events of Instruction* (1998). Cognitive psychologists characterized prior knowledge as networked schema which represents the organization of, and relationships among, existing knowledge and skill: The more extensive and connected, the richer the prior knowledge organization (schema), the more amenable to encoding new, related knowledge (Sweller et al, 1998). Prior knowledge informs and mediates the individual’s questioning and decision-making (Moos & Azevedo, 2009). Prior understanding becomes key to establishing individual expectations and knowledge reconstruction (Hannafin, Hannafin, & Gabbitas, 2009). Learners shape formative, often naive and incomplete theories-in-action as they attempt to interpret, make sense and understand (Land and Hannafin, 1996).

When learners establish individual academic goals, select learning strategies, assess progress and develop motivation to attain their goals, they become engage the task and gain confidence in the ability to meet individual goals (Zimmerman, 2008). Successful college students not only believe they influence their learning, but also their abilities to monitor progress and modify their actions in the face of failure (Haynes, Ruthig, Perry, Stupnisky, & Hall, 2006). Highly self-regulated students tend to employ reflective strategies whereas poor self-regulated students relied on habitual, automatic strategies.

Ineffective self-regulated approaches are distressingly prominent among underperforming students, who as often fail to adapt cognitive when encountering new knowledge in the classroom (Pintrich, 2000). Both prior experiences and expectations in the immediate learning
environment influence one’s cognitive goals. Individual learning strategies involve knowledge about what strategies are (i.e., declarative knowledge), how they are used (i.e., procedural knowledge), and when and why they should be used (i.e., conditional knowledge) (Zimmerman, 2001). For example, Ertmer, Newby, and MacDougall (1996) conducted an exploratory study on veterinary students’ self-regulated learning experiences during a case-based biochemistry course. They reported that low self-regulated students had difficulty in adapting to the Problem-Based Learning (PBL) approach central to the situated cases.

In addition, underperforming college students may become compliant learners who expect to receive explicit direction. Rather, they seek to comply with instructors’ expectations for specific course assessments rather than cultivating individual interpretations, judgments and reasoning skills (Blumberg, 2009). Researchers and theorists examined the interplay among the content and attributes of instruction and associated intrinsic, extraneous, and germane cognitive load. Underperforming students lack effective metacognitive strategies and tend to seek courses with reduced cognitive load. Both college and secondary PBL students often focus on surface-level details of the initial problem description (Xun and Land, 2004; Belland, 2010), perhaps owing to a preference for minimizing cognitive load.

Similarly, underperforming students who lack sufficient prior knowledge rely on monitoring processes, such as assessing how they are learning (Moos & Azevedo, 2008). It has proven challenging for novice learners to deploy metacognitive strategies. Novices lack rich prior knowledge, thus tend to integrate new knowledge differently from experts (Chi, Feltovich, & Glaser, 1981). Students who lack prior domain knowledge tend to develop vague and superficial understandings, fail to refine effective strategies, fail to sustain or abandon inquiries, resulting in fragmented understanding (Land & Greene, 2000).
When learning involves extensive materials and detailed instruction, underperforming students fail to differentiate essential from unessential content. Rather than organizing and synthesizing, college students are unable to conceptualize, organize, and structure knowledge upon entering college (Eiselen & Geyser, 2003). Underperforming students typically focus on secondary or unimportant details and overlook critical aspects (Vermunt, 1996), failing to differentiate essential from non-essential materials. When students fail to evolve theories or explanations, they tend to retain and reify initial misconceptions (de Jong & Van Joolingen, 1998; Gyllenhaal & Perry, 1998; Land & Hannafin, 1997; Nicaise & Crane, 1999). Inefficiencies in knowledge structuring often lead to misjudging, misinterpreting or misunderstanding learning context. To address this issue, instructors need to diagnose ongoing learning progress and provide needed guidance (Land & Hannafin, 2000).

Compared with effective learners, underperforming students hold lower expectations for success, judge themselves lower in ability, and emphasize lack of ability as a cause of failure. Rather than deepening understanding, they tend to focus on course grades [i.e., course grade or Grade Point Average (GPA) over long-term goals (i.e., career opportunities following graduation)]. Underperformers ignore or reject activities designed to promote thinking skills when perceived as not contributing to immediate course goals. Black and Deci’s (2000) study with 137 college students indicated that students with lower self-regulated strategies maintained short-term grade orientations rather than longer term learning goals. Prior learning experiences influence their perceptions about given subjects as well as their academic performances in college. For example, a study conducted with 540 freshman undergraduates found that student with lower high school GPAs appear to be less academically disciplined, determined, and self-confident
along with weaker study skills (Kromarraju, Ramsey, & Rinella, 2012). Eventually, continuous struggles eventually lead students to exhibiting learned helplessness (Dweck, 2002).

As depicted in Figure 2.2, the documented academic concerns involving underperforming students are diverse and vary widely across individuals. While certain approaches have proven applicable for students with similar problems, we need to consider the applicability across individual learning needs.

**Figure 2.2.** Common learning problems of underperforming college students

**Addressing individual needs**

In order to assess diverse learning needs in the classroom, various measurement and assessments have been developed. These assessments are designed to gauge learning readiness including prior knowledge levels, self-regulated learning skills, and motivation (e.g., The Motivated Strategies for learning Questionnaire (MSLQ), The Self-regulated Learning Interview Scale (SRLIS), the Test of Scientific Literacy Skills (TOSLS). The Motivated Strategies for learning Questionnaire (MSLQ), for example, measure students’ self-regulated learning in
academic contexts (Pintrich & DeGroot, 1990). The MSLQ measures intrinsic and extrinsic motivation, mastery and performance goals, self-efficacy, and control of learning of college students. How individuals regulate their learning environments is an important aspect of learning. The MSLQ measures the regulation of the study environment in relation to how individuals construct meaning for the tasks in the context. The MSLQ also has a scale for peer learning--how effective an individual student is in using peers as a resource for learning has been included. However, these assessments are self-report questionnaire instruments which can assess propensities to use self-regulatory strategies but not actual events or the on-going dynamic process of self-regulation. The Self-regulated Learning Interview Scale (SRLIS; Zimmerman & Martinez-Pons, 1986, 1988) assesses self regulated learning as a metacognitive, motivational, and behavioral construct. The Learning and Study Strategies Inventory (LASSI; Weinstein, Schulte & Palmer, 1987) assesses metacognition (skill), motivation (will), and self-regulation strategies (behavior). The LASSI scales classified metacognition includes concentration, selecting main ideas, and information processing, motivation include motivation, attitude, and anxiety, and self-regulation include time management, study aids, self-testing, and test strategies. The results of the self-report assessment or in-class test scores can show the improvements of students’ performance for a short period of time. However, the accuracy of self-report measures has been questioned especially if it is measured by underperforming students. Students have a tendency on over- or under-rating their achievement. According to a study conducted by Winnie and Jamieson-Noel (2002), students were slightly overconfident than they actually achieved. The study provided the academic tasks —how lightening develops—through the software called gStudy and asked students to complete a questionnaire about their methods of studying. In a questionnaire, students are asked how often they used various study
methods and students’ answers were compared with the traces that the software had recorded and students’ subject matter test scores. The study results show that there was a significant correlation between the students’ calibration of the accuracy of their achievement and their posttest score—the more accurate the students achieved from the posttest, the higher score the students achieved. Thus, the self-report measurement is less reliable and accurate when measured by underperforming students than higher-performing students.

For example, one study measured the correlation between autonomous motivation and the performance in the course with 137 college students enrolled in organic chemistry course. The study used the General Causality Orientation Scale (GCOS) (Deci & Ryan, 1985) that consist of self-report oriented questions. The results show that students’ initial level of relative autonomous motivation is not directly related to performance in the course (Black & Deci, 2000).

Also, results cannot be readily generalized to behaviors outside the classroom. Though they used diverse learning strategies such as planning, goal-setting, or note-taking, while in the class tasks, it does not mean that they achieved higher academic performance. For example, most graduate school use the Graduate Record Examinations (GRE) scores for the admission criteria. However, it has been criticized that the GRE score does not guarantee graduate students’ abilities in graduate school. The abilities being assessed on the GRE are different from the abilities that students will need when they are in graduate school—such as reviewing literature, writing a proposal, and so on. Also, the Test of English as a Foreign Language (TOEFL) score has been used to evaluate the linguistic abilities of non-English speaking students. The test evaluates listening, reading, writing, and speaking skills though it has been widely recognized that the students’ actual performance on using English does not necessarily match with their scores. Likewise, the results of the assessments that have been developed to measure students’ readiness
of learning, self-regulated learning abilities, or learning strategies should not be interpreted as evidence that they will use those skills outside the classroom in their everyday lives.

**Individual Learning in Groups**

Group work has been widely used across college settings to acquire new information as well as to develop thinking through peer interactions. Group work has promoted positive interdependence, advanced insights, promoted discovery, and higher-level reasoning (Gabbert, Johnson & Johnson, 1986). According to the social interdependence theory, group collaboration can be integral to facilitating interdependence among members to achieve common goals (Lewin, 1948). Collaborations involving peer-discussions and -assessments have reportedly improved individual student’s knowledge and skills in large-enrollment courses (Derry, Levin, Osana, Jones, & Peterson, 2000; Jensen & Lawson, 2011; Johnson & Johnson, 1998; Nicol & Boyle, 2003). Typically, students are introduced to both alternative ways of reasoning and patterns of thought while engaging in dialogs with more competent others. After repeated experiences, the learner’s thinking and communication processes become internalized with his cognitive skill repertoire (Johnson & Johnson, 1989; Piaget, 1970).

Thus, peer scaffolding has been widely applied to support diverse learners across college classrooms (Cabrera & Cabrera, 2002; Johnson, Johnson, & Smith, 1998). Peer-interactions and collaborations have been reportedly effective in improving each individual student’s learning within the group. Meta-analyses of college students’ peer-collaborative work have documented evidence for enhancing knowledge acquisition, problem-solving, higher-level reasoning, and attitudes towards learning (Johnson, Johnson, & Smith, 1998). Presumably, collaborative learning increases both individual and group’s learning performance to assume responsibility for learning as well as to reflect on and monitor learning processes (Kirschner, 2001).
underperforming college classrooms, peer-interactions have been purported to lowering anxiety while increasing self-efficacy, self-confidence, and ownership of the learning process (Callahan, 2008; Phinney, Dennis, & Chuateco, 2005; Griffin & Griffin, 1998).

However, underperforming students often possess limited understanding of (or skill in) collaborative learning processes; as a consequence, many resist participation believing it does not improve their achievement (i.e., getting a good grade) (Armstrong, Chang, & Brickman, 2007; Choi, Land, & Turgeon, 2005; Eiselen & Geyser, 2003; D. Johnson, 2007). In such instances, group collaborations may conceal the individual performance of underperforming students. Higher performers, in contrast, tend to perceive collaborating with underperformers as burdensome to their individual performance (Armstrong, Chang, & Brickman, 2007; Johnson & Johnson, 1989). All students, including underperformers and higher performers, therefore, may benefit from more sophisticated, structured collaborative activities to promote positive interdependence, individual accountability, promotive interaction, appropriate social skills, and group processing (Johnson & Johnson, 2009). In order to promote effective online group work, both students and instructors assume responsibility for organizing and scaffolding discussion--online as well as in the classroom (Christopher, Thomas, & Tallent-Runnels, 2004).

Unfortunately, few studies have documented the extent to which group work influences, positively or negatively, underperforming students’ performance. Simple grouping may not promote or ensure mutual collaboration and co-regulation (Johnson, 1998). Rather, by design, effective group activities promote and support effective group behaviors while avoiding detrimental, maladaptive activities such as free-riding and social loafing (Kreijns, Kirschner, & Jochems, 2003). Well-designed and implemented supports (scaffolds) may promote task engagement beyond what low performers enact on their own (Vygotsky, 1978). For example,
many instructors purportedly incorporate peer-mediated strategies, yet confess they rarely adhere to or validate their effects (Hmelo-Silver, Chinn, O’Donnell, & Chan, 2013; Johnson & Johnson, 2009). This may prove especially detrimental for underperforming students with documented needs for consistent, structured group experiences to internalize individual strategies.

**Instructional Support**

**Individual vs. group support**

Unlike K-12 teachers, college instructors often assume that students will manage and mediate their learning effectively and independently. Instructors may presume that underperforming students lack interest in their subject yet possess the strategies and skills to succeed in their classes (ref). However, as noted previously, since prior direct-instruction dominated K-12 curriculum, many college students have not engaged environments where self-regulated learning and management skills are needed. College freshman characteristically demonstrate poorer self-regulated learning strategies than experienced college senior students (van den Hurk et al. 1999). Accordingly, freshmen students tend to rely on external guidance while learning (Dolmans and Schmidt, 2000).

Some instructors provide individual as well as group feedback. In large enrollment classes, often common in introductory STEM courses, college instructors’ workloads and responsibilities may be multiplied in efforts to provide individual student scaffolding (Hartfield, 2010). Ironically, since underperforming students often lack the skills needed to structure new knowledge and manage learning processes, instructional supports may prove especially important.

Lack of effective instructor support is widely acknowledged to influence underperforming students’ performance (Eiselen & Geyser, 2003). Lacking support, novice
learners tend to oversimplify and misunderstand new concepts due, in part, to lack prior knowledge (Chi,_Feltovich, & Glaser, 1981). When novices organize new knowledge with erroneous assumptions and prior knowledge, mislearning becomes increasingly robust and problematic to revise (Land & Hannafin, 1997). In contrast, when college students in a large group lectures receive autonomy support, initial negative course perceptions improved (Black & Deci, 2000).

To support varied students, college instructors often incorporate group collaborative work. However, numerous peer discussion studies (online as well as face-to-face) have indicated that unsupported peer interactions are often shallow, and “rarely developed into a higher level of communication where negotiation, co-construction, and agreement occurred” (Tallent-Runnels et al., 2006, p. 100). Students fail to substantially evolve individual theories or explanations, often failing to challenge initial misconceptions (de Jong & Van Joolingen, 1998; Gyllenhaal & Perry, 1998; Land & Hannafin, 1997; Nicaise & Crane, 1999); Students failed to think reflectively and invoke metacognitive processes during inquiry (Atkins & Blissett, 1992; Hill & Hannafin, 1997; Wallace & Kupperman, 1997); Students often failed to develop coherent and supportable explanations, as evidenced by superficial artifacts devoid of supporting evidence (Land & Greene, 2000; Nicaise & Crane, 1999; Oliver, 1999).

On the other hand, those with limited autonomous self-regulation subsequently improved course performance when they perceived effective support from group leaders (i.e., graduate students), whereas those considered as perceiving relatively high individual autonomy were not influenced by perceptions of autonomy support (Black & Deci, 2000). Ironically for underperforming students, group work could pose additional barriers that hinder learning. In a 30-month longitudinal study involving medical students, those who perceived their instructor
supported individual autonomy became increasingly autonomous during the course (Williams& Deci, 1996). Thus, as Christopher, Thomas, and Tallent-Runnels (2004) have argued, instructors need to assume greater responsibility for organizing and scaffolding their students’ learning within these peer discussions.

Thus, it is critical for college instructors to provide effective support with students in diverse performance levels during group activities. Successful instruction reflects thoughtful consideration of individual student learning needs, preferences, and readiness. Effective instructors provide opportunities to integrate diverse, complementary learning strategies to empower students to refine their individual approaches. Among postsecondary students, the abilities and skills needed to regulate or direct individual learning can be scaffolded in various ways (Evensen et al. 2001; Loyens, Magda, & Rikers, 2008; Yew and Schmidt (2009).

Instructor scaffolding has proven especially promising for developing higher-order reflection in instructional contexts (Hannafin & Land, 1997). Scaffolding alternatives are varied, but can be classified based upon functions that support learning in open-ended learning environments: Conceptual (what knowledge to consider); Metacognitive (how to think about the problem); Procedural (how to use learning environment features); and Strategic (what the alternative strategies are) (Hannafin, Land, & Oliver, 1999). In group work, instructors can support students of varied abilities by purposefully organizing heterogeneous or homogenous groups. Underperforming students sometimes performed better or even outperformed peers when they collaborated with either heterogeneous group members (Hooper & Hannafin, 1991) or homogeneous group setting (Jensen & Lawson, 2011).

For instance, alternative representation, such as diagrams, tables, multimedia examples, summary notes, or scenarios provide varied resources to support individual differences such as
encouraging or generating different types of examples (including making a scenario with acquired knowledge or concepts, converting diagrams to tables; finding analogies between concepts). The instructor optimizes guidance via varied scaffolds rather than a single, fixed depiction. Instructor’s discussion of what is known, needs to be known, and possible solutions provides support while modeling associated cognitive processes (Scardamalia, et al., 1989).

However, further research is indicated to validate the extent to which feedback and scaffolding influence the academic performance of underperformers. While diverse guidance has been emphasized, it is not clear the extent to which instructors balance guiding versus simply directing or telling individual processing (Land & Hannafin, 2000). One recent study with 20 classrooms with biology students indicated that group work strategies affect underperforming students differently based on group composition. Underperforming students actually performed better in homogeneous groups than heterogeneous groups when instructors scaffolded inquiry-based instruction. On the contrary, when the instructor provided didactic instruction, underperforming students performed better scores students in heterogeneous achievement groups (Jenson & Lawson, 2011).

**Scaffolding via technology**

Well-designed technology-enhanced learning environments (TELEs) can provide powerful tools for learning by presenting varied representations while enhancing self-regulated learning (Jacobson & Wilensky, 2006). Universal design (UD) principles, focused on supporting diverse abilities, for example, suggest the need for multiple representations, such as the first principle: equitable use. Yet, available literature indicates that related research has not proven sufficiently systematic to support scientific conclusions as to the nature of support or presumed
benefits (Simpson & Oliver, 2007). Fewer studies have focused on the effectiveness of technology integration in post-secondary education classrooms for under-performing students.

Edirippulige and Marasinghe (2011) reviewed evidence blending self-regulated learning with educational programs, such as e-Health teaching, which incorporated different ICT technologies. Student learning and conceptual understanding were significantly improved and interactive when a large upper-division biology class incorporated technology to support students’ participation and cooperative problem (Knight & Wood, 2005). Within large-enrollment classrooms, audience response system (ARS) or Clickers have been widely applied to increase student engagement during class presentations (Caldwell, 2007). However, providing multiple technologies may also increase cognitive processing load. According to Mayer and Moreno’s (2003) study, representing text and animation synchronously or asynchronously could enhance or hamper learning.

Blended learning environments have also been widely implemented for college coursework. The online learning environment presumably supports student understanding via peer interactions and discussions. Several authors have reported positive student course perceptions, increased motivation for learning, and improved course exam scores when technologies are integrated in large courses (Cooner, 2010; Huon, Spehar, Adam, & Rifkin, 2007a; López-Pérez, Pérez-López, & Rodríguez-Ariza, 2011). However, several other studies indicated that students encounter challenges with blended courses including time management skills and lack of individual responsibility for learning (Dziuban & Moskal, 2001; Garnham & Kaleta, 2002). These challenges underscore the learning challenges of addressing different needs; few studies analyzed the effectiveness of blended learning environments for underperforming students.
In blended learning environments, group learning is often limited to discussion activities to supplement offline learning. Students responded to questions posted by instructors or peers and entailed replies from peers before or after offline classes. While this type of discussion task might contribute to collaborative knowledge construction, these types of tasks would not require students to establish a high level of interdependence among each other (Graham & Misanchhuck, 2004). Although instructors assign group work activities in order to encourage students to have cognitive challenges while collaborating, students tend to approach the group work by completing each portion individually first and then combining them into one. Without a well-organized classroom community, students are unable to benefit from online interactions; their academic performance does not improve (Davies & Graff, 2005). The least inactive participation and benefit students are who underperform in the class (Lin & Kelsey, 2009; Mead, 2011,). Within blended learning courses, online learning environments often turn into platforms for the final submission of group work, not a space for sharing ideas and co-constructing knowledge.

**Implications**

**Understanding collaborative learning**

The extent to which group work influences the quality of under-performers’ collaboration and understanding has yet to be documented. Theoretically, every member will benefit proportionally from group work; however, evidence indicates that underperformers often fail to benefit from group work when working with homogeneous as well as heterogeneous groups. Research is needed to promote interdependence among all group members to ensure comparable benefits. What types of instructor scaffolding promotes positive interdependence to support underperforming students’ academic performance? To what extent do they strengthen individual accountability across members? How can instructors support academic performance for group
members during group activities? Both quantitative and qualitative research methodology are needed to document concrete evidence of both the nature and effectiveness of group interactions for learners of varied abilities. Questionnaires may provide quantitative indicators of individual satisfaction with group work, achievement and depth of understanding of subject concepts to determine the extent to which group interdependence is evident. Individual interviews and observations provide opportunities to probe the nature and changes in group dynamics as well as data to triangulate with quantitative outcomes. Ensuring equitability across diverse individuals within groups has proven problematic. To assure equitability, researchers need to assess the extent to which scaffolds enhance the individual performance of typical as well as underperforming students. Social loafing (Latane, Williams, & Harkins, 1979) or free riding (Kerr & Bruun, 1983) effects have been documented involving members with different achievement and prior knowledge levels (i.e., groups with international students and native speakers or groups with majors and non-majors, or groups with seniors and freshmen). Future research should focus on face-to-face group work using techniques such as micro-level observation and video recording. Discourse patterns can depict individuals’ participation during the group discussion and discourse analysis can be used to analyze changes in knowledge construction. On-task discourse has been positively related to individual knowledge acquisition (Cohen, 1994). Anonymous peer evaluations may be used to assess individual student’s perceptions of each group member’s contribution to the group work.

The goals and effectiveness of group work vary according to subject domain; little research has focused on group effects associated across domains. Research is needed to examine group interactions and effects across diverse domains such as STEM, social studies, and humanities to assess the influence on underperformers’ performance. College engineering
education aims to build necessary knowledge and skills. To address a significant range of knowledge and skills, group work has been widely applied to promote collaborative knowledge construction. Art and architecture, in contrast, primarily focus on individually developed unique outcome. Group work may be used to share other’s points of view to improve individual outcomes.

**Technology and collaborative learning**

While technology has been widely adopted in face-to-face and blended college courses, the effectiveness for underperforming students has not been conclusively demonstrated. For classroom applications, technology integration appears to depend on the number of students enrolled. Theoretically, blended learning environments enhance individual learning via instructors’ support. However, in large enrollment courses, instructors report difficulty supporting the needs of individual students even with technology activities. For students who lack the self-regulated learning abilities on time management, learning strategies, self-directed learning skills, online learning environment easily became a library or a platform of offline classroom activities. Future research needs to document the balance needed to support blended learning for large enrollment courses a with instructor guidance. Previous studies with large college courses tended to emphasize the use per se rather than emphasizing effects on students’ learning. Simply analyzing the frequency of online resource access fails to account for the influence of supplementary online resources. Students’ learning progress needs to be documented. The quality of students’ postings and responses can be documented empirically using validated scoring rubrics. To triangulate the evidence from discussion boards, semi-structured students’ reflection journals and interview should help to clarify the net impact on performance.
Assessing engagement and motivation

Among multiple learning issues that underperforming students encounter, the extent to which these issues have influenced underperforming students’ reduced inclination to engage the course has not been demonstrated. Though self-report measures/scales have been utilized extensively to identify individual needs, the relationships between self-reports with participation and performance has proven inconclusive. Compared to providing support for individual learning issues, the extent to which do underperforming students improve their academic performance when being supported their domain-specific relative autonomy/motivation? To what extent domain specific motivation support will improve underperforming students’ academic performance? Autonomous support increased underperforming students’ autonomy on learning but, the influence on their academic performance has remained as questions. This is mainly because self-report measures have been used to identify students’ engagement in learning. Underperforming students tend to over- or under-rate their individual perceptions of progress, needs for support, and confidence in their understanding. Research is needed to corroborate correlations between self-report measures and underperforming students’ academic performance. If no significance correlation has been found, alternative complementary measures or scaffolds may be required. During group learning, it may be useful to compare individual self-reports (self-evaluation) with anonymous peer-evaluations to validate the reliability of the measures as well as to correlate with individual as well as group measures of performance. Interview and reflection journals may prove important to determine the extent to which self-report indicators can be employed with either individual or consensus self-assessment measures. Providing relevant and appropriate scaffolds to support individual needs has been reported. Instructors may provide adaptive scaffolding to support student’s monitoring and reflection on their learning
process. However, for underperforming students, the effectiveness of scaffolds has not been documented conclusively. Future researchers need to document the extent to which instructor scaffolding helps underperforming students’ actual academic performance.

While learning to apply knowledge and skills in everyday lives is considered paramount, little evidence has documented about underperforming students’ applications beyond the immediate academic context and everyday lives. It is important to examine the extent to which academic knowledge and skills are sustained and applied beyond the immediate academic context. Longitudinal studies are indicated to examine the longer-term impact of scaffolds and supports on those identified and underperforming students. Design-based research methods can be implemented to optimize both the impact of supports during and following academic rigors as well as to examine the scaffoldings’ underlying theory based. Future research needs to address gaps between academic theory and practice along with the viability and sustained impact of such practices for everyday applications.

References


evaluation of Science Museum of Minnesota’s Atmospheric Explorations computer


Hannafin, M. J., & Land, S. M. (1997). The foundations and assumptions of technology-

Hartfield, P. J. (2010). Reinforcing constructivist teaching in advanced level biochemistry

Hativa, N., Barak, R., & Simhi, E. (2001). Exemplary university teachers: Knowledge and
beliefs regarding effective teaching dimensions and strategies. *Journal of Higher
Education, 699-729.*

academic risks of over-optimism: The longitudinal effects of attributional retraining on

Settings. *College Student Journal, 36*(1), 69.


handbook of collaborative learning.* Routledge.


CHAPTER 3

INDIVIDUAL AND GROUP INQUIRY IN COLLEGE SCIENCE CLASSROOMS:

WHO BENEFITS?\(^2\)

---

\(^2\) Chang, Y. and Hannafin M. Submitted to *Studies in Higher Education*, 12/02/14
Abstract

Group work has been widely used to support participation in both small and large enrollment college classroom. However, group work sometimes inadvertently encourages rote learning and reifies misconceptions among students with limited background knowledge and experience. This study examines how individual and group inquiry-based activities influence achievement among academically diverse students. We employed a mixed methods study involving 303 undergraduate, non-science majors enrolled a required large-enrollment college Biology course. We examined differences in the extent to which group activities influenced both content knowledge and higher-order thinking skills between higher and lower performers. The results indicated that some group-based activities positively influenced the achievement of higher performers but no group activities improved lower performers’ learning achievement. Future research is needed to examine group methods that benefit the academic performance of all participants equitable across achievement levels.

Key Words: group work, lower performers, inquiry-based activities, large enrollment college classroom
Scientific literacy for all students has become a core requirement for undergraduate general education. Developing higher-order skills, including critical thinking, problem solving, and scientific reasoning are the foci of college-level teaching and learning (Fox & Hackerman, 2002; Meinwald & Hildebrand, 2010). The skills are critical in science, technology, engineering, and mathematics (STEM) (McCray et al., 2003); many universities offer mandatory STEM courses at the undergraduate level (Hartfield, 2010). In case of the United States, National Science Council indicated the necessity to develop a broad set of skills to approach scientific phenomena quantitatively, as well as abilities to apply basic quantitative concepts in their daily lives (Kutner et al., 2007). Large-enrollment introductory biology courses (e.g. over 100) are designed to enhance undergraduate students’ abilities to apply scientific knowledge in everyday lives.

In a large-classroom setting, didactic instructional methods have been widely used to address requisite knowledge and skills. Yet, several limitations have been documented, particularly for large enrollment courses (e.g. > 100 students). Johnson & Johnson (2009) reported that cooperative college student groups were more engaged than individuals in competitive groups. Davies (2009) reported that students involved in competitively structured discussions were more anxious, less self-assured, and more self-oriented. In contrast, students in cooperatively structured discussions were described as less tense and more task-oriented. Still, it is often difficult and time-consuming to integrate lectures with discussion, and particularly to provide individual student learning feedback and while ensuring that all students are actively engaged. The diverse learning needs and preferences of students need to be accommodated, but solutions for large enrollment courses have proven elusive.

Group work has been widely used to support students’ thinking in both small and large
enrollment classroom. Collaborations involving peer-discussion and peer-assessment have supported students’ understanding of requisite knowledge and skills and in large enrollment courses (Derry, Levin, Osana, Jones, & Peterson, 2000; Jensen & Lawson, 2011; Nicol & Boyle, 2003). Learners acquire both new information as well as new ways of thinking through peer interactions (Johnson & Johnson, 1989; Piaget, 1970; Vygotsky, 1978).

Inquiry has become increasingly critical to learning science. In a recent survey, 150+ life sciences faculty members across institutions identified problem solving/critical thinking, oral and written communication, and the ability to interpret data as critical skills students need to develop and refine inquiry skills. College science instructors integrated peer-collaborative activities to challenge students’ understanding through in-depth peer inquiries. Inquiry-based active learning encourages students to engage critical thinking skills inherent in the science process (Johnson, Johnson, & Smith, 2007; Handelsman et al., 2004). Inquiry-based methods have included case-based learning (CBL), problem-based learning (PBL), group discussion, and writing in college-level STEM courses. Case-based learning (CBL), problem-based learning (PBL), peer discussion/debate, formative quizzes, and essay/writing (e.g., evidence-based argumentation, explaining phenomena) based on inquiry-based learning models have been applied to a few college science classrooms. Increased individual involvement in inquiry-based activities provides students opportunities to contrast differing conceptual understanding.

Collaborative peer activities have been employed both to engage students conceptually and to deepen student reasoning. Typically, students are introduced to new ways of reasoning and patterns of thought as they engage in dialogs with more knowledgeable others. Collaborative learning involves students working in small groups (3 to 4 members) to pursue common goals. Essentially relationships become symmetrical, so no single member dominates while all
contribute to and assist group members. Eventually, after repeated exposure, thinking and communication processes become internalized cognitive skills (Johnson & Johnson, 1989; Piaget, 1970). Learning supports (scaffolding) enable group members to complete tasks that they could not do alone (Vygotsky, 1978).

However, peer-collaborative work may inadvertently reify misconceptions among students with limited background knowledge and experience and encourage rote learning. College students report difficulty due to limited abilities and insufficient support from instructors (Desruisseaux, 1998). Peer collaborations often promote shallow online participation due to insufficient instructor guidance; instructors need to assume increased responsibility for organizing and scaffolding students’ learning during online as well as classroom discussions (Christopher, Thomas, & Tallent-Runnels, 2004). Multiple studies document the need for increased support to encourage higher-level thinking skills, since students are often inefficient or incapable of independently optimizing their learning (Hadwin & Winne, 2001). Lacking needed support, students focus narrowly on satisfying explicit expectations and course grades rather than their independent reasoning. As a consequence, students fail to evolve personal theories or explanations, and retain initial misconceptions (de Jong & Van Joolingen, 1998; Hannafin & Land, 1997; Nicaise & Crane, 1999); For example, when students failed to engage in reflective thinking and metacognitive activities during inquiry (Atkins & Blissett, 1993; Hill & Hannafin, 1997; Wallace & Kupperman, 1997), they were unable to provide coherent explanations and produced primitive, often superficial artifacts devoid of related evidence. College students, especially chronic underperformers, reported limited understanding of (or skill in) collaborative learning; therefore, they resist training, believing it is unnecessary (Armstrong, Chang, & Brickman, 2007; Choi, Land, & Turgeon, 2005; Eiselen & Geyser, 2003; D. Johnson, 2007).
Higher performers, in contrast, may perceive collaborative activities with underperformers as a hindrance to their own learning (Armstrong, Chang, & Brickman, 2007; Johnson & Johnson, 1989). Both underperformers and higher performers, therefore, need well-structured support to promote positive interdependence, individual accountability, promotive interaction, the appropriate use of social skills, and group processing.

The purpose of this study is to examine how inquiry-based learning activities influence achievement among diverse students in a large-enrollment college science classroom. We examine the extent to which specific inquiry activities influence both formal content knowledge and higher-order thinking skills. We predict that high achievers in homogeneous groups will benefit from peer collaborative inquiries on both individual and group measures, whereas underperformers will improve on group measures but not individual understanding.

**Research Questions**

1. Which inquiry based activities influence performance among non-science majors?
   a. Which activities influence content knowledge acquisition and higher-order thinking skills?
   b. How do learners perceive the value and effectiveness of inquiry-based activities?

2. Which attributes differentiate achievement among of high v. low-achievers?
   a. To what extent are content knowledge acquisition and higher-order thinking skills predicted by collaborative participation?
   b. How do students perceive inquiry-based science learning activities?
Methods

Methodology

This study employed concurrent triangulation in a mixed methods design (Creswell, 2009). Since the process and learning outcomes are important in collaborative learning, mixed methods draw from qualitative and quantitative paradigms to address the methodological challenges. Quantitative analyses included student contributions and learning achievement in content knowledge acquisition and higher order thinking development. Qualitative evidence provided insights into how learning occurred in the specific large-enrollment college context. We examined both the breadth and depth of learning by integrating divergent findings from qualitative and quantitative methods (Teddlie & Tashakkori, 2003). Qualitative data and quantitative data were collected concurrently and analyzed independently. To explore the influence of each inquiry based learning activities and the challenges of inquiry-based learning that learners encountered by triangulation, results from the qualitative data and quantitative data were compared and contrasted.

Research Context

Participants. A total of 303 non-science major college students enrolled in an introductory biology course at a large public university in the southeastern United States participated in the study. Most students were freshman and were divided into small groups for group works: 74 (four to five group members per one group) small groups were created. The instructor uploaded open-source textbook, relevant multimedia materials on the learning management site (LMS). Students accessed LMS to view the course materials and grades, and to submit outside-class group work and their projects. During class meetings, students either used a smartphone or a laptop to respond to quizzes and download lecture slides.
Inquiry-based activities. Inquiry-based learning activities were designed to improve students’ scientific literacy. Activities to acquire content knowledge, analyze, evaluate, and argue the merits of scientific evidence or ideas were central inquiry-based activities. The activities focused on acquiring content knowledge for scientific inquiry will refer as content-knowledge oriented activities. In this study, in-class pop quizzes and group work focused on content knowledge. Project and outside-class group work activities focused on developing and applying higher order thinking skills (i.e., analyzing, evaluating, or arguing). The course was divided into five units (modules) with each unit delivered over 3-4 weeks. Each unit was evaluated by individual and group assignments and solo and group tests.

Group-based activities. Group-based activities included in-class group works, outside-class group assignments, group test, and peer-evaluations for group work. In-class group works were enhanced understanding about the content knowledge during lectures. Groups completed group worksheets to enhance understanding about the topic of the day and each member earned the same scores. Worksheets included activities such as structuring or summarizing content knowledge (i.e., drawing a diagram of the acquired knowledge, finding relevant resources from the website). The outside-class group work required applying and synthesizing knowledge within a unit. Real-life related situations were provided for group members to discuss and report their interpretations. For example, in alcohol metabolism unit, college students’ story after drinking alcohol was provided as a case. Students were asked to analyze why some students’ had glowing and to explain how enzyme impacts the occurrence. All group members received the same earned from the outside-class group assignment scores. To support group activities, students evaluated each group member anonymously via the online system to examine individual
perceptions of the group’s dynamics. The peer-evaluation score applied to individual student’s final grade to encourage individual students’ equal contribution to the group work.

*Individual-based activities.* Individual support activities included formative quizzes, practice tests, and a project. Students responded individually using an Audience Response System (ARS) during quizzes. The in-class quizzes were designed to provide formative feedback for content knowledge acquisition during the lecture. The items included simple multiple-choice questions of content covered during the lecture; and served as each individual’s final grade. Throughout the semester, individual students also completed one project which involved applying course concepts to personal decisions whether to have personal DNA analysis. Project scores were aggregated to the individual’s final grade. In addition, individuals took practice tests via the course website before unit tests. The practice test questions paralleled the multiple choices questions on the unit test but not aggregated to the final scores. The practice test provided individual students with formative feedback prior to the unit test (see, Table 1, for summary).

*Test.* Upon completing each unit, individual students were assessed using both the individual test (solo test) as well also group test. Unit exam questions required both content knowledge and higher-order thinking. After submitting individual unit test responses, group members gathered and collaboratively discussed response options for each item which provided immediate feedback regarding collaborative performance. Group test scores were added to solo test scores to assign each individual’s final course grade.
Table 3.1. *Inquiry-based Activities*

<table>
<thead>
<tr>
<th>Category</th>
<th>Activities</th>
<th>Focus of Activities</th>
<th>Participation</th>
<th>Process</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Content knowledge</td>
<td>Higher order thinking</td>
<td>Support</td>
<td></td>
</tr>
<tr>
<td>Group-based activities</td>
<td>In-class group work</td>
<td>v</td>
<td>During every class</td>
<td>With group members</td>
<td>Group worksheets scores</td>
</tr>
<tr>
<td></td>
<td>Outside-class group work</td>
<td>v</td>
<td>One per unit, after the class</td>
<td>With group members</td>
<td>Outside-class group work scores</td>
</tr>
<tr>
<td></td>
<td>Group unit test</td>
<td>v, v</td>
<td>One per unit, after solo test</td>
<td>With group members</td>
<td>Group unit test scores</td>
</tr>
<tr>
<td></td>
<td>Peer-evaluation</td>
<td>v</td>
<td>Three times a semester</td>
<td>Anonymously and individually via online</td>
<td>Average of peer group’s evaluation scores</td>
</tr>
<tr>
<td>Individual-based activities</td>
<td>In-class pop quizzes</td>
<td>v</td>
<td>During every class</td>
<td>Individually</td>
<td>Average of individual quizzes scores</td>
</tr>
<tr>
<td></td>
<td>Project</td>
<td>v</td>
<td>One per semester, after the class</td>
<td>Individually</td>
<td>Individual project score</td>
</tr>
<tr>
<td></td>
<td>Practice test</td>
<td>v, v, v</td>
<td>Before the unit test</td>
<td>Individually via online</td>
<td>Not aggregated to the final grade</td>
</tr>
<tr>
<td></td>
<td>Solo unit test</td>
<td>v, v</td>
<td>One per unit</td>
<td>Individually</td>
<td>Individual unit test scores</td>
</tr>
</tbody>
</table>
Measures

Quantitative Measures. Seven independent variables were examined as potential student achievement predictors of content knowledge acquisition and higher-order thinking development. Independent measures included individual subcomponents: in-class pop quizzes scores, practice test scores, individual project scores and group work scores (broken into three subcomponents: group test scores, in-class group work scores, outside-class group work scores, and peer-evaluation scores). In-class group work and in-class pop quizzes focused on content knowledge acquisition. Outside-class group work, project, and unit tests focused on higher-order thinking skills. The dependent measure was an individual test which required both content knowledge and higher order thinking.

Qualitative Measures. Interview data, field observation notes, and students’ open-ended responses to course mid-evaluation were used as complimentary data for quantitative data. The researcher recruited student interviewees by announcing in front of the classroom three weeks before the semester ended. Field notes were recorded during classroom observations to observe instruction and group work, interactions between and among students and instructor, group members and individual dynamics. Students responded to anonymous mid-course evaluations to obtain formative opinions during the course. Open-ended questions asked students to course activities that worked well or poorly.

Data Analysis

Quantitative analysis. The primary analysis involved stepwise regression to identify predictor variable(s). Each unit exam had different mean and standard deviations since unit exams assessed different outcomes. To assure normal distribution, individual test scores were rank ordered and averaged. Based on a median split of solo test scores, students who were ranked
in upper 50% were categorized as higher performers (n=151) while the lower 50% were
categorized as lower performers (n=152).

**Qualitative analysis.** Eleven interviewees volunteered to participate in the interview: seven were
higher performers and four were lower performers. Before the interview, each interviewee signed
a consent form that includes information about the purpose of the interview, length of the
interview, and confidentiality of the responses. Pseudonyms were used to conceal identities.
Interviews were recorded and transcribed. Interview questions elicited individual thoughts,
preferences, and barriers during the semester. Since we were concerned that students who did not
perform well might hesitate to share their experiences the researcher began by assuring the intent
was to reflect diverse experiences and not to judge the experiences. Qualitative data were
transcribed verbatim and the interviews transcribed and coded using a memoeing process
through multiple readings of the transcripts. We generated initial codes to search for themes then
defined and named themes (Braun & Clarke, 2006). We used ATLAS.ti 7.1 software to analyze
multiple data.

**Triangulation.** Results from regression analysis were triangulated with interview data,
field notes, and students’ open-ended responses from mid-course evaluation. Measures per
research questions are summarized in Table 3.2.
### Table 3.2: Measures per Research Questions

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Measures</th>
<th>Triangulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which inquiry based activities influence student performance among non-science majors?</td>
<td>Which activities influence content knowledge acquisition and higher-order thinking skills?</td>
<td>Content knowledge acquisition activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher order thinking skills achievement</td>
</tr>
<tr>
<td></td>
<td>How do learners perceive the value and effectiveness of inquiry-based activities?</td>
<td>- Interview (N=11) - Field observation - Students’ responses to mid-course evaluation</td>
</tr>
<tr>
<td>Which individual attributes differentiate achievement among of high v. low-achievers?</td>
<td>To what extent are content knowledge acquisition and higher-order thinking skills predicted by collaborative participation?</td>
<td>Content knowledge acquisition activities skills achievement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher order thinking</td>
</tr>
<tr>
<td></td>
<td>How do students perceive inquiry-based science learning activities?</td>
<td>- Interview (N=11) - Field observation - Students’ responses to mid-course evaluation</td>
</tr>
</tbody>
</table>

**Procedures**
As outlined in Figure 3.1, the instructor delivered two 75-minute classes per a week. Groups were created at the second week of the semester and the instructor explained the process and the goals of group works. Instructor asked students autonomously create groups with four to five members and was not involved in group composition: 75 groups were created. Beginning with unit 1, the instructor delivered lectures with PowerPoint slides and asked individual students to complete group assignments during the lecture. In every class, students responded to three to five of content knowledge related questions via Audience Responsive System (ARS). In each unit, groups completed one to two outside-class group assignments and submitted the assignments through the learning management website. At the end of each unit, students took a unit exam in two formats; individually (solo test) and with group members (group test). After individual students took the exam individually and submitted, group members gathered and took collaboratively the same test that they took individually. Practice tests were provided through learning management system prior to the unit exams.

During the semester, students completed one individual project and two anonymous online peer evaluations to document perceptions of group dynamics. Each group member was able to view the anonymous peer scores and comments. All activities and test scores were weighted to compute each student’s’ final course grade: solo test score 36%, project 12%, group works 28%, quizzes 12%, and group tests 12%.
Figure 3.1. *Overview and flow of semester-long course*

**Results and Discussion**

The quantitative and qualitative data were triangulated. For qualitative data, excerpts from interview transcriptions are presented with their pseudonyms. The brief profiles of interviewees including names, gender, achievement level, and perceptions about group works are described in Table 3.3.

*Research question 1. Which inquiry based activities influence student performance? Which activities influence content knowledge acquisition and higher-order thinking skills?*

Among seven inquiry based course activities, two (group test and project) were statistically significant predictors of higher performing students’ solo test scores (see, Table 3.4). However, no activities significantly influenced lower performers. Inquiry-based activities accounted for 18.4% of the variance (P < .001) among higher performers; for lower performing students, inquiry-based activities explained 17.7% of the variance.
### Table 3.3. Interviewee Profiles

<table>
<thead>
<tr>
<th>Pseudonyms</th>
<th>Achievement Levels</th>
<th>Gender (M/F)</th>
<th>Profiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daniel</td>
<td>Higher</td>
<td>M</td>
<td>Negative perspectives about having group works but had positive group functioning</td>
</tr>
<tr>
<td>Emma</td>
<td>Higher</td>
<td>F</td>
<td>Negative perceptions about group work and complained about being a sucker</td>
</tr>
<tr>
<td>Ethan</td>
<td>Higher</td>
<td>M</td>
<td>Skeptical about the effectiveness of inquiry-based activities/group works in the class</td>
</tr>
<tr>
<td>Henry</td>
<td>Higher</td>
<td>M</td>
<td>Positive perceptions about inquiry-based activities and understood goals of courses/group works</td>
</tr>
<tr>
<td>Luke</td>
<td>Higher</td>
<td>M</td>
<td>Positive perceptions about inquiry-based activities but skeptical about the effectiveness of group work</td>
</tr>
<tr>
<td>Olivia</td>
<td>Higher</td>
<td>F</td>
<td>Negative perceptions about inquiry-based activities and the course but had positive group interactions</td>
</tr>
<tr>
<td>Owen</td>
<td>Higher</td>
<td>M</td>
<td>Positive perceptions about group activities and willing to help lower achievers</td>
</tr>
<tr>
<td>Chloe</td>
<td>Lower</td>
<td>F</td>
<td>Positive perceptions about group works but had low self-confidence and passively participated</td>
</tr>
<tr>
<td>Jacob</td>
<td>Lower</td>
<td>M</td>
<td>Negative perceptions about group works and complained about being a sucker</td>
</tr>
<tr>
<td>Laura</td>
<td>Lower</td>
<td>F</td>
<td>Positive perceptions about group works and had positive interactions with group members</td>
</tr>
<tr>
<td>Ryan</td>
<td>Lower</td>
<td>M</td>
<td>Negative perceptions about inquiry-based activities and group works</td>
</tr>
</tbody>
</table>

### Table 3.4 Regression results for all independent variables

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solo test (ordinal)</td>
</tr>
<tr>
<td></td>
<td>Higher Performers</td>
</tr>
<tr>
<td></td>
<td>Lower Performers</td>
</tr>
<tr>
<td></td>
<td>18.4%, F (7, 295), P &lt; .001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Standardized Beta</th>
<th>P&lt;</th>
<th>Standardized Beta</th>
<th>P&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group tests</td>
<td>0.199</td>
<td>.000***</td>
<td>0.011</td>
<td>0.906</td>
</tr>
<tr>
<td>Project</td>
<td>0.202</td>
<td>.045*</td>
<td>0.013</td>
<td>0.896</td>
</tr>
</tbody>
</table>

* P < .05  
** P < .005  
*** P < .001
Similar to the regression analysis, qualitative evidence indicated few students acknowledged the value of inquiry-based activities. Three of seven higher performers reported positive perceptions about the activities but none of the poorer performers reported positive perceptions. Three higher performers characteristically identified why they engaged the activities; “in class she’d lecture about facts, like, ‘This is what happens in the cell’ and then the worksheets are more like ‘What about in real life? How does it apply there?’ and I think that’s really good because it helps us find applications for biology in reality.” [Henry]. They described how to learn: "this class is different from others I’ve taken because it’s a lot of memorization but then it’s a lot of like application and figuring out based on previous information.” [Luke].

However, 2/7 higher performers and 3/4 lower performers still questioned the value of the activities: “Sometimes we felt a little lost because …we didn’t fully understand the lectures and then we were given a sheet and told to think about it more and we were like, “We don’t understand the first part” [Emma], “I wish we’d actually relate to the test” [Henry]. Activities were described as irrelevant for learning and test performance. One of the lower performer, Laura said, “…it correlates with the lecture some ways but in other ways it’s kind of off topic...like those questions that we have to do or whatever we have formulate for the group assignment is not on the test.” As a group, five higher performers and three lower performers reported they completed activities to document their work rather than engaging in the inquiry. For instance, one in higher performer mentioned, “…it’s (inquiry-based activity) not that it affects your grades and cannot really find why it is related to what you’re learning right now and so that makes you like, “Okay, let’s move on” [Emma]. Laura, one of the lower performers but who expressed positive perceptions about her group work, mentioned, “We simply just wrote it (group work sheet) down and passed it on.”
Group tests, which included content knowledge and higher-order thinking items, documented collaborative test performance. However, only higher performers benefitted statistically from the group test scores (P < .001). Two higher performers described the group test as being as important as individual test, although they noting, “if you’re not going to do well on that even if you completely like rely on your group members, you’re still not going to do well in the class and so it would seem that you have some incentive to study to do well on those which would lead to doing well on the group tests...[Luke]” The second noted that higher performers contributed more to group performance than lower performers; “Group tests bring grades down [Emma].”

The course project, an individual activity which applied prior content knowledge to develop higher-order thinking, also predicted achievement among higher performers but not lower performers. Higher performers improved statistically by the course project (P < .05). Three interviews documented the benefits of inquiry-based activities; “...activities were more of an open ended question and we were just free to fill in the way that we thought that they differed and that they were similar. So, that helped. And I think it just gave us more of a chance...it wasn’t like question, answer, question, answer...it was more free and open.” [Ethan].

In contrast, lower performers did not benefit from the course project and not directly mentioned about the project. Interviews revealed negative perceptions about both inquiry-based activities and lack of understanding of the course objectives. Two interviewees stated that the course should focus on delivering basic concepts and not emphasize deep knowledge for non-majors. Ryan mentioned; ‘non-biology major course, this is obviously something that the students are not going to proceed down into further study so I guess what we want is to kind of get the most of the class that we can so that we have the basic concepts that the class is there it
teach”. Chloe mentioned that diverse activities did not help test performance; "I feel like...content wise I get it...but I don't get it and then it comes off like I don't get it on my tests."

**Research question 2: Which attributes differentiate achievement among of high v. low-achievers?**

To examine the extent to which these activities influenced achievement, an additional regression analyses identified four core inquiry based activities (two content knowledge oriented activities and two higher-order thinking related activities): two individually focused and two group-based.

Students involved in group-based as well as individual-based activities to acquire content knowledge and develop higher order thinking. The study took stepwise regression to see the extent to which group and individual based activities predicted higher and lower performing students’ content knowledge acquisition and higher-order thinking development by collaborative learning. Among diverse inquiry-based activities, two content knowledge acquisitions related activities (one individual-based and the other group-based) and two higher order thinking related activities (one individual-based and the other group-based) were set as predictors. In-class and outside class group work were group-based activities and project and in-class quizzes were individual-based activities. The results indicate that inquiry activities influenced students’ achievement differently. Higher performing students benefitted from both individual (in-class quizzes) and group-based activity (outside-class group work). However, lower performing students benefitted only from the individual activity (in-class quizzes) (see, Table 3.5). Higher performing students’ individual test scores were significantly influenced by the individual content activity (20.2% of correlation) and the group-based higher order thinking activity (19.9%
of correlation). In contrast, only one individual content knowledge-oriented activity (P < .05) but no higher-order or group-based activities predicted achievement (P < .005).

Table 3.5. *Regression results for significant variables*

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependent Variable</th>
<th>Higher Performers</th>
<th>Lower Performers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solo test</td>
<td>11.2%, F (4, 151), P &lt; .001</td>
<td>14.1 %, F (4, 138), P &lt; .001</td>
</tr>
<tr>
<td></td>
<td>Standardized Beta</td>
<td>P</td>
<td>Standardized Beta</td>
</tr>
<tr>
<td>1 In-class pop quizzes</td>
<td>0.202</td>
<td>0.001**</td>
<td>0.317</td>
</tr>
<tr>
<td>2 Outside-class group work</td>
<td>0.199</td>
<td>0.001**</td>
<td>0.117</td>
</tr>
</tbody>
</table>

* P < .05  
** P < .005

Several trends appeared to limit the benefits of group work. Higher performer interviewees tended to identify benefits of group work, noting that group work supports understanding by through discussions with group members (n=4); *(the reason why I like group work is because of) Discussion. That is the key I think because...you have to bounce ideas off of each other whether you’re right or wrong because if you’re wrong you’ll work together to make the right answer. If you’re right, you’ll get reaffirmation for it [Owen]*” One higher performer noted that group work benefits team members by challenging thoughts and thinking processes; *’if you’re here to participate as a group, as a whole unit together because that means four brains are now one brain. The thinking process must be taught to others and told to the others and then if the group member agrees then they’ll tell them and if they disagree, then they’ll tell them why they disagree, etc. They’ll give the reasons, they’ll give debates here and there...so that’s how people learn, you know? You give out your ideas and if you make a mistake, then you learn from it [Luke].* However, two complained about the limited contributions of their lower performance
group members and expressed unwillingness to help; “And so it’s like getting really frustrating and so...I’m starting to like to act like really irritating towards them, just like when they ask me a question about what happened and I’m like, “It’s on the slide” [Olivia].”

Lower performing students did not show any statistical influence from group-based activities. We found some supportive evidences from lower performing students’ interview. The interview data found that lower performers prefer non-collaborative learning and prefer just listening to group members’ discussion and only engaged in the activities that would be graded. Jacob and Chloe mentioned that they prefer listening rather participating in the discussion; "I probably like study differently and even when I did study with group like in high school, usually while they’re talking, I’m doing my own thing [Jacob], ‘I was in the conversation but not really. If I’d be thinking about what I was going to say and I’d forget about everything else...(so) I listen to the whole conversation and wait until the end [Chloe]. Ryan valued the group work but if it was not graded, he was not into the activity; ‘so I’m like...I didn’t really want to say anything because I was like, ‘I don’t know if we’re being graded on this [Ryan]. Furthermore, Chloe confessed that he needed helps from higher performers in their groups but could not; ‘...I don’t really understand but everybody else seems to understand more....because sometimes they say the word and I’m like, “What are you talking about?”

Outside-class group work was assigned to apply acquired knowledge to promote higher-order thinking and might require as much knowledge and higher order thinking strategies as unit tests. Based on student responses, outside-class activities appear to require additional time and efforts beyond the in-class group activities focused on content knowledge. Five students (four higher performers and one lower performer) complained that meeting outside of the class was almost impossible due to the schedule conflicts between group members; ‘somebody will decide
Tuesday, “Oh, I can’t do Tuesday between this hour and this hour because...” okay, so Wednesday...and we’ll decide on Wednesday and I think for this last example, a girl in my group, she’s an equestrian and so she had to take her horse to the doctor so we had to push that to Thursday. That’s the day before the test [Daniel]’. Eventually, groups tended to divide individual portions of the group assignment and submit without group discussion (n=7); ‘And so we just kind of split up those four paragraphs. And we just emailed the information to Ben and he submitted it. [Emma].’ Typically, higher performers contributed the majority of time and effort to the outside-class group work and benefitted from the outside-class activity; lower performers rarely engaged activity and perceived little value. Emma, an higher performer, shared his experiences, “we all don’t see the final document which is kind of worrying because you never know exactly what’s going on and I’m a bit of a control freak when it comes to like my work and what is submitted and so I’d like to see it but...I know I’m not going to be able to look at it, (so I just did it by myself) [Emma]’

**General Discussion and Implications**

The results indicated that higher and lower performing students benefitted differently from groups, and the benefits were mainly realized by higher performers. For higher performing students, two inquiry based activities positively influenced content knowledge acquisition and higher order thinking skills, although a few, higher performers also benefitted from individual and group-based activities. However, only individually- based, content knowledge activities influenced lower performer’s learning achievement. Challenges and barriers were noted during group oriented learning activities in particular.
**Lower performers failed to benefit from group work**

The results demonstrated unequal and potentially detrimental learning influence of group work among lower performing students. Theoretically, all students should benefit from group work by sharing knowledge and deepening understandings of course concepts: When higher performing students benefit from outside-class group work, for example, lower performing students should also benefit. However, results indicated that only higher performers benefitted from outside-class group work while lower performers failed to benefit. In addition, group test scores significantly predicted higher performers’ individual test scores but lower performers’ group test scores did not. Interview data showed higher performers typically devoted extra time and effort to group activities while lower performers reported limited active engagement in group work. Negative interactions frequently discouraged participation, resulted in negative effects (i.e., frustration) and reduced the quality of socially shared regulation (Johnson, 2007). These findings question the extent to which students benefit equitably from learning in small-group settings, especially when individual members are openly criticized or discouraged from participating by their collaborating peers.

Previous research indicated that composition may prove critical in mediating the effectiveness of group work for learners of different achievement levels. When lower achievers collaborated with more capable group members, they scored 50% higher on mathematics test scores than those with lower performers within homogeneous groups (Hooper & Hannafin, 1991). In effect, higher performers benefitted individually and as groups in heterogeneous study groups. In contrast, Jensen and Lawson (2011) explored the influence of group composition on scientific reasoning among high and low achieving students. In their study, lower achievers performed better in homogeneous groups than heterogeneous groups during inquiry-based
instruction. However, previous studies involved small enrollment classroom with fewer than 20 students per section. In the current large classroom study, collaborative learning activities benefitted higher performers but provided little benefit for lower performers.

The present study also indicated that lower performers lacked self-regulated learning skills which hampered collaborations. Similar to this finding, Haak, HilleRisLambers, Pitre, & Freeman (2011) found that lower performers improved their collaborative learning under highly structured course formats. They focused on increase retention in STEM field by minimizing the achievement gap between diverse learners in an introductory college STEM courses. The result showed structured instruction involving daily and weekly problem-solving practice, problem solving, data analysis improved higher-order cognitive skills and minimized the achievement gap separating high and low performers. Similarly, Ertmer, Newby, & MacDougall (1996) reported that low self-regulators demonstrated by ineffective cooperative problem-solving, case analyses, and strategies to support PBL demands.

Among poor self-regulators, technology might also have hampered learning. Use of technology may have added extraneous cognitive load among students with limited prior knowledge and metacognitive strategies. When exposed to unstructured technology-enhanced learning and diverse instruction, extraneous cognitive load likely increased (Van Merrienboer & Sweller, 2005). Similarly, medical education students with limited science knowledge reported difficulty understanding embedded science knowledge within PBL, while those who completed science prerequisite courses did not (Tedman, Alexander, Massa, & Moses, 2011). While technology has been widely adopted in large enrollment college courses, the effectiveness among underperforming students has not been conclusively demonstrated.
Further research is needed to document the effects of group activities on both individual and group performance. Peer tutoring, for example, may support diverse student learners (Topping & Ehly, 2001). When a group leader facilitated problem-based learning, all group members were more engaged in the problem solving process. Leaders pushed group members to think deeply which supported others students to establish individual learning agendas (Hmelo-Silver, Katic, Nagarajan, & Chernobilsky, 2007). Experts and experienced tutors focused on metacognitive support over content expertise which may explain why limited content knowledge among peer tutors yielded minimal student learning effects (Leary, Walker, Shelton, & Fitt, 2013).

*Higher and lower performing students were reluctant to collaborate with group members.*

The benefits of interdependence rely on dynamic rather than individual performance alone; improvements by any individual member or subgroup should benefit all members when investing in common goals (Lewin, 1948). Positive interdependence facilitates the development of new insights and discoveries and the more frequent use of higher level reasoning strategies (Gabbert, Johnson, & Johnson, 1986; Skon, Johnson, & Johnson, 1981) Challenging each other’s reasoning and conclusions should promote both decision making and creativity among the group (Lizzio & Wilson, 2006; Johnson, Johnson, & Smith, 2007). Flynn & Klein (2001) reported that college students who engage in collaborative case-based learning were more highly motivated and learned more effectively than those working independently.

However, our study indicated that students and groups failed to develop positive interdependence or promotive interactions. Consistent with previous research, social loafing occurred during the group work; negative interdependence resulted in oppositional interactions (Curşeu & Pluut, 2013; Johnson & Johnson, 2009; ). Three to four of higher performing
interviewees complained about being a sucker of the group work; one half of higher performers complained about being a sucker and expressed their unwillingness to help other group members. In addition, half of the including higher and lower performer interviewees indicated they were not acquainted with their group members though they met three times a week. One lower performer considered himself a sucker within his group as group members’ course expectations were very low.

According to advocates, fairness, motivation to compete, positive group work perceptions, and positive relationships among group member should enhance collaborative learning (Tjosvold, Johnson, Johnson, & Sun, 2003). Yet, previous studies also indicated that under competition situations, individuals demonstrated in self-worth protection, self-handicapping behaviors, and defensive pessimism (Johnson & Johnson, 1989). The current study confirmed this trend: lower performing students hesitated to ask questions citing concern over bothering others who seemingly understood course concepts. Overall, half of the lower performers were passively engaged in group discussions but rationalized passiveness as having different learning styles. Questionnaires may provide useful indicators of satisfaction with group work and depth of understanding to assess the extent to which group interdependence was evident. Interviews and observations provide opportunities to probe the group dynamic activities to triangulate with quantitative evidence. To examine equitability, we need to assess the extent to which scaffolds enhance individual performance of typical as well as underperforming students. Social loafing (Latane, Williams, & Harkins, 1979) or free riding (Kerr & Bruun, 1983) effects have been documented involving students with varied achievement and prior knowledge levels. Future research is needed on face-to-face group work using micro-level observation and video recording.
Guidance is essential to implement and optimize group collaborations.

Both higher and lower performers reported limited time for group work and lack of guidance to work effectively as a group. Higher performing interviewees cited indicated that the lack of time for in-class group works prevented them from engaging group activities. Roughly 30% of interviewees mentioned that they did not apply themselves during in-class group work once they learned that group work sheets were not graded. Learning environments need to promote effective group behaviors while discouraging maladaptive activities such as free-riding and social loafing (Kreijns, Kirschner, & Jochems, 2003).

What types of collaborative work enhances all students’ academic performance? Previous authors have suggested “how to” guidelines to promote effective collaboration while minimizing competition within groups (Johnson & Johnson, 1989; Johnson, Johnson, & Holubec, 1998) However, guidelines alone do not ensure effectiveness learning. Cooperation is unlikely when students work competitively or individualistically. Within groups, students need to work collaboratively to maximize individual as well as group learning (Johnson & Johnson, 1989). When factors that promote effective cooperation have been implemented within-group, group activities are more likely to promote become collaborative learning. However, instructors tend to have a very limited understanding of how to structure cooperative learning effectively and, therefore, they tend to resist training, believing it is unnecessary. To maximize student learning from group work, instructors should consider the optimal size of groups, a method for assigning students to groups, and which roles to assign to group members, and how to arrange the materials and classroom (Johnson, Johnson, & Holubec, 2008). Before assigning roles, for example, students need enough time to get used to each other. The roles should be rotated within group members by creating role interdependence.
Technology has been incorporated widely to facilitate independent and collaborative learning. Blended learning environments, for example, are designed to promote learning by developing the capacity for reflection. Students often report positive outcomes among courses that incorporate technology (Cooner, 2010; Huon, Spehar, Adam, & Rifkin, 2007). Different teaching and learning methods: a) enable students to acquire a deeper understanding of the subject; b) promote positive perceptions of the teaching received; c) clarifies goals and rules; d) provide students with a higher level of independence in the learning process (Ginns & Ellis, 2007). Students may suggest that extra resources or activities are external to the principal activity (the one to be evaluated), but note that they that assist in the construction of academic understanding (Orton-Johnson, 2009).

However, among students who lack self-regulated learning skills, use of technology may actually inhibit learning. Students with effective metacognitive strategies, and those who develop them during SRL, perform more successfully than those who do not. In the current study, the instructor allowed to use laptops and smartphones during the class. During interviews, both higher and lower performers mentioned self-regulation concerns when using laptops or smartphones during the class. College age students obtain and document evidence in portfolios and generate hypotheses to guide future inquiries. SRL functioned as expected only when students had adequate background knowledge, evaluated their knowledge limitations, critical questioned and clarified, and evaluated faulty explanations (Land & Zembal-Saul, 2003). Yet, others planned faulty experiments which yielded flawed evidence and subsequently misdirected future inquiries even when confronted with contradictory evidence. Smidt & Hegelheimer (2004), following interviews to identify adults Web-learning strategies, reported that only advanced learners deployed metacognitive strategies actively while middle- and low-performing students
relied on basic cognitive strategies. College freshman demonstrated poorer self-regulated and self-directed learning strategies and therefore needed scaffolding whereas seniors were more self-directed and self-regulated. For example, seniors pursued study-related activities beyond initial learning tasks (van Den Hurk, 2006).

Previous studies with large college courses tended to emphasize the use of technology per se rather than emphasize effects on students’ learning. Simply analyzing the frequency of online resource access fails to account for the influence of supplementary online resources. In the current study, the instructor integrated technologies in the class for in-class activities as well as outside group activities. However, during the interview, the study found that students’ usages of technologies were limited and the effects of using multiple technologies were questioned. For example, some groups used email communication as instructed, while others did not even though they were required to submit outside class group work in online.

When integrating technologies in large classroom settings, learning progress needs to be documented. In online learning environments, we need to determine when, where and how instructors are able to trigger positive interdependence to support all students’ academic performance? How, when and where does use of embedded interaction formats (e.g., discussion board, guided discussion threads, chats, group work) promote diverse underperforming students’ participation and academic performance in asynchronous online learning environments? The use of students’ postings and responses may be documented empirically using empirically validated scoring rubrics. Triangulating evidence from discussion boards, semi-structured students’ reflection journals and interviews should clarify their unique as well as collective impact on student performance. In order to gauge whether individuals improve their understanding from discussions, contents of the postings should be analyzed accordingly by using content analysis or
thematic analysis. According to Cohen & Lotan (1995), comparing the quantity and quality of online discussions may provide important indicators of knowledge construction. By analyzing both the frequency and quality of participation empirically, the relative value to individual group participants can be determined.

**Limitations**

Since the target interviewees of the current study were students, reactivity may cause and negatively affect the research result. Reactivity is the influence of the researcher on the setting or individuals studied (Maxwell, 2012, p.124). Student interviewees were wary about the possible influence of the interview to their final grade and lower performing students tended to hesitate sharing their learning experiences. The researcher began the interview with assuring the interviewees that the interview would not affect their grades in any ways and shared a consent form. Still, interviewees might not fully share their learning experiences in the interview.

Researcher bias may also influence the effects in the study. The selection of methods that align with the researcher’s theories, goals, and preconceptions, and the selection of learning outcome evidence may also influence findings as well as interpretations (Maxwell, 2013). Other researchers have focused on affective measures of satisfaction and expectations, which merit consideration. To minimize the potential influence of researcher bias, we triangulated multiple qualitative as well as quantitative data sources while focusing primarily on questions of the relative individual versus group learning benefits.

Our study was not restricted to controlled or laboratory conditions, but rather we explored both process and outcomes in an authentic, real world undergraduate science classroom environment. The results contributed to identifying barriers and challenges but did not test or validate solutions to address those challenges. Design-based research methods can be
implemented to optimize both the impact of possible solutions. Future research may be needed to address gaps between academic theory and impact and the durability of such practices for everyday applications.

**Conclusions**

Although groups have been implemented widely in college level education, few studies have documented strategies that enhance the effectiveness of group work. Effective group work needs to support all participants’ thinking skills and knowledge acquisition. However, our study revealed that lower performers rarely benefitted from group work and only a few higher performers benefitted. Group work was implemented but its effectiveness among students of different achievement levels remains to be verified.

Ineffective group work is likely the product of insufficient instructor support, widely varied prior knowledge within groups, lack of student preparation or willingness to engage group work strategies, or deficient individual learning strategies (Armstrong, Chang, & Brickman, 2007; Christopher, Thomas, & Tallent-Runnels, 2004). Still, it is unclear which factors contribute to ineffectiveness among learners of diverse achievement levels. Authors have provided guidelines to facilitate effective group work, but such guidelines have rarely been validated in the college classrooms.

Research is needed to identify circumstances and methods where group work benefits performance across achievement levels, as well as how to improve college learners’ achievement. The extent to which the logistics associated with the learning impact of group work within large-enrollment courses also requires further study. These methods and mechanisms entail cognitively complex tasks that are commonly implemented in social activities such as discussion, negotiation, and consensus building. The extent to which learner variables, instructor
variables and context variables encourage or discourage individual as well as group learning needs to be scrutinized.

References


CHAPTER 4

SCAFFOLDING COLLABORATIVE WORK IN A LARGE-ENROLLEMENT CLASSROOM

FOR UNDERPERFORMING COLLEGE STUDENTS

3 Chang, Y. and Hannafin M. To be submitted to Journal of Learning Sciences.
Abstract

Group work has been widely used to support participation in both small and large enrollment college classroom. However, group work sometimes inadvertently encourages rote learning and reifies misconceptions among students with limited background knowledge and experience. This study examines how individual and group inquiry-based activities influence achievement among academically diverse students. We employed a mixed methods study involving 245 undergraduate, non-science majors enrolled in a required large-enrollment college Biology course. The study mainly examined circumstances and methods where group work benefits performance across achievement levels. The results indicated that lower performing groups were more likely to benefit when they included higher performers and/or received additional instructor guidance. In addition, although some lower performing groups exhibited positive interdependence and promotive interaction, these attributes were not consistently associated with improved learning.
Introduction

Developing higher-order thinking skills, such as critical thinking skills, problem solving skills, and scientific reasoning skills, are indicated as the foci of college-level teaching and learning (National Research Council, 2003). Since the fields of science, technology, engineering, and mathematics (STEM) are recognized as good domains for developing these abilities (NRC, 2003), most universities offer STEM courses as mandatory courses at the undergraduate level (Hartfield, 2010). National Science Council (2003) indicated the necessity of developing a broad set of skills to approach scientific phenomena quantitatively, as well as abilities to apply basic quantitative concepts in their daily lives (Kutner et al., 2007). Large-enrollment introductory biology courses large (e.g. over 100), for example, are provided in the undergraduate level to enhance undergraduate students’ abilities to use scientific knowledge in their everyday lives.

In a large-classroom setting, didactic instructional methods have been widely used to present requisite knowledge and skills. Yet, several limitations with such methods have been documented, especially for large class sizes (e.g. over 100). Deutsch (1949) reported that college individuals in cooperative groups were more secure than college individuals in competitive groups. Haines and McKeachie (1967) found that college individuals in a competitively structured discussion were more anxious, were less self-assured, and showed more incidences of self-oriented needs; college individuals in a cooperatively structured discussion were described as less tense and more task-oriented. It proves difficult and time-consuming to manage combinations of lecturer input and discussion, and to provide feedback on individual student learning and to ensure that all students are actively engaged. The diverse learning needs and preferences of different students need to be accommodated, but solutions for large enrollment courses have proven elusive.
Multiple studies document the need for instructional support to encourage students to develop higher level thinking skills, since current college students are deficient in independently optimizing their learning (Hadwin & Winne, 2001). Moreover, some college students have difficulty continuing learning due to a lack of learning abilities and insufficient support from instructors (Desruisseaux, 1998). For this reason, without proper support, students tend to focus on what an instructor wants to hear or how to get a good grade rather than developing their thinking skills.

However, students often fail to evolve personal theories or explanations, often retaining initial misconceptions (De Jong & Van Joolingen, 1998; Gyllenhaal & Perry, 1998; Hannafin & Land, 1997; Nicaise & Crane, 1999); For example, students have failed to engage in reflective thinking and metacognition during inquiry (Atkins & Blissett, 1993; Hill & Hannafin, 1997; Wallace & Kupperman, 1997); they have also failed to develop coherent explanations and produce primitive, often superficial artifacts devoid of related evidence (Land & Greene, 2000; Nicaise & Crane, 1999).

Peer collaborations have been widely used as an effective way of supporting students’ necessary thinking in both small and large enrollment classroom (Johnson & Johnson, 2009). Collaborations involving peer-discussion and peer-assessment have supported students’ understanding of requisite knowledge and skills and in large enrollment courses (Derry, Levin, Osana, Jones, & Peterson, 2000; Jensen & Lawson, 2011; Johnson & Johnson, 1998; Nicol & Boyle, 2003). Learners acquire both new information as well as new ways of thinking through peer interactions (D. W. Johnson & Johnson, 1989; Piaget, 1970; Vygotsky, 1978).
Typically, students are introduced to new ways of reasoning and patterns of thought as they engage in dialogs with more competent others. Collaborative learning involves students working in small groups (3 to 4 members) to accomplish shared goals. Essentially the relationships become symmetrical, so no single member dominates and all contribute to and assist group members. Eventually, after repeated exposure to these experiences, a learner’s thinking and communication processes become internalized as part of his or her repertoire of cognitive skills (Johnson & Johnson, 1989; Pigaet, 1970). Learning supports (scaffolding) enable them to complete tasks that they could not do alone (Vygotsky, 1978).

Whereas many instructors allege to employ peer-mediated learning strategies, some confess they rarely adhere to these procedures (Hmelo-Silver, Chinn, O’Donnell, & Chan, 2013; Johnson & Johnson, 2009). This has proven especially detrimental for underperforming students, many of whom require consistent, structured experiences to internalize strategies. However, simply grouping students does not ensure mutual collaboration and co-regulation (Johnson, 1998). Rather, effective approaches intentionally promote and support effective group behaviors and discourage detrimental, maladaptive activities such as free-riding and social loafing (Kreijns, Kirschner, & Jochems, 2003). Well-designed and implemented supports (scaffolds) enable them to engage tasks that they could not do alone (Vygotsky, 1978).

College students, especially underperforming students, typically have a limited understanding of (or skill in) collaborative learning; therefore, they resist training, believing it is unnecessary (Armstrong, Chang, & Brickman, 2007; Choi, Land, & Turgeon, 2005; Eiselen & Geyser, 2003; D. Johnson, 2007). Higher performers, in contrast, tend to perceive collaborative activities with underperformers as a burden to their own learning (Armstrong, Chang, & Brickman, 2007; Johnson & Johnson, 1989). Both underperformers and higher performers,
therefore, need sophisticated, structured support to enact collaborative activities to promote positive interdependence, individual accountability, promotive interaction, the appropriate use of social skills, and group processing (Johnson & Johnson, 2009).

Scientific literacy for all is a core goal for science educators as part of general education requirements for undergraduates (Meinwald & Hildebrand, 2010). Learning scientists have proposed ideal approaches for students to learn by engaging science as professional scientists do. In a recent survey, 150+ life sciences faculty members from a variety of institutions identified problem solving/critical thinking, oral and written communication, and the ability to interpret data as critical skills students need to develop (Coil, Wenderoth, Cunningham, & Dirks, 2010). Science classes adapted inquiry based learning by using peer-collaborative work to encourage students to challenge current views of knowledge through in-depth interactions with others. However, ineffective peer-collaborative work among underperformers tends to reify misconceptions and rarely stimulates higher-order thinking level. One possible explanation for students’ shallow participation in online discussions is lack of guidance from the instructor (Johnson & Johnson, 2007). It has been argued that instructors must assume responsibility for organizing and scaffolding students’ learning during online as well as classroom discussions (Christopher, Thomas, & Tallent-Runnels, 2004).

**Statement of the Problem**

Peer-discussion has been used as a way of encouraging students to have cognitive conflicts, revise, and synthesize their current views of knowledge through in-depth interactions with others (Garrison, Anderson, & Archer, 2001). However, findings from numerous studies of peer discussion (online as well as face-to-face) forums have indicated that students’ interactions are often quite shallow, and “rarely developed into a higher level of communication where
negotiation, co-construction, and agreement occurred” (Tallent-Runnels et al., 2006, p. 100). Students have failed to substantially evolve theories or explanations, often retaining initial misconceptions (de Jong & Van Joolingen, 1998; Gyllenhaal & Perry, 1998; Land & Hannafin, 1997; Nicaise & Crane, 1999); Students have failed to engage in reflective thinking and metacognition during inquiry (Atkins & Blissett, 1992; Hill & Hannafin, 1997; Wallace & Kupperman, 1997); Students have failed to develop coherent explanations, as evidenced by superficial artifacts devoid of supporting evidence (Land & Greene, 2000; Nicaise & Crane, 1999; Oliver, 1999).

One possible explanation for students’ shallow participation and undesirable learning performance in peer discussions is lack of guidance from the instructor. Thus, as Christopher, Thomas, and Tallent-Runnels (2004) have argued, instructors must take greater responsibility for organizing and scaffolding their students’ learning within these peer discussions. Still, the extent to which peer collaborative work can be used by instructors and how it influences the nature of student’s collaborative knowledge construction and scientific thinking skills has not been fully explored.

The extent to which peer-collaborative work can be incorporated by instructors within large-enrollment courses requires further study. Specifically, the influences of collaboration on student’s (underperformers as well as higher performers) collaborative knowledge and reasoning require scrutiny. These processes entail tasks that are cognitively complex and are often implemented in social activity such as discussion, negotiation, and consensus building. This study examined a scaffolding framework to support two key processes: acquisition of content knowledge and ability to analyze the new information for scientific inquiry synthesized from current descriptions of scientific reasoning and related to the models of scaffolding. The purpose
of the study is to examine the influence of scaffolding peer collaborative support on underperforming Biology students’ content knowledge and scientific literacy (see Figure 4.1).

![Scaffolding Diagram]

**Figure 4.1. Hypothesis of the research**

**Research Questions**

Two research questions will be addressed:

*Does instructional scaffolding with group-based activities influence college students’ content knowledge acquisition?* This question aims to identify the influence of guided group-based activities on underperforming students’ knowledge acquisition.

a. Which guided group-based activities influence content-knowledge acquisition among lower v. higher achievers?

b. To what extent is content knowledge acquisition among lower achievers predicted by scaffolded group-based activities?

c. How do students perceive the value and effectiveness of scaffolded group-based activities?

*Does instructional scaffolding with group-based activities influence the ability to analyze and evaluate evidence of claim improve underperforming college students’ scientific literacy?* This question explores the influence of guided collaborative work on underperforming students’
scientific literacy skills, especially the ability to analyze and evaluate the acquired knowledge and new information. Misinterpreting evidence, sources, and knowledge leads inaccurate argument and eventually, create misconception. Prior researchers report that appropriately phased scaffolding improved scientific literacy skills, reasoning skills, and self-regulated learning skills.

a. Which group-based activities influence abilities to analyze and evaluate evidence of claims?
b. To what extent are abilities to analyze and evaluate evidence of claims predicted by scaffolding group-based activities?
c. How do students perceive scaffolding with group-based learning activities?

**Methods**

The design-based research methodology was informed by two years prior observations and interviews with both faculty and students. Design research is often situated within a domain and in many cases uses the structure of the domain as a theoretical guide (Cobb et al., 2003). The ongoing study was conducted in situ to monitor the failure or success of group work in a biology classroom to identify and support emergent needs. Figure 2 illustrates the progression from preliminary studies to the current research. Preliminary studies yielded design improvements in the pilot study to focus on group learning among diverse instructional activities in large-enrollement classrooms. Ten interviewees indicated group learning as a prominent challenge in the large-enrollement classroom.
Following a year of preliminary study, the pilot study was conducted in Fall, 2013 which was conducted in the same course with the same instructor. During the pilot study, 303 students’ learning performance along with interviews from eleven volunteer students were collected and analyzed to refine the current research design. Since the pilot study result revealed that group learning only benefitted a few of higher achievers’ learning, the current study designed scaffolding group works for both higher and lower achievers’ learning improvement.

Instructors used learning management system and Clickers as instructional supportive tools. Structured PowerPoint slides with clear objectives of the class, diagrams, multimedia examples, and summary were uploaded in the system before the class began. In the second week, students created groups autonomously at the second week of the semester, and the instructor explained the process of the group work. In every class, the instructor asked individual students to respond to the content knowledge related questions via Top Hat Monocle (THM). Then, guided peer-discussion guide was provided with the group dynamic building activity (see Appendix A). With the group dynamics building, students collaborated with some content related

---

**Figure 4.2. Procedure of the study**

- **Preliminary Study** (Fall 2012-Spr 2013) - Observation • Interview (N=10)
- **Pilot Study** (Fall 2013) - Observation • Interview (N=11) • Regression
- **Current Study** (Spring 2014) - Observation & Open-ended responses • Interview (N=15) • MANOVA
activities with the group; drawing a diagram, share the ideas, and submit the group answer. Students submitted group work sheet and after the discussion via eLeC (E-Learning Commons).

Based on students’ individual final grade, student who were ranked in upper 33% were categorized as higher performers while the lower 33% were categorized as lower performers. At the end of the semester, seven higher achievers and eight lower achievers participated in individual interviews. By triangulating qualitative and quantitative data, instructional scaffolding with guided group-based activities were refined for the current study.

**Current Methodology**

During Spring 2014, the current studies were conducted in large-enrollment introductory biology courses including 200-300 non-science majors; 15 interviewees participated voluntarily. From the preliminary interview, perceptions of non-science major students’ learning science were explored; learning goals, challenges, learning strategies, study routines, perceptions of instructors’ guidance, group-collaborative work, and writing assignment.

We employed concurrent triangulation in a mixed methods design (Creswell, 2009). Since the process and learning outcomes are important in collaborative learning, mixed methods draw from qualitative and quantitative paradigms to address the methodological challenges. We examined both the breadth and depth of learning by integrating divergent findings from qualitative and quantitative methods (Teddlie & Tashakkori, 2003). Both qualitative and quantitative data were collected concurrently and analyzed independently. Quantitative analyses included student contributions and learning achievement in content knowledge acquisition and higher order thinking development. Qualitative evidence provided insights into how learning occurred in the specific large-enrollment college context. To explore the influence and
challenges associated with inquiry-based learning activities, results from the qualitative data and quantitative data were compared and contrasted.

**Current Research Context**

*Participants.* A total of 245 non-science major college students enrolled in an introductory biology course at a large public university in the southeastern United States participated in the study. Most students were freshman and were divided into small groups for group work: 65 (3-4 members per group) small groups were created. The instructor uploaded open-source textbook, relevant multimedia materials on the learning management site (LMS). Students accessed LMS to view the course materials and grades, and to submit outside-class group work and their projects. During class meetings, students either used a smartphone or a laptop to respond to quizzes and download lecture slides.

*Inquiry-based activities.* Inquiry-based learning activities focused on improving scientific literacy. The activities focused on acquiring content knowledge for scientific inquiry referred as content-knowledge oriented activities. In-class pop quizzes and group work focused on content knowledge. Project and outside-class group work activities focused on developing and applying higher order thinking skills (i.e., analyzing, evaluating, or arguing). The course was divided into five units (modules) with each unit delivered over 3-4 weeks. Each unit outcome was evaluated using both individual and group assignments as well as solo and group test performance.

*Group-based activities.* Group-based activities included in-class group work, outside-class group assignments, group test, and peer-evaluations for group work. In-class group work enhanced understanding of content knowledge covered during lectures. Groups completed collaborative worksheets to enhance understanding about the topic of the day and each member earned the same scores. Worksheets included activities such as structuring or summarizing
content knowledge (i.e., drawing a diagram of the acquired knowledge, finding relevant resources from the website). Outside-class group work assignments required applying and synthesizing unit knowledge. Real-life related situations were provided for group members to discuss and report their interpretations. For example, in alcohol metabolism unit, college students’ story after drinking alcohol was provided as a case. Students were asked to analyze why some students’ had glowing and to explain how enzyme impacts the occurrence. All group members earned the same scores from outside-class group assignments. To support group activities further, students evaluated each member’s performance anonymously via an online recording system to assess each individual’s perceptions of the group’s dynamics. The peer-evaluation score was applied to individual student’s final grade to encourage individual students’ equal contribution to the group work.

**Individually-based activities.** Individual support activities included formative quizzes, practice tests, and a project. Students responded individually using an Audience Response System (ARS) during quizzes. The in-class quizzes were designed to provide formative feedback for content knowledge acquisition during the lecture. The items included simple multiple-choice questions of content covered during the lecture; and served as each individual’s final grade. Throughout the semester, individual students also completed one project which involved applying course concepts to personal decisions whether to have personal DNA analysis. Project scores were aggregated to the individual’s final grade. In addition, individuals took practice tests via the course website before unit tests. The practice test questions paralleled the multiple choices questions on the unit test but not aggregated to the final scores. The practice test provided individual students with formative feedback prior to the unit test.
Test. Upon completing each unit, students were assessed using both the individual test (solo test) as well also group test. Unit exam questions required both content knowledge and higher-order thinking. After submitting individual unit test responses, group members gathered and collaboratively discussed response options for each item which provided immediate feedback regarding collaborative performance. Group test scores were added to solo test scores to determine each individual’s final course grade.

Peer Evaluations During the semester, students completed anonymous online peer evaluations on three occasions to document perceived group dynamics. Each group member viewed anonymous peer scores and comments after all members submitted their responses. As shown in Appendix C, peer evaluations included eight multiple-choice questions and one open-ended question. Multiple-choice questions were included to evaluate individual group member’s preparation, participation, collaboration, attitude, and performance during group work. Using open-ended question, students provided feedback comment to fellow group members.

Anonymous Mid-course Evaluation After completing the first half of the semester, students completed a mid-course evaluation, developed by the university level teaching support organization. The mid-course evaluation expert of the organization visited the classroom and conducted a mid-course evaluation per the course instructor’s request to assess students’ needs and preferences. The mid-course evaluation included three open-ended questions (What aspects of the class do you believe should be changed; What aspects of class are working well (what aspects of the class are having a positive impact on our learning); What aspects of the class are working poorly (what aspects of the class are having a negative impact on your learning). Student responses related to peer collaborative learning were of particular relevance to the current research.
**Fostering Positive Interdependence: group-dynamics.** Throughout the semester, each group was provided opportunities to strengthen group dynamics (see, Appendix A). Students collaborated during a group assignment and a group-test. Group members were assigned to different roles in a group; 1) discussion peer facilitator, 2) note-taker; 3) reporter; or 4) planner. Each student rotated across roles during the study. The Discussion peer-facilitator provided metacognitive scaffolding during discussions; Reporters submitted group work sheets; Note-takers summarized discussion; Planners asked questions during the discussion. Role assignments balanced participation of each group member (Johnson & Johnson, 1998).

**Scaffolds**

In order to examine the influence of scaffolding, we incorporated procedural, conceptual, strategic, and metacognitive scaffolding to guide peer-collaborative learning. Each scaffold support was designed to address issues among underperforming students in science courses (see Table 4.1).

**Table 4.1. Scientific thinking process, problems, and scaffolds**

<table>
<thead>
<tr>
<th>Process</th>
<th>Abilities</th>
<th>Problems</th>
<th>Scaffolds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquire Content Knowledge</td>
<td>Structure knowledge</td>
<td>• Inaccurately structure and misinterpret the content</td>
<td>• Conceptual scaffolds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Metacognitive scaffolds</td>
</tr>
</tbody>
</table>
| Scientific Literacy           | Evidence: analyze and evaluate evidences | • Misinterpret information  
|                               |                             | • Referencing incomplete/inaccurate/unreliable information  
|                               |                             | • Use of inaccurate prior knowledge                                                           | • Metacognitive Scaffolds  
|                               |                             |                                                                                           | • Procedural Scaffolds  
|                               |                             |                                                                                           | • Strategic Scaffolds |

**Metacognitive Scaffolding.** Instructors provided prompts to assist in planning, monitoring and reflecting on each individual’s learning using online self-checklist. The checklist provided students to check learning resources, assignments, and evaluation schedules. In
addition, students were able to reflect their own learning strategies by monitoring others’ study strategies via online discussion board (see Table 4.2).

During peer-collaborative work, instructors prompted groups to initially create and to subsequently revise a shared contract during the semester. Prior to creating and revising group contracts, the instructor presented documented evidence to support the effectiveness of the group collaborative learning by PowerPoint slides. Group members set ground rules (e.g., penalties when group members break the rules), goals, and contact information. Instructors provided group planning work sheets to monitor group processes; to summarize and categorize discussion topics, and to record discussion outcomes. Instructors also encouraged groups to exchange and monitor Procedural Scaffolding. Procedural scaffolding was designed to reduce cognitive load by providing step-by-step directions related to important aspects of the task. For individuals, instructors provided online checklists for each unit so students can track their learning process. The checklist includes categories such as reading resources, quizzes, assignments, and peer-evaluations. Students were able to access to the learning resources, assignments submission dropbox, and online evaluation through the checklist.

Structured collaborative worksheets asked groups to construct step-by-step process to document their scientific “claims and warrants.” To support equal contribution to the group projects, students had to complete the individual portion of group work and submit in the online dropbox prior to the group discussions.

Strategic Scaffolding. Recommended study guides and strategies were introduced by the instructor with learning objectives of each unit. For assignments and projects, the instructor provided examples of expected outcomes and/or rubrics. An online discussion board was created to share and reflect study strategies. Students, who achieved upper 80% of scores from the
previous unit, were allowed to post their study strategies or summary notes with attached documents in the online discussion board. Every student could read the posted study strategies.

During group-discussions, instructors prompted groups to analyze evidence by (1) sharing each group member’s evidence, (2) comparing and contrasting similarities and differences between group members’ answers, (3) selecting one best answer, (4) evaluating the answer by posing competing perspectives on the evidence. During discussions, peers shared perspectives, ideas, suggestions, and feedback.

In addition, group members assessed group members’ performance via anonymous online peer evaluation. Students responded to multiple choices and open-ended questions in regards to each group member’s performance during the group work. Each group member could view group members’ feedback on his/her performance during the group work. Peer evaluation conducted three times in a semester. To further enhance group interactions, the instructor offered two 10-minute lectures to introduce effective and enhance group collaborative learning.

*Conceptual Scaffolding.* To support conceptual scaffolding, instructors summarized lectures prior to and following PowerPoint slides. To support peer-collaborative work, instructors assigned each group to develop share conceptual understanding among group members. Each group created a shared conceptual map or diagram by reorganizing and refining individual understanding.
Table 4.2. Examples of Instructional Scaffolding

<table>
<thead>
<tr>
<th></th>
<th>Instructional Scaffolding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Procedural</strong></td>
<td></td>
</tr>
<tr>
<td>Class-wide</td>
<td>Provide online checklist per module</td>
</tr>
<tr>
<td></td>
<td>Provide an online board to share study strategies per unit</td>
</tr>
<tr>
<td></td>
<td>Provide multiple-choices questions before and during the class, online study strategy board</td>
</tr>
<tr>
<td></td>
<td>Provide PowerPoint slides before and after lectures</td>
</tr>
<tr>
<td>Peer-</td>
<td>- Provide four step-by-step group work sheets to learn how to analyze and evaluate evidence</td>
</tr>
<tr>
<td>collaborative</td>
<td>- Encourage positive interdependence</td>
</tr>
<tr>
<td>Work Sheets</td>
<td>- Rotating roles during group works</td>
</tr>
<tr>
<td></td>
<td>- Anonymous peer evaluation</td>
</tr>
<tr>
<td></td>
<td>- Group Contract: Plan the group work; set the grounded rules, group names, and goals.</td>
</tr>
<tr>
<td></td>
<td>- Two 10 minute-lectures about the effectiveness of the group learning</td>
</tr>
<tr>
<td></td>
<td>Group work sheet includes questions to organize/summarize the concepts</td>
</tr>
<tr>
<td></td>
<td>Learn and share the scientific thinking skills; (1) structure content knowledge, (2) analyze &amp; evaluate evidence</td>
</tr>
<tr>
<td></td>
<td>Monitor the group work processes; (1) scientific literacy related group work progress, (2) positive interdependence related progress.</td>
</tr>
<tr>
<td>Category</td>
<td>Activities</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Group-based activities</td>
<td>In-class group work</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outside-class group work</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group unit test</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peer-evaluation</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual-based activities</td>
<td>In-class pop quizzes</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Practice test</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solo unit test</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3. Names, foci, process, and outcome of group-based activities and individual based activities
Measures

Quantitative Measures.

Two dependent measures were examined: solo test scores and group test scores. Individual unit and group test scores were completed on the same day. Based on final course grades, students were divided into three categories: higher, mid, and lower achievers. Groups were categorized into two based on group performances: higher performing groups and lower performing groups.

Qualitative Measures.

Interview data, field observation notes, and open-ended responses to anonymous course mid-evaluation and anonymous peer evaluations were used as complimentary data for quantitative data. To analyze scaffolding dynamics, we conducted in-depth interviews at the end of the semester, including what and how the interviewee thinks and behaves in a short period of time (Esterberg, 2002). In-depth interview questions were used to document participant’s thoughts and barriers during peer-collaborative work as well as the effectiveness of scaffolding (see, appendix D for Interview Protocol). We recruited student volunteers three weeks before the end of the semester. Student responses to anonymous mid-course evaluations and peer evaluations were also analyzed to complement interview data. Observation was conducted for 25 times and field notes were recorded during classroom observations to document instruction and group work, interactions between and among students and instructor, group members and individual dynamics.
**Table 4.4. Measures per Research Questions**

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Measures</th>
<th>Triangulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Does instructional scaffolding with group-based activities influence college students’ content knowledge acquisition?</em></td>
<td>Which guided group-based activities influence content knowledge acquisition among lower v. higher achievers? To what extent is content knowledge acquisition among lower achievers predicted by scaffolded group-based activities?</td>
<td>MANOVA</td>
</tr>
<tr>
<td></td>
<td>Content knowledge acquisition activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- in-class groupwork</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- in-class pop quizzes</td>
<td></td>
</tr>
<tr>
<td><strong>How do students perceive the value and effectiveness of scaffolded group-based activities?</strong></td>
<td>- Interview (N=15)</td>
<td>Thematic analysis</td>
</tr>
<tr>
<td></td>
<td>- Field observation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Students’ responses to mid-course evaluation and peer evaluation</td>
<td></td>
</tr>
<tr>
<td><strong>Does instructional scaffolding with group-based activities influence the ability to analyze and evaluate evidence of claim improve underperforming college students’ scientific literacy?</strong></td>
<td>Which group-based activities influence abilities to analyze and evaluate evidence of claims? To what extent are abilities to analyze and evaluate evidence of claims predicted by scaffolding group-based activities?</td>
<td>MANOVA</td>
</tr>
<tr>
<td></td>
<td>Higher order thinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- in-class groupwork</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- in-class pop quizzes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- outside class groupwork</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- individual project</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- solo test scores</td>
<td></td>
</tr>
<tr>
<td><strong>How do students perceive scaffolding with group-based learning activities?</strong></td>
<td>- Interview (N=15)</td>
<td>Thematic analysis</td>
</tr>
<tr>
<td></td>
<td>- Field observation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Students’ responses to mid-course evaluation and peer evaluation</td>
<td></td>
</tr>
</tbody>
</table>
**Data Analysis**

*Quantitative analysis.* The initial performance analysis involved two-way multivariate analysis of variance (MANOVA) to identify scaffolding’s influence on both higher and lower learner student performance levels. To minimize error variances, students ranked in upper 33% were categorized as higher performers (n=82) and the lower 33% were categorized as lower performers (n=84) based on the final course grades. Following MANOVA, stepwise regression was conducted to identify group-based activities on learning performance. Since each exam assessed unit topics, individual test scores were rank-ordered and averaged. Likewise, group measures (group test scores and group assignment scores) were rank-ordered and averaged to classify higher- and lower performing groups. Groups ranked in > 50% were classified as higher groups (n=32) while < 50% were categorized as lower groups (n=33).

*Qualitative analysis.* We purposefully selected 15 interviewees from among 27 volunteers to examine the group dynamics: seven higher performers and eight lower performers. Among the higher performers, five were from higher performing groups and two were from lower performing groups; three lower performers were included from higher performing groups and five were drawn from lower performing groups. Prior to the interviews, interviewees consented to the purpose of the interview, length of the interview, and confidentiality of responses. Pseudonyms were used to conceal identities. Interviews were recorded and transcribed.

Interview questions elicited the individual’s thoughts, preferences, and barriers during the semester. To assure diverse experiences, qualitative data were recorded verbatim, transcribed and coded using a memoing process through multiple transcript readings. We then employed thematic analysis of science learning experiences and to examine the influence of scaffolding...
with peer-collaborative learning. We generated initial codes to search for themes and defined and named themes (Braun & Clarke, 2006).

ATLAS.ti 7.1 software was employed to analyze multiple data.

**Triangulation.** Results from MANOVA analysis were triangulated with interview data, field notes, and open-ended responses from anonymous online peer evaluations and mid-course evaluations. The purpose of the triangulation is to corroborate whether scaffolding group-based activities affected higher vs. lower performers’ learning achievement. Students’ experiences shared through multiple data sources were used to interpret the quantitative data results.

Measures per research questions are summarized in Table 4.4.

**Procedures**

As outlined in Figure 4.3, the instructor delivered two 75-minute classes per a week. Groups were created during the second week of the semester as the instructor explained the process and the goals of group works. The instructor told students autonomously create groups of 4-5 members but did not determine group composition: a total of 65 groups were created. Beginning with unit 1, the instructor delivered lectures with PowerPoint slides and asked individual students to complete group assignments during the lecture.

During every class session, students responded to 3-5 content knowledge related questions via Audience Responsive System (ARS). In addition, each group completed 1-2 outside-class group assignments and submitted the assignments through the learning management website. At the end of each unit, students took a unit exam in two formats; individually (solo test) and with group members (group test). After individual students took the exam individually and submitted, group members gathered and took collaboratively the same test
that they took individually. Practice tests were provided through learning management system prior to the unit exams.

Throughout the semester, students completed one individual project and three anonymous online peer evaluations to document perceptions of group dynamics. Each group member was able to view all anonymous peer scores and comments. All activities and test scores were weighted to compute each student’s’ final course grade: solo test score 36%, project 12%, group works 28%, quizzes 12%, and group tests 12%.

Figure 4. 3 Overview and flow of semester-long course
Results and Discussion

Quantitative Evidence

<table>
<thead>
<tr>
<th>Group Performance level</th>
<th>Higher Performing Group</th>
<th>Lower Performing Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Performance level</td>
<td>Higher Achievers</td>
<td>Lower Achievers</td>
</tr>
<tr>
<td>Higher performers</td>
<td>Mean</td>
<td>Std. Deviation</td>
</tr>
<tr>
<td>Solo Tests</td>
<td>Higher Achievers</td>
<td>84.81</td>
</tr>
<tr>
<td>Lower Achievers</td>
<td>64.32</td>
<td>6.41</td>
</tr>
<tr>
<td>Total</td>
<td>81.16</td>
<td>9.37</td>
</tr>
<tr>
<td>Lower Performing Group</td>
<td>Higher Achievers</td>
<td>87.88</td>
</tr>
<tr>
<td>Lower Achievers</td>
<td>66.36</td>
<td>13.79</td>
</tr>
<tr>
<td>Total</td>
<td>71.45</td>
<td>15.22</td>
</tr>
<tr>
<td>Group Tests</td>
<td>Higher Achievers</td>
<td>94.64</td>
</tr>
<tr>
<td>Lower Achievers</td>
<td>87.50</td>
<td>4.44</td>
</tr>
<tr>
<td>Total</td>
<td>93.37</td>
<td>4.60</td>
</tr>
<tr>
<td>Lower Performing Group</td>
<td>Higher Achievers</td>
<td>95.51</td>
</tr>
<tr>
<td>Lower Achievers</td>
<td>85.86</td>
<td>7.81</td>
</tr>
<tr>
<td>Total</td>
<td>88.14</td>
<td>8.08</td>
</tr>
<tr>
<td>Total</td>
<td>Higher Achievers</td>
<td>94.87</td>
</tr>
<tr>
<td>Lower Achievers</td>
<td>86.11</td>
<td>7.39</td>
</tr>
<tr>
<td>Total</td>
<td>90.44</td>
<td>7.24</td>
</tr>
</tbody>
</table>

Table 4.5. Descriptive Statistics, Mean score, standard deviation of higher and lower achievers by overall group performance. N presents number of students included in higher and lower performing groups

Both higher and lower achievers received the effect of scaffolded group-based activities on their individual and group learning. As shown in Table 4.6, a significant scaffolding effect was evident for solo tests during group-based activities, $V=0.63$, $F(2, 161) = 67.8$, $p < .01$. However, there was no significant scaffolding effect on group tests scores, $V=.015$, $F(2,161) = 1.2$, $p < .01$. 
Table 4. 6. Multivariate Tests results of solo and group tests scores

<table>
<thead>
<tr>
<th>Effect</th>
<th>Multivariate Testsa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
</tr>
<tr>
<td>Solo Tests</td>
<td>Pillai’s Trace</td>
</tr>
<tr>
<td>Group Tests</td>
<td>Pillai’s Trace</td>
</tr>
</tbody>
</table>

While univariate ANOVAs indicated significant scaffolding effects on both solo test scores, $F(1, 162) = 6541.3, P > .01$ and group test scores, $F(1, 162) = 2980.7, P < .01$ (see, Table 4.7).

Table 4. 7. Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>Solo Tests</td>
<td>6541.330a</td>
<td>1</td>
<td>6541.330</td>
<td>185.688</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Group Tests</td>
<td>2980.695b</td>
<td>1</td>
<td>2980.695</td>
<td>122.418</td>
<td>.000</td>
</tr>
</tbody>
</table>

Although group tests scores were not statistically influenced by group performance, a marginal difference was evident between higher and lower performing students. Across group performances, there was a large disparity between higher and lower achievers’ group test achievements (see Figure 4.4 for details). Higher achievers paired in lower performing groups (LG) obtained higher group test scores compared with higher performer counterparts paired in higher performing groups (HG). In contrast, lower achievers’ group test scores were lowest when paired in lower performing groups than in HG (see, Table 4.8, column under Mean). As shown in Table 4.8 (see, Group Tests cell, Mean columns), the group tests mean score differences between higher achievers in higher performing groups (M=94.65) and lower performing groups (M=95.51)
was .86. On the other hand, the mean score differences between lower achievers in G (=87.5) and lower performing groups (=85.86) was 1.64.

Table 4.8. Estimated marginal means for the interaction of group performance and individual performance

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Group Performance</th>
<th>Higher/Lower Achievers</th>
<th>Mean</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solo Tests</td>
<td>Higher Performing Group</td>
<td>Higher Achievers</td>
<td>84.81</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower Achievers</td>
<td>64.32</td>
<td>2.70</td>
</tr>
<tr>
<td></td>
<td>Lower Performing Group</td>
<td>Higher Achievers</td>
<td>87.88</td>
<td>2.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower Achievers</td>
<td>66.36</td>
<td>1.15</td>
</tr>
<tr>
<td>Group Tests</td>
<td>Higher Performing Group</td>
<td>Higher Achievers</td>
<td>94.64</td>
<td>.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower Achievers</td>
<td>87.50</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>Lower Performing Group</td>
<td>Higher Achievers</td>
<td>95.51</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower Achievers</td>
<td>85.86</td>
<td>.68</td>
</tr>
</tbody>
</table>

Figure 4.4. Performance differences in solo test and group test

11=Higher Achievers
22=Lower Achievers
1= Higher performing group
2=Lower performing group
Qualitative Evidence & Themes

Excerpts from interview transcriptions are presented with their pseudonyms. Brief profiles of interviewees including names, achievement level, group performance level, and group composition are described in Table 4.9.

Table 4. 9. Interviewee Profiles. H=Higher performer, L=Lower performer, HG=Higher performing Group, LG=Lower performing Group

<table>
<thead>
<tr>
<th>Pseudo</th>
<th>Individual H/L</th>
<th>Overall Group Performance</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monica</td>
<td>H</td>
<td>HG</td>
</tr>
<tr>
<td>2</td>
<td>Min</td>
<td>H</td>
<td>HG</td>
</tr>
<tr>
<td>3</td>
<td>Chen</td>
<td>H</td>
<td>HG</td>
</tr>
<tr>
<td>4</td>
<td>Beth</td>
<td>H</td>
<td>HG</td>
</tr>
<tr>
<td>5</td>
<td>Ginger</td>
<td>H</td>
<td>HG</td>
</tr>
<tr>
<td>6</td>
<td>Chloe</td>
<td>H</td>
<td>LG</td>
</tr>
<tr>
<td>7</td>
<td>Nora</td>
<td>H</td>
<td>LG</td>
</tr>
<tr>
<td>8</td>
<td>Ethan</td>
<td>L</td>
<td>HG</td>
</tr>
<tr>
<td>9</td>
<td>Jenn</td>
<td>L</td>
<td>HG</td>
</tr>
<tr>
<td>10</td>
<td>Amy</td>
<td>L</td>
<td>HG</td>
</tr>
<tr>
<td>11</td>
<td>Emma</td>
<td>L</td>
<td>LG</td>
</tr>
<tr>
<td>12</td>
<td>Ruth</td>
<td>L</td>
<td>LG</td>
</tr>
<tr>
<td>13</td>
<td>Karen</td>
<td>L</td>
<td>LG</td>
</tr>
<tr>
<td>14</td>
<td>Brian</td>
<td>L</td>
<td>LG</td>
</tr>
<tr>
<td>15</td>
<td>Zoe</td>
<td>L</td>
<td>LG</td>
</tr>
</tbody>
</table>

Successful students equated group activities with course objectives. Higher achievers mentioned that group activities helped them to apply what they had learned in the class to real
life. Beth, a higher performer in higher performing group, perceived the benefits of group activities, “it was more real life situations which I found interesting because it was more relatable and like a lot of my classes it would be like scientific theories and tons of stuff that wouldn’t never apply to you, all of the quizzes are like based on how it would affect something in real life. (Beth)” However, qualitative evidence indicated that lower achievers failed to connect group activities with course objectives or develop higher-order thinking. Except one lower performer, all lower performer interviewees tended to complain group activities as time-consuming activities that were irrelevant with exams. “Why do that and spend an hour and going through all of that stuff when I could just finish it in ten minutes (Jenn)”, “something don’t seem very important that I know they were meant to relate close to our lives so that we understand it more but sometimes it jumps all around the place. It sounds silly but I don’t see any relationships with my real life. (Zoe)” However, Brian, a lower performer, mentioned the benefits of group activities, “it was more real life situations which I found interesting because it was more relatable and like a lot of my classes it would be like scientific theories and tons of stuff that wouldn’t never apply to you, all of the quizzes are like based on how it would affect something in real life. (Brian)”

Students expressed positive experiences with group members. Whether students were in higher performing groups or lower performing groups, twelve interviewees perceive group work positively. Except three interviews, students described that the overall communication with group members went well via text messages, social networking websites, or email. Nora, a higher performer in a lower performing group, described the benefit of group work as follows; “You can ask your questions to your group especially in a such a huge class.” Karen, in lower performing group working with lower achievers, communicated whenever they had questions
and helped each other, “I could text them, they help. Email them, they help…I mean, any time I don’t understand because someone there is always going to be able to help you.” For tests, “I really don’t understand this, I need help really bad”…I will text one of them and say, “Can you explain this to me real fast?” or a week before class….they usually respond really quickly. It always goes email first and then text messages (Karen).” Higher performer sometimes assisted their group members test by sharing his or her study guides; “I let them (group members) know ‘the activities will be on the test. You should understand it. I looked at learning objectives and I know those will be on the tests. So, I took my notes and shared it with other group members. Then I cheered them to respond to the practice quizzes. (Ginger)”.

Group activities and evaluating claims. Several trends appeared to limit the benefits of group work to develop ability to analyze and evaluate evidence of claim. Students described inactive or dominating attitudes and behaviors during group work. Some students described that one group member dominated their group activities; “I just think she didn’t know how to really make her point without overriding everybody else (Clair)”, “I know she might want to do it herself but that’s not what we’re supposed to do in a group... I couldn’t contribute or did something more..she never offers… (Ruth).” For passive group members, some students tried to help the group member. “We’re going to get her to work, give her the opportunity to do stuff” and “Hey, Anne (pseudonym), we’re kind of confused on this, will you come over here and help us?” and so she came over and then we went through one part of the worksheet and then Tory (pseudonym) and I kept saying stuff and she’d be like, “Oh, yeah, that’s what I was thinking, too” and so then I texted Val and “Let’s just be quiet for the next section and see if she’ll jump in”….because even if we don’t understand it, we’ll still talk about it and try and figure it out. [Amy]”
Membership influenced group effectiveness. Furthermore, based upon group’s performance and composition, some group members had to become the only person responsible for all group work. Ethan, who was the only lower performer, in a group with three mid-achievers, had to complete and submit group activities on time, “they’d send me like not very good information and I’d have to redo their how thing, if they sent me their portion of the things, I had to go through all of their information and put it together. But I’d imagine my other members they didn’t have to go through the individual information….once I actually put a document together and submitted it, they probably never even look at it, you know? I know of the members, she just checked to make sure it was there but they actually never even looked at it. And so I actually go through the information and actually learn it to format it correctly. They didn’t help me in a way that could have helped them because they never really even looked at it.” Ruth, who worked with three other lower achievers described the difficulties of group work as follows; “it’s more difficult to get all the members to contribute equally especially if someone is….doing all the work and then other people feel like they can relax, “You’re doing all the work and I can just sit back and get a hundred” sort of like the prisoner effect. So, that’s what I’ve been experiencing mainly with our group.” Whenever taking group test, Ruth’s group members heavily depended on Ruth even though Ruth was a lower performer as they were. “ (Other group members said,) “Oh, I hope you guys know a lot for the group test because I don’t really know anything” basically telling me that “Oh, I hope you know a lot so I can write off your intelligence and get a good grade” (Ruth)

Groups merged and submitted, but did not discuss, outside group work. Even higher performing groups submitted their outside assignments by merging individual portion without discussion. Among 15 interviewees from 12 different groups, only two groups had in-depth
discussion on their outside-class assignment. Groups tended to divide individual portions of the group assignment and submit without group discussion. Ginger and Clair’s group began with dividing individual portion of the group assignment but after merging them, they had reviewed and shared what group members contributed. “to one person and then that person usually puts into a document and then sends it back to us to review and then we all kind of tweak it and make sure it’s right before that person submits in the Dropbox (Ginger), “Oh, we might want to add this to be more clear….everyone has gotten it done and then brought it in ready to bounce ideas off of each other. (Chloe).” Emma’s group tried to perform well and reported they did well in group activities, “after everyone does their own part they submit the document back onto Facebook, we attach it and so someone can continue from the other person. So, this person can add their part but the thing is…we usually don’t go and like edit it. Sometimes I just look at it and just review it and “Okay, that’s good”… usually it’s all good because everyone does the best that they can and we usually don’t have someone like edits or synthesizes.” [Emma]

**Triangulation**

**Research Question 1.** Does instructional scaffolding with group-based activities influence college students’ content knowledge acquisition?

Instructional scaffolding with group-based activities influenced both higher and lower achievers’ learning. Qualitative evidence supports the quantitative evidence; for example, Karen, a lower performer, mentioned that pop quiz helped her to acquire content knowledge. “…go back to the (pop quizzes) questions that we went through and look because it highlights…I would ask to other members, “What was your answer? And then be like, “How did you get that? I don’t understand”…we always do that. This one is correct and you answered this one, it was
wrong”….so I will go back through the quizzes response and look at the questions to prepare for the test”.

Qualitative data also indicated perceived value and effectiveness of group work. Five out of seven higher performing interviewees (four from higher performing groups, one from lower performing group) and six out of eight lower performing interviewees (three from higher performing groups, three from lower performing groups) mentioned that they benefitted from group work. Monica, a higher performer, described that the group work helped her learning when her group members tried to help to each other to understand the concept, “And we all study differently and so if I thought of something in a certain way...if I understood something because like my brain works a certain way but they didn’t get it, I could sort of verbalize and explain it to them. Like for the last test study, what we each did was we each split up and took different units and then we learned that unit really, really well and then we all went around one night and like taught our unit to the other two people.” Ethan, a lower performer, mentioned, “I’d be like, ‘I don’t know what’s going on’ and she’d be like, “Oh, it’s this and this”, like she would explain it to me. If I was in a class with thirty people, I would have asked the teacher what I asked her and so she elaborated on...went into a little deeper context with me and tried to explain in it my terms in a way that the teacher couldn’t because there is just so many people.” Brian, a lower performer in lower performing group, also expressed that group work helped him to engage in the class, “It definitely helped engaged me more with the learning and I also enjoyed the online tests, they’re definitely helpful.”

However, fourteen interviewees questioned the effectiveness of outside class group work due to time management and communication issues. Nora, a higher performer, for example, perceived benefits of in-class group work but “hated” outside class group work; “outside
classroom really hard to coordinate everyone else is doing it...we all have different types of personality. With different personalities, you always have to do more”.

**Research Question 2.** Does instructional scaffolding with group-based activities influence the ability to analyze and evaluate evidence of claim improve underperforming college students’ scientific literacy?

Groupwork improved higher achievers’ ability to analyze and evaluate evidence of claim to a greater extent than lower achievers. As shown in Figures A and B, higher achievers obtained higher solo and group test scores when they were in either High Performance Groups or Low Performance Groups. Higher achievers in Low Performance Groups (M=95.5) actually outperformed their counterparts in High Performance Groups (M=94.6). However, lower achievers’ solo test scores demonstrated fewer differences (Mean =2.0) than higher achievers’ score differences (Mean =3.0).

Both higher and lower achievers perceived the value and effectiveness of scaffolded group-based activities on higher order thinking. Beth, a higher performer in higher performing group, valued and described group work as “to be able to talk to people about it and kind of work through it and figure it out. it was like a nice little support system. you didn’t feel like you were alone in the class” Amy, a lower performer in a higher performing group, described group test, “i think the tests in this class were not my forte because i guess i feel like the tests in this class were more like application, like you’d learn a certain...i don’t know the word for it....but you’d learn a strategy kind of and then like the tests would be like applying that strategy but to a different situation...” Ethan, a lower performer in a higher performing group, was benefitted from group discussion. He described, “it helped me to discuss with them, “oh, is the way this is
supposed to be?" We all had very deep discussions about each question and why the answer was what it was and so I came out of that test every time knowing more just discussing it with my group members even if our grade didn’t reflect how well we did, you know, we learned more just discussing the information with each other.”

General Discussion and Implications

Lower performing groups were more likely to benefit when they included higher achievers and/or received additional instructor guidance. Positive interdependence has been associated with developing new insights and discoveries as well as more frequent use of higher-level reasoning strategies (Gabbert, Johnson & Johnson, 1986; Nam & Zellner, 2011). Five of seven lower performing groups showed positive interdependence and promotive interaction with the help of effective communication. Four of lower performing groups did not need role assignments because all group members naturally rotated their roles during the semester. Zoe, who was in a lower performing group, described about her group as “Groups are just like our comfort zone.” She valued her group and believed no one struggled although their group performance was low; “I like my group members. Any of us were struggled with contents. For all of us it was quite easy. We all understood the materials.” Our evidence supports previous findings that positive interdependence promotes a deep sense of belongings to a group and group cohesion which includes mutual trust and familiarity (Strijbos, Martens, & Jochems, 2004).

although some lower performing group’s exhibited positive interdependence and promotive interaction, these attributes were not consistently associated with positively learning among lower performing students. Emma, a lower performer in a lower performing group, was satisfied with their group work when taking group tests, but was not confident about the group’s performance, “So, the group tests we try to ... work on it all together but like honestly we’re not
really sure” and “…wanted to change my group to be with people who know like the content more….know how to manipulate the questions and get the right answer.” Ruth and Karen also worked with lower achievers and both mentioned the necessity of a member who might perform better than them: “so I couldn’t get as many questions as I wanted…(Ruth), “….biology majored teaching assistants and so like tutors or mentors in this class…(Karen)”.

Ginger, who worked with lower achievers, mentioned, “(I need someone who will explain) why it correlates to something else because then they’ll be able to connect and maybe make them more interested in what their learning and help them have better learning skills and also just self-confidence knowing that they know what they’re doing and knowing that they can complete the material.”

Brian suggested instructor’s guidance during the in-class group work, “(after group assignment) she (the instructor) could pick on one group to say something….that would be a good idea.”

In addition, whereas one or two student’s social loafing may not negatively affect group’s performance’ it may well influence their individual performance. In previous free-riding studies, social loafing negatively influenced not only overall group performance (Dommeyer, 2007; Maiden and Perry, 2010), it also influenced individual performance of fellow group members (Aggarwal & O’Brien, 2008; Brooks & Ammons, 2003). In these studies, both higher and lower achievers indicated they perceived they had become a sucker of their group.

Similarly in the current study, among eleven interviewees who shared social loafing concerns in their group, five were lower achievers and six were higher achievers. Among lower performing groups, 5of 7 reported social loafing issues whereas 3 of 8 higher performing groups reported social loafing issues. Three groups (1 lower performing group and 2 higher performing groups) had both free-rider(s) and a bossy leader and five groups had free-rider(s). Among 5 lower performing groups who reported a free-rider, only one group expressed efforts to involve a
free-rider; meanwhile two higher performing groups described unsuccessful efforts to involve a free-rider in group activities. Thus, among lower achievers, purposeful group composition may be needed to promote equitable knowledge acquisition and higher-order thinking. Our finding contrasts with previous researchers suggesting rotating roles within group members should reduce the incidence of free-riding (Johnson & Johnson, 1989). Rather, our evidence suggests that group composition may be needed to promote equitable learning across learners. Lower performer groups may need to have at least one higher performer who can lead the group discussion.

Whereas previous studies indicate that successful achievers tend to perceive themselves suckers within groups, we found that both higher and lower achievers perceived themselves as suckers within their respective groups. Min, a higher performer complained about another higher performing group member, “At least (they should) summarize it but they just sent me all copy and paste. They didn’t do any research and follow any APA format. But they simply sent me the link of the resources and said, ‘here is the link’. So I have to go back to the website that they’d found and had to summarize them. They don’t care.”

Both higher and lower performing students reported members who did not participate or care about group work. Students in higher performing groups and lower performing groups were willing to assist students to participate in group work. Students valued members’ efforts to provide “their own arguments” (though they brought wrong answers), “prompt responses,” and to show “care about” the group work. Min mentioned, “At least they need to try explain with their own examples during the group discussion.” When group members lack active participation, students perceived them as free-riders or lower achievers, even though sometimes he or she turned out to be a higher performer.
Future researchers may also need to consider the influence of diverse languages, cultures and nationalities on group collaborations. Does scaffolding group-based activities ensure equity of learning within diverse members? In the current study, the instructors shared concerns with engaging international students in group activities. According to recent publications, group collaborative work involving culturally diverse students affects students’ satisfaction level (Cotton, George, & Joyner, 2013) as well as interaction patterns and decision making process (Strauss & Young, 2011). During student interviews, native English speaking students, who collaborated with international students with limited English proficiency, shared frustrations during group discussions. International students tended to collaborate with the same nationalities and mother tongue. In addition, multiple nationality groups reported cultural differences during group discussions and evaluations. International students sometimes became involuntary and a result of feeling inadequate or not competent to complete the assigned tasks. Uneven contribution to group work due to language barrier could lead other group members to believe that his or her lack of interests (Dommeyer, 2007). To prepare students to collaborate with culturally diverse teams and environments, it is important to foster positive collaborative learning experiences to interact effectively (Steir, 2003; Summers & Volet, 2008).

The extent to which these issues influence inclination and effectiveness to collaborate has not been adequately demonstrated. Self-reports have been used extensively to identify individual needs, the relationships between self-reports with participation and performance in learning have proven inconclusive. A lower performer in the current study, Clair, was reluctant to engage in the group discussion due to low confidence. She mentioned, “Like, I don’t want to bother them maybe or….they might not know the answer either or they might think that they do and they don’t and I don’t want to get the question wrong if I go ahead and take their word for it that’s it
right.” Regarding anonymous peer evaluations, half of interviews mentioned peer pressure not to criticize to each other. Ethan, a lower performer, mentioned, “I felt like everybody in the group, unless one group member which was completely slacking, if they come to class, even if they don’t participate, it’s still makes you feel like you have be nice about it. You can’t completely be honest because they could see it.”

Thus, future research needs to demonstrate the extent to which domain-specific motivation support influences underperforming students’ academic performance. In the current study, autonomous support improved most underperforming students’ perceptions but not their academic performance has remains; self-report measures have been used primarily to assess student perceptions but not actual learning. Underperforming students tended to over- or under-rate their individual progress, needs for support, and understanding. Research is needed to corroborate correlations between self-report measures and academic performance. If correlations are not found, alternative measures and scaffolds may be required. During group learning, it may prove useful to compare individual self-reports (self-evaluation) with anonymous peer-evaluations to correlate with individual as well as group performance measures. Interview and reflection journals may prove important to determine the extent to which self-report indicators can be employed with either individual or consensus self-assessment measures. Instructors may provide adaptive scaffolding to support student’s monitoring and reflection on learning process.

**Limitations**

Since the interviewees were students, reactivity may negatively affect the research result. Reactivity is the influence of the researcher on the setting or individuals studied (Maxwell, 2012, p.124). Students expressed wariness of possible influence of the interview on course grades and lower performing students hesitated to share their learning experiences. The researcher began the
interview by assuring that the interview would not affect grades in any ways and shared a consent form. Still, interviewees might have proven reticent to fully share their experiences during the interview.

Researcher bias may also influence our findings. The methods aligned with the researcher’s theories, goals, and preconceptions, as well as the selection of learning outcomes may influence both findings as well as interpretations (Maxwell, 2013). Other researchers have focused on affective measures of satisfaction and expectations, which merit consideration. To minimize the potential influence of researcher bias, we triangulated multiple qualitative as well as quantitative data sources while focusing primarily on relative individual versus group learning benefits.

Our study was not restricted to controlled or laboratory conditions, but rather we explored both process and outcomes in an authentic, real-world undergraduate college science classroom environment. The results contributed to identifying barriers and challenges but did not test or validate solutions to address those challenges. Balanced data may provide corroborate results to examine the effectiveness of group work across the performance levels and the solutions to promote the effectiveness. Balanced data implies that each participant was measured on each variable an equal number and at the same point of time, resulting in equal numbers of repeated observations (Kenny, Bolger, & Kashy, 2002). However, logistical problems prevent the instructor from creating purposeful groups; a group with one higher, two mid, and one lower achievers to compare students in diverse performance levels. Higher performing groups had more higher achievers than lower achievers. Likewise, lower performing groups had more lower achievers than higher achievers. Design-based research methods or longitudinal data analyses can be implemented to optimize both the impact of possible solutions. Design research studies
has been increased in mathematics and science education by spending amounts of time in classrooms implementing and investigating interventions to support students’ conceptual growth (Suter & Frechtling, 2000). Future research is indicated to address gaps between academic theory and impact and the durability of such practices for everyday applications.

References


*Educational Technology Research and Development, 47*(1), 29–50.


CHAPTER 5
CONCLUSION

This dissertation reported design-based research to promote equitable learning through collaborative work in large-enrollment classrooms. Considering goals and challenges of learning in higher education, the studies examines optimal learning environments for underperforming students. This dissertation focused on collaborative group learning as it has been widely used to support participation in both small and large enrollment college classroom. However, group work sometimes inadvertently encourages rote learning and reifies misconceptions among students with limited background knowledge and experience. Although groups have been implemented previously in college level education, few studies have documented strategies that enhance the effectiveness of group work.

This research was conducted in large-enrollment introductory biology courses for non-science majors as (1) those classes were registered by a range of academically different learners, (2) course objectives primarily focused on promoting learning abilities that college students should equip, and (3) collaborative group learning was used. Whereas instructors often assume students to be capable adults capable of learning independently, multiple studies document persistent problems and the need for additional support. Thus, the study analyzes and synthesizes research, theory and practice related to underperforming students in postsecondary settings, and identifying research needed to support both underperforming college students and their instructors. Finally, a research agenda is presented to design college learning environment for underperforming students and instructors.
In Chapter 3, the study examined how individual and group inquiry-based activities influence achievement among academically diverse students. A mixed methods study was employed involving 303 undergraduate, non-science majors enrolled in a required large-enrollment college Biology course. The study focused on exploring differences in how group activities influenced both content knowledge and higher-order thinking skills between higher and lower achievers. The results indicated that some group-based activities positively influenced the achievement of higher achievers but no group activities improved lower achievers’ individual achievement. Theoretically, effective group work needs to support all participants’ thinking skills and knowledge acquisition. However, this study revealed that lower achievers rarely benefitted from group work and few higher achievers benefitted. Group work was implemented but its effectiveness among students of different achievement levels remains to be verified.

Ineffective group work likely results from several factors: insufficient instructor support, widely varied prior knowledge within groups, lack of student preparation or willingness to engage group work strategies, or deficient individual learning strategies (Armstrong, Chang, & Brickman, 2007; Christopher, Thomas, & Tallent-Runnels, 2004). Still, it is unclear which factors contribute to ineffectiveness among learners of diverse achievement levels. Authors have provided guidelines to facilitate effective group work, but such guidelines have rarely been validated in college classrooms.

The study detailed in Chapter 4 examined group methods designed to benefit the academic performance of all participants equitable across achievement levels. The study mainly examined circumstances and methods where group work benefits performance across achievement levels. The extent to which the logistics associated with the learning impact of group work within large-enrollment courses was scrutinized. The study indicated that lower
performing groups were more likely to benefit when they included higher achievers and/or received additional instructor guidance. In addition, although some lower performing groups exhibited positive interdependence and promotive interaction, these attributes were not consistently associated with improved learning. Our evidence supports previous findings that positive interdependence promotes a deep sense of belongings to a group and group cohesion which includes mutual trust and familiarity (Strijbos, Martens, & Jochems, 2004). However, those relationships have rarely been associated with developing new insights and discoveries as well as higher-level reasoning strategies.

Whereas one or two student’s social loafing may not negatively affect group’s performance’ it may well influence their individual performance. These results did not support suggestions to create effective group work. In previous free-riding studies, social loafing negatively influenced not only overall group performance (Dommeyer, 2007; Maiden and Perry, 2010), it also influenced individual performance of fellow group members (Aggarwal & O’Brien, 2008; Brooks & Ammons, 2003).

**Implications for program of inquiry**

The extent to which inclination and effectiveness to collaborate has not been adequately demonstrated. Self-reports have been used extensively to identify individual needs, but the relationships between self-reports and learning performance proven inconclusive. Thus, future researchers need to demonstrate the extent to which domain-specific motivation support influences underperforming students’ academic performance. In the current inquiries, autonomous support improved most underperforming students’ perceptions but not their academic performance; self-report measures have been used primarily to assess student perceptions but not actual learning. Underperforming students tended to over- or under-rate their
individual progress, needs for support, and understanding. Research is needed to corroborate correlations between self-report perception measures and academic performance.

Future researchers may also need to consider the influence of diverse languages, cultures and nationalities on collaboration. In the current studies, the instructor shared concerns about engaging international students in group activities. According to recent publications, group collaborative work involving culturally diverse students affects students’ satisfaction level (Cotton, George, & Joyner, 2013) as well as interaction patterns and decision-making process (Strauss & Young, 2011). During student interviews, native English speaking students, who collaborated with international students with limited English proficiency, shared frustrations during group discussions. International students tended to collaborate with the same nationalities and in their native tongue. In addition, multiple groups reported cultural differences during group discussions and evaluations. International students sometimes participated sparingly feeling inadequate or not able to complete assigned tasks. Uneven contributions to group work due to language barrier could influence other group members to perceive his or her lack of interest (Dommeyer, 2007). To prepare students to collaborate with culturally diverse teams and environments, it is important to foster positive collaborative learning experiences to interact effectively (Steir, 2003; Summers & Volet, 2008).

While technology has been widely adopted in face-to-face and blended college courses, the effectiveness for underperforming students has not been conclusively demonstrated. For classroom applications, effective integration appears to depend on the practical issues such as the number of students and technology availability. Theoretically, blended learning environments enhance individual learning via instructors’ support. However, in large enrollment courses, instructors report difficulty supporting the needs of individual students even with technology
activities. For students who lack self-regulated learning abilities or time management skills, s, online learning environment tended to use as a repository of resources rather than collaborative learning platform. Future research needs to document the balance needed to support blended learning for large enrollment courses a with appropriate instructor guidance. Previous studies with large college courses tended to emphasize technology use per se rather than effects on quality of students’ learning. Simply analyzing online resource access fails to account for the use and interpretation of related resources—online as well as human. The quality of students’ postings and responses can be documented empirically using validated scoring rubrics. To triangulate the evidence from discussion boards, semi-structured students’ reflection journals and interview should help to clarify the net impact on performance.

References


Appendix A: Get to Know Each Other & Be Ready

*(Building Positive Interdependence)*

1. **Group number and name:** Number______, Name:

2. **What are your group member’s names and what are common or different group behaviors that can describe each one?**

<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
<th>Constructive Group Behaviors</th>
<th>Destructive Group Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Constructive Group Behaviors**

- Cooperating: Is interested in the views and perspectives of the other group members and is willing to adapt for the good of the group.
- Clarifying: Makes issues clear for the group by listening, summarizing and focusing discussions.
- Inspiring: Enlivens the group, encourages participation and progress.
- Harmonizing: Encourages group cohesion and collaboration. For example, uses humor as a relief after a particularly difficult discussion.
- Risk Taking: Is willing to risk possible personal loss or embarrassment for the group or project success.
- Process Checking: Questions the group on process issues such as agenda, time frames, discussion topics, decision methods, use of information, etc.

**Destructive Group Behaviors**

- Dominating: Takes much of meeting time expressing self views and opinions. Tries to take control by use of power, time, etc.
- Rushing: Encourages the group to move on before task is complete. Gets "tired" of listening to others and working as a group.
- Withdrawing: Removes self from discussions or decision making. Refuses to participate.
- Discounting: Disregards or minimizes group or individual ideas or suggestions. Severe discounting behavior includes insults, which are often in the form of jokes.
- Digressing: Rambles, tells stories, and takes group away from primary purpose.
- Blocking: Impedes group progress by obstructing all ideas and suggestions. "That will never work because..."
3. Here is the list of common barriers of peer-collaborative work. Discuss what your group will do, when you encounter following situations.

<table>
<thead>
<tr>
<th>Possible Situations</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• When a member talks too much, monopolizing the discussion.</td>
<td></td>
</tr>
<tr>
<td>• When a member rejects every suggestion that others make.</td>
<td></td>
</tr>
<tr>
<td>• When a member interrupts others or brings up inappropriate or irrelevant subjects.</td>
<td></td>
</tr>
<tr>
<td>• When a member's problem doesn't match up with what the group is meant to address.</td>
<td></td>
</tr>
</tbody>
</table>

4. In each module, your group will have four times of discussion. There are four roles that each of your group member needs to take throughout the discussion. How does your group assign group roles? Please assign each member’s name in the table.

<table>
<thead>
<tr>
<th>Roles</th>
<th>Discussion 1</th>
<th>Discussion 2</th>
<th>Discussion 3</th>
<th>Discussion 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion leader</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reporter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note-taker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questioner/naysayer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Appendix B: In-class Group Worksheet

1. Based on group work sheet 1, your group will rate and choose the best answer for your group. Rate each member’s claims by assessing them according to the following criteria. Strongly agree (5)- Agree (4) – Neutral (3)- Disagree (2) – Strongly Disagree (1).

<table>
<thead>
<tr>
<th>Member Name</th>
<th>Evidences</th>
<th>Current sources?</th>
<th>Reliable sources?</th>
<th>Relevant to the claim?</th>
<th>Rigorous methodologies?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elliot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YooJin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>George</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Which answer should be the best answer? Describe (1) which one does your group choose and (2) why?. Please explain your group’s rationales with specific examples.

<table>
<thead>
<tr>
<th>The best answer is..</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Because,</strong></td>
<td></td>
</tr>
<tr>
<td>1. George’s source is mostly from primary sources including peer-reviewed journal.</td>
<td></td>
</tr>
<tr>
<td>2. The data he found was the most recent one, published in 2012....</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Anonymous Peer Evaluations

Please provide an overall rating for each team member. Please rate each of your team members on their contributions to the performance of your group. Their rating should be based on **all** the work done as a team. You may use non-integer values (i.e. 2.5). To receive all of the points your group earned for their group problem grade, a student's average score from all of their peers must be 3 or higher. Ratings of 1 and 4 should be reserved for very special cases. If you give a rating of 4 or less than 2 for any category, you must explain why in your comments.

Rate each team member based on the following scale:
- 1 = unacceptable performance, I would fire this person
- 2 = improvement needed
- 3 = good, met or exceeded all expectations
- 4 = outstanding, a rare individual

<table>
<thead>
<tr>
<th>Category</th>
<th>Team Member 1</th>
<th>Team Member 2</th>
<th>Team Member 3</th>
<th>Team Member 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation: Was this person reliably prepared for working on the group work?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation: Could you count on this person to perform their part of the in-class group work?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation: Did this team member contribute their fair share of the work and actively participate in group assignments and tests?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation: Did this person always seem to be working in your group meetings? Did you always see them in class?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration: Did this person try their best to help the group function effectively?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude: Did this person have a positive attitude that helped the group function? Were they pleasant to work with?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance: Did this group member add substantially to the score on the group assignments and tests?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance: Did this group member bring special skills to the task?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment feedback is currently set to require 10 or more words. You can set the word length or simply turn it off. When we use this feature we recommend that students who are not native English speakers use one of the widely available text translators listed below. The Dialectizer - convert to a humorous dialect BabelFish - convert from English to another language and back (http://babelfish.altavista.com/)

Team Member X

Team Member Y

(Enter a comment for your groupmate here. Do not copy and paste the same comment for all team members.)
Appendix D: Interview Protocol

1. What is your major and what year are you in?

2. Other than mandatory course, are there any reasons that you are registered for this course?

3. Almost end of the semester, how do you feel about your performance?

4. What is the meaning of group work for you? What are benefits and challenges of group work in a large classroom?
   a. Did you have any challenges or strategies that your group used for a successful group work?

4. Group work in general
   a. How the group composed? Group contract? STEAM evaluations
   b. Communication?
   c. Role assignments?
      i. How does your group discuss the topic during the class?
      ii. What was your role in the group discussion? Please choose one or more that you undertook.
         1. Discussion leader
         2. Reporter
         3. Note-taker
         4. Questioner/naysayer
   d. Had meetings outside the class?

5. Instructor’s support?
   a. Individual source first and then come back
   b. Group assignments preparation
   c. Tech-support: Checklist in elcnew, Email check, Practice test, Via response questions, SSS (Share Study Strategies) board

6. Perceptions about multiple individual and group-based activities. How do you perceive multiple activities in this course?

7. You may have questions to ask about the contents or concepts. If you got assistance from others when you had questions, please choose from the lists below.

8. If you can give recommendations for next semester’s BIOL1103, what would you like to give?
Appendix E: Examples of Outside Class Group work Assignment

Endocrine Disruptors

Now that you understand the complete cycle of exposure to estrogen (or estrogen mimics) on gene expression, you are ready to investigate one of the wide range of compounds that have been implicated in this process.

Step 1: Read about endocrine disruptors

The following link to Tulane University’s e.hormone site on endocrine disruptors will introduce you to some of the suspected culprits (phytoestrogens in things like soybeans; pesticides, synthetic estrogens in birth control pills, BPA in plastics, heavy metals. You can also read about the Tier 1 Assays for Detecting in vitro ER transcriptional activation here http://www.regulations.gov/#/documentDetail;D=EPA-HQ-OPPT-2010-0877-0021

Step 2: Choose a Culprit to Describe in Depth

Choose two compounds to investigate to fill in Table 1 below. One each from each of the following two slide shows:

Pesticides
http://e.hormone.tulane.edu/learning/animations/pesticide-slideshow.swf

Persistent Organochlorines & Product Additives
http://e.hormone.tulane.edu/learning/animations/other-slideshow.swf

Step 3: Conduct Research on the Status of your Culprit

Fill out the following table with the information you found about the compound you investigated. Click here to download a .docx version of this assignment.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Source of Contamination</th>
<th>Method of Action on Cells</th>
<th>Effects on the Body</th>
<th>Regulatory Status for this Compound</th>
<th>Reproductive Toxicity</th>
<th>Carcinogenic</th>
<th>Water Contaminant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticide:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You can find information about the status of Pesticides at: http://www.pesticideinfo.org/ Click on the pesticide of interest, then you can click on Toxicity, Regulatory Status, or Water. You can also look at the Environmental Protection Agency List of Chemicals identified for the Tier 1 Endocrine Disruptor Screening Program http://www.epa.gov/endo/pubs/prioritysetting/draftlist2.htm