Effects of Gender and Role Selection in Cooperative Learning Groups on Science Inquiry Achievement

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EFFECTS OF GENDER AND ROLE SELECTION IN
COOPERATIVE LEARNING GROUPS
ON SCIENCE INQUIRY ACHIEVEMENT

By

Maria Geralyn Affhalter

THESIS

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Northern Michigan University
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Graduate Studies Office

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SIGNATURE APPROVAL FORM

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ABSTRACT

EFFECTS OF GENDER AND ROLE SELECTION IN COOPERATIVE LEARNING GROUPS ON SCIENCE INQUIRY ACHIEVEMENT

By

Maria Geralyn Affhalter

An action research project using science inquiry labs and cooperative learning groups examined the effects of same-gender and co-educational classrooms on science achievement and teacher-assigned or self-selected group roles on students’ role preferences. Fifty-nine seventh grade students from a small rural school district participated in two inquiry labs in co-educational classrooms or in an all-female classroom, as determined by parents at the beginning of the academic year. Students were assigned to the same cooperative groups for the duration of the study. Pretests and posttests were administered for each inquiry-based science lab. Posttest assessments included questions for student reflection on role assignment and role preference. Instruction did not vary and a female science teacher taught all class sections. The same-gender classroom and co-ed classrooms produced similar science achievement scores on posttests. Students’ cooperative group roles, whether teacher-assigned or self-selected, produced similar science achievement scores on posttests. Male and female students shared equally in favorable and unfavorable reactions to their group roles during the science inquiry labs. Reflections on the selection of the leader role revealed a need for females in co-ed groups to be "in charge". When reflecting on her favorite role of leader, one female student in a co-ed group stated, "I like to have people actually listen to me".
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Northern Michigan University has a reason to be very proud of the professors I have had the pleasure to work with in this online community.
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Chapter One: Introduction

The dynamics of any classroom vary greatly and depend on several factors such as socioeconomic status, ethnicity, and family background, size of classes, learning disabilities, behavioral problems, and gender balance. Educators seeking authentic learning experiences in their classrooms employ many teaching strategies to engage as many students as possible regardless of class composition. A well-studied, effective teaching strategy used by educators to promote achievement is the use of cooperative learning groups (Gillies, 2008).

Cooperative learning methods promote learning because these collaborative experiences engage students in an interactive approach to processing information, resulting in greater retention of subject matter, improved attitudes toward learning, and enhanced interpersonal relations among group members (Slavin, 1991a). The general research base on cooperative learning is extensive, and has been recommended as effective in most school subjects across various groups of students measured on several cognitive and affective outcomes (Robinson, 1991).

Students involved in cooperative learning achieve many social and academic benefits. Cooperative classrooms are classes where students group together to accomplish significant cooperative tasks. Students are likely to attain higher levels of achievement, to increase time on task, to build cross-ethnic friendships, to experience enhanced self-esteem, to build life-long interaction and communication skills, and to master the habits of mind (critical, creative and self-regulated) needed to function as productive members of society (Harskamp, Ding, & Suhre, 2008).
Composition of cooperative grouping is an additional consideration when employing this strategy within a classroom. With a few exceptions, heterogeneous groups with regard to academic achievement, gender, ethnicity, task orientation, ability, and learning style promote thinking that is more elaborate and explanations and provide opportunities for students to develop feelings of mutual concern (Webb, Nemer, & Zuniga, 2002).

Many factors affect student choices to participate and engage in learning within the classroom. Instruction in science, particularly inquiry-based science, requires students to communicate, collaborate, and manipulate tools and information. Gender-based classrooms create a unique opportunity to observe females and males within mixed and single gender cooperative groupings. In classrooms where collaboration is practiced, students pursue learning in groups of varying size for negotiating, initiating, planning, and evaluating together.

Rather than working as individuals in competition with every other individual in the classroom, students are given the responsibility of creating a learning community where all students participate in significant and meaningful ways. Students understand group work implies all members have a job to do. While working in cooperative learning groups, each member of the group is assigned a task and given a role. Role assignments and selection increase the level of interaction and teach children how to ask and how to give assistance (Cohen & Lotan, 1990).

The role or job students choose when working in a cooperative group has several factors, including comfort in roles, dispositions etc. The current study investigated the
effect of group roles on achievement while completing an inquiry lab in both a co-
educational grouping and same-sex grouping. The remaining part of this chapter will
provide an overview of background information, purpose of study, theoretical
framework, research questions, and definition of key terms.

**Background of Problem**

Cooperative learning groups are an accepted strategy to increase student success
in many academic settings. Group composition has a great effect on learning achievement
in science, especially where problem solving or inquiry style lessons are involved
(Harskamp, Ding, & Suhre, 2008). Within traditional coeducational classrooms, mixed-
gender cooperative learning groups assigned by an educator are composed of high, low,
and middle achievers of both genders, with various ethnic and cultural backgrounds
(Smith & Spindle, 2007). In a gender-based classroom of all males or all females,
balancing cooperative group roles by gender is a nonissue and the focus of learning has
one fewer factor affecting achievement and success.

**Purpose of Study**

The study was conducted in a small rural public middle school offering gender-
based classes at seventh grade level in English, Social Studies, Math, and Science.
Gender-base learning options are one strategy this middle school used to increase
achievement for participating students. The importance of encouraging all students,
males and minorities in particular, in science and mathematic courses in middle grades
is a key focus of STEM (Science, Technology, Engineering and Mathematics) initiatives.
Data from National Assessment of Educational Progress (NAEP) states less than one-
third of U.S. eighth graders show proficiency in mathematics and science. A large interest and achievement gap exists among some groups in STEM, and African Americans, Hispanics, Native Americans, and women are seriously underrepresented in many STEM fields. (The President’s Council of Advisors on Science and Technology PCAST, 2010)

Schools offering gender-base classes find unequal distribution of gender in co-ed sections unavoidable. Based on section choice, parents and students identify a specific learning environment as the best “fit” for their children. This unique opportunity has allowed research of one aspect of student achievement, how students benefit from cooperative learning groups composed of single gender students.

**Theoretical Framework**

Cooperative learning requires students to work together to achieve goals they could not achieve individually (Johnson, Johnson, & Holubec, 1994). Five elements are necessary to achieve cooperative groups, positive interdependence, face-to-face interaction, individual accountability, practice of specific social skill and group processing (Johnson & Johnson, 2008). This study is examines the strength of having students chose their own group roles versus having group roles be assigned by the teacher, which is a test of positive interdependence.

When a group of students gather for job or role selection, common patterns emerge. Students with neat penmanship may accept the role of data collector. Other students may feel comfortable with a speaking role. This research questions the motivations of students to choose one role over another within cooperative groups.
**Research Questions**

In studies of partner gender and achievement, partners in all-female groups appear to do better in problem solving tasks than mixed-gender groups (Harskamp, 2008). The first question is, “Does role choice and achievement also benefit from same-sex grouping, in particular, do students in an all-female group choose different group roles than female students in a co-ed grouping?” The focus of this research is how cooperative inquiry groups affect the role choices of both co-ed and all-female groups.

**Key Terms**

The following terms are used throughout this thesis.

**Cooperative Learning.** Cooperative learning may be broadly defined as any learning situation in which students of all levels of performance work together in structured groups toward a shared or common goal. Cooperative learning is the instructional use of small groups through which students work together to maximize their own and each-others learning (Johnson, Johnson, & Holubec, 1994).

A variety of formal cooperative learning models have been developed, such as Jigsaw, TGT (Teams, Games and Tournaments), STAD (Student Teams Achievement Divisions), and Group Investigation. In addition, a number of specific cooperative learning designs, such as think-pair-share, peer response groups for writing, paired problem solving for mathematics, reciprocal teaching in reading, group experiments in science, and discussion circles in social studies have been successfully applied in the classroom. The selection of a particular model or design is influenced by the desired
outcomes for instruction, the subject area, and the social skills of the students (Robinson, 1991).

**Cooperative Learning Group Roles.** Common roles can be used in informal, as well as formal, cooperative learning groups include facilitator, recorder, reporter, and timekeeper. In addition, instructors may choose to design other procedural roles depending on the age of the students and the nature of the task (Wright, 2002).

Participants in this study fulfilled specific roles in the cooperative learning process to divide tasks within group work for individual responsibility. The following roles were utilized for the inquiry-based science lessons in this research.

- **Leader:** Makes sure every voice is heard. Focuses work around task.
- **Presenter:** Present finished work to class and organizes information.
- **Data Collector:** Compile group members’ ideas on lab sheet/graphic organizer.
- **Monitor/Observer:** Encourages group to stay on task. Check time constraints.
- **Materials Manager:** Collects and returns materials needed for task completion.

**Inquiry based science.** The process of “inquiry” is modeled on the scientist’s method of discovery. Inquiry based science is a constructed set of theories and ideas based on the physical world, rather than as a collection of irrefutable, disconnected facts. The focus is on asking questions, considering alternative explanations, and weighing evidence. The process includes high expectations for students to acquire factual knowledge, but inquiry based science expects more from students than the mere storage and retrieval of information (NSF, 1997).
Assumptions

Throughout research literature, several terms are used to describe groupings of students. The terms coeducational is accepted to describe groupings including male and female students. This study will use the terms same-sex, gender-based, and single-sex when describing groupings of a single gender to reflect terms used in specific research literature cited.

Cooperative learning is an effective strategy to help students through interaction when solving a problem or in an inquiry based science lesson (Webb, Nemer, & Zuniga, 2002). Cooperative learning groups should include students with a range of ability, learning style, personality, and gender. Group composition is an important factor in effectiveness of the cooperative learning strategy. The purpose of studying role selection within coeducational and all-female cooperative groups is to examine the effect on achievement and patterns revealed through role choice to affect student learning in a positive way. Young women should feel comfortable choosing a variety of roles when working in any group. The main barrier for middle school aged females is self-confidence in achievement, body image, intellect, social standing, and independent thinking.

Summary

In summary, Chapter 1 has an overview of cooperative learning basic teaching strategy, background, purpose of study, theoretical framework, research questions, definition of terms, and assumptions. Chapter 2 has research of current literature in four main areas: Gender Achievement in STEM (Science, Technology, Engineering and
Mathematics), Gender Achievement is Same-Gender Classrooms, Cooperative Learning Influences on Achievement, and Role Assignment/Selection Influenced on Achievement.
Chapter 2: Literature Review

A review of literature pertaining to gender, grouping and achievement in science led to research how same-gender cooperative learning groups affect achievement. Current emphasis on STEM (Science, Technology, Engineering, and Mathematics) career training and coursework lead middle school science teachers to increase the use of inquiry and active participation in science lesson planning. The research completed in this study examines the achievement and role choice among rural middle school students. Chapter 2 is organized into subsections including gender achievement in STEM and same-gender classrooms, cooperative learning influences, role assignment and selection influences on achievement.

Gender Achievement in STEM

At a time when growing numbers of studies show U.S. women have achieved parity or are close to parity on science and math achievement tests, men still outnumber women at the top levels of many of those fields, particularly in quantitative sciences such as engineering and math.

Within schools, the STEM gender gap phenomenon has been reported. Girls and boys take math and science classes in equal numbers through high school, and their performance appears generally equivalent. Yet when women get into college, suddenly, fewer of them actually pursue STEM majors. The gap grows in graduate school and gets even wider post-graduation, in the work force. In academia, while women make up 40% of full-time faculty in colleges and universities, they make up only a quarter in computer and information sciences and 12% in engineering (Hill, Corboett, & Rose, 2010).
Data from the National Science Foundation on women, minorities, and persons with disabilities in science and engineering indicate women were a lower percentage of scientists and engineers who were managers than of all scientists and engineers employed in business or industry in 2006. Women were 19% of all managers and 15% of top-level managers in business or industry compared with 34% of all scientists and engineers in business or industry in 2006. Women were 8% of engineering managers, and 11% of natural sciences managers. Only in medical and health services were women more than half of managers (e.g., National Science Foundation [NSF], 2006).

As trends are followed from employment in STEM related fields and educational paths, gender gaps in STEM courses selected in high school reveal surprising data. According to MSRP Research Brief 2005, a larger percentage of female than male graduates earned credits in the following four courses: algebra II, advanced biology, chemistry, and health science/technology. A larger percentage of males than females, on the other hand, earned credits in physics, engineering, engineering/science technologies, and computer science (Laird, Alt, & Wu, 2005). Research over the past decade supports the narrowing of the gender gap in STEM related fields and course selection in high school students, and is reflective of a demonstrated need for educators to explore strategies to close the gender gap in science.

**Gender Achievement in Same-gender Classrooms**

Research related to same-gender classrooms and schools is diverse and varied. One study reported same-gender grouping leads to higher academic achievement and a more positive classroom climate than coeducational groupings (Friend, 2006). Other
findings include same-gender classrooms and groupings eliminated certain distraction from the opposite gender, especially for females. Within parochial and private schools, same-gender educational settings have provided an opportunity for students to learn without the psychosocial stresses and competition of coeducational classrooms (Gurian, 2010).

Lee and Bryck (1986) compared graduates of Catholic single-sex high schools with graduates of Catholic coeducational private schools. Boys in the single-sex high schools scored better in reading, writing, and math than did boys at co-ed high schools. Girls at the single-sex schools did better in science and reading than girls in co-ed schools. In fact, these researchers found that students at single-sex schools had not only superior academic achievement, but also had higher educational aspirations, more confidence in their abilities, and a more positive attitude toward academics, than did students at co-ed high schools. In addition, girls at the single-sex schools had less stereotyped ideas about what women can and cannot do (Lee & Marks, 1990).

Research studies and standardized assessment results have demonstrated a need for educators to explore ways to close the gender gap in the area of science favoring males. Friend (2006) cited research reported finding same-gender grouping leads to higher academic achievement and a more positive classroom climate than coeducational groupings. Some research found that results are negative or inconclusive when comparing achievement and environment in same-gender and coeducational settings (Friend, 2006).

A limited research base exists in the United States for same-gender education in public schools, due to Title IX restrictions on such programs. Since 2002, federal
regulations governing NCLB and a U.S. Department of Education review of Title IX have changed to expand flexibility in providing single-sex schools or classes within the public school system (U.S. Dept. of Education, 04-5156).

According to National Association of State Boards of Education (NASBE), NCLB recent flexibility has led to an increase in single-sex public school programs from the 12 that existed in May 2002 to 223 as of April 2006 (NASSPE). The NASBE update also reported the perception that for boys, same-gender schools are effective in reducing dropout rates, truancy, and violence while improving academic achievement. The perceived benefits for female students include better academic performance, improved attitudes toward subjects traditionally dominated by male students, and the pursuit of a wider range of career paths.

**Cooperative Learning Influence on Achievement**

Johnson, Johnson and Smith (1991) reviewed studies and literature that support the positive impact cooperative learning has on student achievement and socialization. Over 675 studies in the past 90 years have indicated cooperative learning improves academic performance, self-esteem, and interpersonal relationships more than individual or competitive strategies.

Many studies have found a relationship between cooperative learning and academic performance. Students working cooperatively completed tasks more accurately and quickly than individuals did working alone (Johnson, Johnson, & Scott, 1978). When a two-month delayed posttest was administered, cooperative groups’ scores were higher than individuals’ scores. Cooperative learning groups use higher level thinking strategies,
and elaboration more often to achieve greater learning than those working individually or competitively (Spurlin, Dansereau, Larson, & Brooks, 1984).

Cooperative groups spent more time engaged in the task, checked their concept learning more often, and scored higher on posttests than students scored working individually (Singhanayok & Hooper, 1998). Cooperative learning also appears to benefit lower-achieving students, as well as, higher-achieving, and gifted students. Gifted students gained just as much from cooperative groups as average or low-achieving students in all areas except language mechanics (Slavin, 1991).

Cooperative learning models have been demonstrated to have a markedly positive impact on student achievement. In 2002, Johnson and Johnson conducted a meta-analysis of only literature specifically analyzing the impact of cooperative learning on student achievement. In their analysis, students score on average across many studies almost two thirds of a standard deviation higher in cooperative learning situations than their peers score in competitive or individualistic learning situations.

**Role Assignment/Selection Influences on Achievement**

In general, student roles within a cooperative group should reflect equal access to inquiry-based labs. Both males and females should be actively performing inquiry-based science. Males are more active participants in conducting experiments than females are (Javonovic & King, 1989). Males tended to be more involved in manipulating science equipment and directing the activities while females performed the passive tasks of gathering, and organizing the equipment. When female students are placed in groups, are they more comfortable in assigned and selected roles? Does their achievement reflect this
confidence? Should same-sex cooperative grouping occur within a co-ed classroom? Do skills and knowledge gained from the assigned roles affect test scores?

All students should have access to learning both process and inquiry science skills and are critical to students' conceptual understanding of science. Students should be actively engaged in behaviours of planning and designing investigations (i.e., directing activities), manipulating variables, making observations, asking questions, recording data, constructing explanations, and communicating ideas to others.

Many science classes have at least one team or group project during the course of a semester, even in the absence of formal cooperative learning. Often, these groups tend to have no structure, and the work and productivity of the group may be decided by the dominant personalities. Teachers can facilitate positive interdependence among group members during a team project, through assigning, randomly or specifically, appropriate roles within groups.

Assigned roles in cooperative learning are procedural in nature and not roles of intellect or talent. Roles serve to delegate individual authority to students and engage all students in the work of the group. Structured by cooperative group roles, the intellectual work of the group is accomplished cooperatively by all team members (Tanner, Chatman, & Allen 2003). Common roles can be used in informal, as well as formal, cooperative learning groups include facilitator, recorder, reporter, and timekeeper. In addition, instructors may choose to design other procedural roles depending on the age of the students and the nature of the task (Wright, 2002).
Roles used in the study were modified to describe tasks within a middle level science inquiry-based lesson. Division of work (labor) in young students builds workplace skills for later employment, encourages individual responsibility, as well as identifying work that is meaningful to the group as a whole.

Summary

Reflective in the research literature, more research should be completed on same-gender cooperative groupings and role selection on student achievement. Identifying best practices in cooperative groups for inquiry-based science labs to increase achievement, interest, and equity within the science classroom is a goal of this study.

Chapter 3 focuses on methodology used to collect data on the effect of gender and role selection in cooperative grouping in science inquiry. Included are descriptions of the research question, identification of study participants, explanation of the procedure utilizing inquiry-based science lessons, and data discrepancies resulting from a normal public school setting.
Chapter 3: Methodology

As any educator can attest, a variety of factors affect student choices within the classroom environment. Instruction in inquiry-based science requires students to communicate, collaborate, and manipulate tools and information within pairs or groups when investigating concepts. Inquiry-based science learning involves students working cooperatively to generate their own working hypotheses, construct and generate and search for new knowledge and understanding (Veermans et al., 2005). The assumption behind inquiry-based science is that children are more motivated to learn when they are encouraged to be active participants in the learning process, investigate problems that challenge their curiosity and think creatively as they work towards commonly agreed conclusions (Turner & Patrick, 2004). The focus of this research is how individual student role assignment or choice of role cooperative groups affected test scores or achievement.

Research Questions

Specifically, the study addressed the following research questions: (1) Will the composition of cooperative learning groups affect what role a student chooses in an inquiry-based science lesson? (2) Does choice or assignment of group role have an effect on academic achievement?

Research Design

This action research study sought to investigate the impact of gender in cooperative learning groups, and how roles fulfilled within groups effected achievement. The independent variables were the coeducational and same-sex classrooms. The dependent variables were pretest and posttest scores (achievement-quantitative) and
student reflections on group roles, both assigned and selected (qualitative). The design of
this study administered a pretest and a posttest after two inquiry lessons approximately
one month apart. Each posttest included opportunity for student reflection on learning,
role participation, and future role selection.

The controls for research included the physical environment because each class
section was held in same classroom. The science teacher was the same teacher throughout
the research. Identical equipment, inquiry lessons, and assessments were used in all
science classrooms under observation. Steps were taken to limit factors that could distort
the collection of valid and reliable data. Students were in same sized groups. No
randomization of students to classrooms was possible because parents of students select
the students’ science classroom at the beginning of each academic year. The teacher
assigned students to laboratory inquiry groups based on skills, abilities, and personalities.
No outside classrooms were selected as control groups at the time of this study.
Comparisons of dependent variables were between genders and sections.

Participants

The middle school students participating in this study attend a small rural school
district in the Midwest. At the time of research, the district population of 690 students
was composed of 60% students receiving free and reduced lunch, 82% Caucasian, 17 %
Native American, and 1% African American. During school years from 1997 to 2008,
this public school offered gender-based classes to sixth and seventh grade students. When
gender-based sections are offered, unequal distribution of gender in co-ed sections is
unavoidable. Based on section choice, parents and students identify which learning
environment is the best “fit”. The practice is accepted within the gender-based program
and is the “norm” for this particular study. The student sample for this study was a
sample of convenience, with research conducted in school established class sections. The seventh grade was grouped into three sections of one same-gender and two coeducational classrooms, which created a unique opportunity to observe 23 females as a subset of a 59-student seventh grade class population.

**Research Procedure**

The two coeducational classes and one single-gender science class examined in this study met in the morning in the same science room with the same class instructor. The female science teacher has more than fifteen years of experience teaching science at the middle grades and was completing a Master’s degree in Science Education at the time of this research. Sampling in this research was conducted in a public middle school with pre-assigned classrooms, which resulted in a sample of convenience and a lack of randomization.

The research was conducted in the last marking period of the school year to ensure students’ had repeated opportunities for group inquiry and experience with various group roles. Students completed pretests and posttests for both inquiry science lessons. Pre-tests were administered prior to cooperative group inquiry lesson. Both pretests were constructed on ten objective item (multiple choice and true/false) questions that reflected the learning objectives of the inquiry lesson. Students were asked to list their group role and reflect how their role affected success in the lab. Posttests were constructed with the same test items, and scrambled choice or sentence selection. Students reflected on assigned and selected roles on each pretest and posttest. Students answered questions about roles, likes and dislikes regarding the role, and affect of the role on their learning.
Cooperative Group Roles

Role assignments increase the level of interaction and teach children how to ask, and give assistance in cooperative learning groups (Cohen & Loten, 1990). Identifying roles within a group provides structure for task completion, and equitable access to collaboration. Without role assignment, tasks are dominated by confident, “high-status” student members and do not receive the contribution of less confident student members. Cooperative learning roles vary greatly, and depend on the problem, task or inquiry the group encounters, but are generally based on roles as related by Kagan (1990) in *Cooperative Learning Resources for Teachers*.

Participants in this study played specific roles in the cooperative learning process identified as follows:

Leader: Makes sure every voice is heard. Focuses work around task.

Presenter: Presents finished work to class and organizes information.

Data Collector: Compiles members’ ideas on lab sheet or graphic organizer.

Monitor/Observer: Encourages group to stay on task. Checks time constraints.

Materials Manager: Collects and returns materials needed for task completion.

Within the science classroom, models of collaboration using cooperative learning groups are a popular way of organizing for classroom instruction. Harp (1989) indicates one of the characteristics identifying cooperative learning is student work on individual assignments (roles) related to the group task. Role assignments increase the level of interaction during a cooperative learning task (Cohen & Lotan, 1990). Group roles in the author’s classroom reflect over a decade of gender-based instruction. Roles are intentionally identified and created with gender neutrality in mind. Roles commonly used
in Cooperative Learning Resources for Teachers include taskmaster, recorder, cheerleader, gatekeeper, and checker. Roles used in this study are identified as leader, presenter, data collector, monitor/observer, and materials manager (Kagan, 1990).

All roles must be defined clearly, so the group can function with positive interdependence. Students are reinforced for functioning in their roles, as shown when a group member is absent or otherwise unable to perform part of their role. Conducting an experiment, collecting data, utilizing various materials, and meeting the objective within the class period is clearly a “group effort”.

Roles are defined before assignment and examples of interactions or scripts are offered to help students have success in the role. An example for leader role script for a student might be as follows: “Let’s hear from ________ next.” “That’s interesting, but let’s get back to our task.”

Student role assignments were based on ability and disposition. Student reflections indicating they were uncomfortable with a leader role in their previous cooperative groups were given consideration for changing roles in Lab 2. For example, some special education students express nervousness with roles that require reading of procedures (ability), or leadership role when emotionally impaired (disposition). Most students have experience with roles used in this study, and had no difficulty identifying why they favored one role over another role.

Cooperative group assigned roles in the first inquiry lab consisted of leader, presenter, data collector, and monitor/observer. During student selection of roles in the
second inquiry lab, students recommended combining the task of leader and presenter, and adding role of materials manager to increase participation in the group.

Roles of leader and presenter in Lab 1 were combined for Lab 2, after discussion in groups and class revealed a lack of “work” associated with the presenter role. Presenter has the responsibility of organizing information for presentation and presenting the group’s work to the class. The role of presenter was discussed after pre-selection data was collected, but before Lab 2 role selection took place. The decision to combine leader and presenter roles into one role was agreed to in all class sections. Students felt the leader role naturally lead to presenting group findings. Materials manager was added to include a more active role of gathering materials and tools for the lab.

**Selection of Group Roles**

Qualitative data in the form of student reflection on group roles revealed a remarkable wealth of information. Participant reflections on group roles, whether assigned or self-selected, were categorized as favorable, unfavorable, or no reflection recorded. Reflections were recorded in response to the following sentence completion questions:

1. *My role is the lab was _________________________________.*

2. *I liked my role because ________________________________.*

3. *I did not like my role because ________________________________.*

4. *Which role would you choose for the next lab and why?*

5. *How did your role help you learn the concept?*
On Lab 1 posttest, students response to item 4 “Which role would you choose for the next lab and why?” was recorded as pre-selection of role choice for Lab 2. Pre-selection did not ensure students had their role choice, but was important when looking at the effect role choice had on achievement. Lab 2 students selected roles in cooperative groups and may encounter competition for a role or settle for a second role choice.

On Lab 2 posttest, an additional question was added to inform the author of future preference in role and whether students understood the skills needed for specific roles. Students were asked to list their favorite role this year and explain what skills are needed to do this job well. The question set has been included on previous cooperative group inquiry labs during the school year. Items 4 and 5 are not included in the results, except for informing each group on future role choice.

**Group Composition**

Cooperative groups of mixed ability were established prior to student participation in the study. Of 16 cooperative groups created, six groups were all-female and 10 were co-ed. The co-ed groups were predominately male, with an average of one female to three males in groups of four. Only one co-ed grouping had two females and two males. When parents choose to place their child in an optional gender-based section, unequal gender distribution is unavoidable and is “normal” within the middle school during this research.

Cooperative groups were formed in the coeducational classes balancing achievement levels, previous behavior issues, and gender. Within the coeducational classes, female students were lower in number, representing less than one third of class composition. Each cooperative group included three or four students, one female, and
two or three male students. The all-female class cooperative groups included four
students with one group exception. For the first inquiry lesson, group roles were teacher
selected based on previous experience, ability, and academic level.

**Consistency of Inquiry Labs**

The first inquiry lesson focused on modeling the water cycle, and the second on
modeling ocean currents. Both concepts are part of the hydrosphere unit in Michigan
Grade Level Content Expectations for seventh grade science. The labs used in this study
are part of regular curriculum as selected by the author.

Michigan Grade Level Content Expectations (MDE, 2009) are organized to build
on students’ prior knowledge, and contain specific objectives for students to learn and
understand. Expectations covered in Lab 1 include identifying the sun as the major source
of energy for phenomena on the surface of the Earth. This expectation asks students to
demonstrate, using a model or drawing, the relationship between the warming by the sun
of the Earth and the water cycle as it applies to the atmosphere (evaporation, water vapor,
warm air rising, cooling, condensation, clouds).

The Water Cycle Bag Lab (UAF Geophysical Institute, 2008) is used to fulfil part
of the expectation in the author’s classroom. Lab 1 builds on prior experience of students,
and extends learning on the expectation (objective). This lab is conducted to ensure all
students feel successful, and though simple, allow students to pose additional questions
for extended learning. It is important to the author to create an atmosphere within the
classroom that fosters wonder, questioning and extension of knowledge. Simply meeting
the state requirement, although sufficient, does little to promote scientific thinking.
Expectations in Lab 2 have students describe the relationship between the warming of the atmosphere of the Earth by the sun and convection within the atmosphere and oceans. Minimally, students are required to tell or depict in written or spoken words how this relationship occurs on Earth. As this expectation is expanded in discussion, students learn convection is the transfer of heat energy through liquids and gases by moving particles, and convection currents move warmer air through the atmosphere and warmer water through the oceans. The level of difficulty in Lab 2 is determined in part by student ability and interest. The Ocean Current Lab is compiled from several similar lessons and remains flexible to meet the minimum expectation, while extending to follow student ability and curiosity.

**Inquiry-Based Lesson: Water Cycle**

The Water Cycle Bag Lab is an inquiry lab lasting two to five days, depending on group interest, questioning and available time. Students at this grade level are expected to understand how the water cycle works and interacts with the environment. Water Cycle Bag Lab pre- and post assessments are reflective of students’ prior knowledge of this content expectation. Many students do well on pretests where the objective items are vocabulary, and include familiar content.

A version of this lab is introduced at the 4th grade level using a plastic sandwich baggie and blue-tinted water. Students readily recall the previous lab and make assumptions based on previous knowledge and memory. Michigan Grade Level Content Expectations (GLCE) are scaffolding in nature, and build each grade level to include complex content, and higher order thinking skills (Blooms, 1956). Textbooks, visual aids, discussion, current events and previous content create conditions that allow students to
work independently as groups, collaborating, and problem solving with little teacher direction.

In the lab, each group creates a closed system for observing how solar energy drives the water cycle. Instructions are simple and the inquiry is “guided” with procedure, diagrams, data, analysis, and opportunity for further questioning. Much conversation, diagramming and argument occurs in this lab, as students are not given the “answer”, but search together to reach a common understanding.

Each group was asked to read the question: *What will happen to water in a cup if the cup is placed inside a sealed bag in a warm area and left overnight?* Discussion of the question within the group identified any background knowledge that would help the group predict what might happen with the scenario posed by the question. The group was directed to complete a statement of hypothesis: *If a cup of water is sealed inside a plastic bag and left overnight in a warm area, then the water in the cup will* . . .

Day 1 of the experiment includes the construction of a model to help answer the question and proposed hypothesis.

**Instructions**

1. Using a one gallon-size re-sealable plastic bag, one clear plastic cup, pink tinted water, fill the plastic cup half full of pink water, place the cup in the lower corner of the plastic bag.

2. Seal the plastic bag, making sure to leave some air inside.
3. Using duct tape, affix the bag with cup to a south-facing window, with the cup nested upright in the lowest corner.

4. Groups diagram the model and label the bag, cup, water and heat source on your drawing.

Models were left hanging overnight. All models for each class were located on the same south-facing window in the science room.

Day 2 of the inquiry lesson involved groups making observations, collecting data and diagramming changes in the model. Questions on lab sheet prompted groups to analyze data, reflect on hypothesis and draw conclusions. Additional questions and diagrams asked groups to label areas of evaporation, condensation, and precipitation on the models, and a water cycle diagram on the Earth.

This particular lab lasted four days with each group posing an additional question after the construction of the water cycle model was successful. The posttest was administered the following day. In addition to answering ten test items, students listed individual group role, preselected a role for the next lab, and reflected on the success of the collaboration.

**Inquiry-Based Lesson: Ocean Currents**

The second pretest was administered three weeks later, using the same cooperative groupings. The pretest of 10 true and false test items included two questions regarding past group role choice and preference. During this lab, students chose the group role they preferred and in most cases, were happy with their selection. Disappointment is
nearly impossible to avoid when students want the same role in some groups, but normal conditions existed during research.

The Ocean Current Inquiry Lab, adapted from "Visit to an Ocean Planet" [NASA], has students investigating currents by creating models of ocean currents. This lab is a continuation of expectations within the hydrosphere unit of study. Extending learning to include more complex and new concepts normally occurs at this time of the school year. The Ocean Current Lab required students integrate information from a display of maps on wind-driven ocean currents, sea surface temperature, and surface salinities of the oceans prior to modelling through inquiry.

Objective true and false questions on lab pretest may heighten student connections to content before exposure to map engagement activity. Looking at maps for relationships between sea surface temperature, salinity, and the locations of warm and cold currents requires higher level thinking skills of students. Groups conduct the experiment to learn more about the relationship between salinity and deep ocean currents. This lab requires map analysis, discussion of and reading new information, and creating models to construct new learning. In this experiment, the students hypothesize the cause of ocean currents and then develop a model to explain the role of salinity and density in deep ocean currents.

Initially, students are engaged through a display of maps showing (1) wind-driven ocean currents, (2) sea surface temperature, and (3) surface salinities of the oceans. Each group uses four baby food jars, two laminated index cards, table salt, red and blue food coloring, stir stick and pie pan (for spills). Each group filled both baby food jars with water, and read the following instructions.
Instructions

1. Dissolve the salt in one of the jars, add blue food coloring, and mark the jar "Salt Water."

2. Add a drop of red food coloring to the other jar and label "Fresh Water."

3. Place a 3 x 5 - index card on top of the salt water and carefully invert it.

4. Place the saltwater jar on top of the fresh water container and have a group member carefully remove the card.

5. Observe the results.

6. Use the second set of jars to repeat the experiment. This time, invert the fresh water jar over the saltwater jar.

7. Remove the card, and observe the results.

8. Take both sets of jars, turn horizontally and observe the results.

Groups answer the following questions: Is salt water heavier or lighter (higher or lower in density) than fresh water? Explain your answer in terms of the results that you obtained from your group experiment. If evaporation causes surface water to be salty, where would you expect ocean water to be very dense? Using the display of ocean maps, does the location correspond to where deep ocean currents originate? If not, can you explain why? Does the density of ocean water have any relationship to the temperature of ocean water?

Groups were asked to diagram the results and work as a group to answer questions that are more specific related posted maps and pretest questions. A normal
procedure within the science class was discussion of lab results, review of maps, overview of teaching content, and suggestions to improve lab. Groups were given the option of posing additional questions, stating hypothesis, and conducting additional tests. Several groups tested the effect of salinity, temperature, baby food jar shape and food coloring on creation of ocean currents. Results of new questions were shared in class discussion, and with other sections of seventh grade science classes. The posttest was administered the following day. Items on the posttest include reflections on success and role choice. Reflections from students were used only to inform the author, and were not graded or scored in any manner.

**Discrepancies**

During the study, gaps in complete data reflect student absences and changing school districts. Student illness, behavior issues, and family decisions affected the completion of data in seven students. Other factors effecting data were special education students requiring modified assessments, including reduction of test items on content, reading test items aloud, and accepting oral responses.

Within the student population studied, special education students required test modifications in accordance with individualized education plans. The impact of incomplete data from student absence on overall collection from this small sample was not significant. Students in groups within a school setting routinely practice flexibility under less than ideal conditions, and readily fill those roles left vacant by classmates in a laboratory experience.
Summary

The methodology used in this study is replicable and clear. Cooperative learning groups can take on many forms, and inquiry-based science lessons range from narrowly guided to completely open-ended. Cooperative groupings with specific roles enable students to identify the function they serve in the group and may increase achievement. Guided inquiry-based science lessons provide a structure for students to learn new content, discuss connections to prior knowledge, and explore ways of modeling or experimenting with scientific concepts. The results of this study are included in Chapter 4 and focus on study participants, inquiry labs, and pretest and posttest results, effect of gender and student reflections on role selection.
Chapter 4: Results

Chapter 4 has the results of statistical analyses of data for two middle school science classes (all females or co-ed). Analysis of data uses descriptive statistics and repeated measures ANOVA. Repeated measures ANOVA uses only students who experience all measures (Lab 1 pretest and posttest, and Lab 2 pretest and posttest), so student numbers will drop when examining statistical significance. This chapter has five sections, which include Participants, Inquiry Labs, Pretests and Posttests, Gender, and Student Reflections on Group Roles.

Participants

Inquiry-based science lessons completed by 59 seventh grade students at the middle school consisted of three sections, two co-educational and one all females. Coeducational sections were 17 students with three 3-member groups and two 4-member groups, and 19 students with four 4-member groups and one 3-member group. The all-female section had 23 students with five 4-member groups and one 3-member group.

Inquiry Labs

Descriptive statistics on both pretests and posttests show mixed results. Differences in pretest and posttest scores indicate learning occurred (i.e., quiz scores rose on the posttest) for most students. Difficulty levels of the two inquiry-based science labs are statistically significant. Inquiry Lab 2 was statistically more difficult ($F(3,47) = 13.753, p = .001$).
**Inquiry Lab 1.** Results from the first inquiry lab pretest were recorded from 59 participants and included a mean of 69.3% (SD = .1956). The Lab 1 posttest mean was 78.1% (SD = .1699), indicating an overall achievement in learning.

**Inquiry Lab 2.** Results from the second inquiry lab pretest were recorded from 58 participants with a mean of 59.9% (SD = .1545) and a posttest score of 70.9% (SD = .1577), indicating an overall achievement in learning. Ocean Current Lab pretest and posttest data show similar increase in overall group learning of about 10%.

**Pretests and Posttests**

Students generally achieved higher scores on posttest than pretests. Results of pre- and posttests in the study are consistent with previous years. The repeated measures statistic was validated by Mauchly’s Sphericity Test. Repeated measures ANOVA was used on pretest and posttest scores of two inquiry labs. Sphericity requires equal variances for each set of difference scores. Violations of this assumption of equal variances can invalidate the conclusions of a repeated measures analysis. The hypothesis of sphericity of equal variances was not rejected ($p > .05$). Consequently, the sphericity assumption was met. The resulting $F$-value from the repeated measures statistical analysis revealed statistical differences with sphericity assumed for the two inquiry lab difficulty levels namely ($F(1,48) = 13.415, p = .001$).

Lab 1 pretest and posttest means for all students are reflected in Table 1. The all-female and co-ed sections scored within average levels, with female section scores 5.6% higher than co-ed scores. Co-ed posttest means reflect largest gains in overall posttest average of 12.3% from pretest to posttest score. All-female section posttest scores
increased by 2.4% over pretest scores. All students averaged an increase of 8.2% comparing pretest and posttest scores, indicating student achievement.

Table 1

*Lab 1 Pretest and Posttest Means and Standard Deviations*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Pretest 1</th>
<th>Posttest 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Girls</td>
<td>21</td>
<td>73.3% (SD = 0.1826)</td>
<td>75.7% (SD = 0.1826)</td>
</tr>
<tr>
<td>Co-ed</td>
<td>30</td>
<td>67.7% (SD = 0.2161)</td>
<td>80.0% (SD = 0.1145)</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>70.0% (SD = 0.2030)</td>
<td>78.2% (SD = 0.1582)</td>
</tr>
</tbody>
</table>

*Note. N = Number of students. SD = Standard Deviation*

Pretest and posttest means for all students during Lab 2 are reflected in Table 2. Student averages were lower in Lab 2. Both sections scored within 1% on the pretest (all females = 61.4%; co-ed = 60.7%) and achieved an overall Lab 2 pretest mean of 60.1%. The all-female section Lab 2 posttest scores were 15.3% higher than co-ed posttest scores of 6.6%. Female posttest means reflect largest gains in overall posttest increase from pretest to posttest score. All students averaged an increase of 10.2% comparing pretest and posttest scores, indicating student achievement.
Table 2

*Lab 2 Pretest and Posttest Means and Standard Deviations*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Pretest 2</th>
<th>Posttest 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Girls</td>
<td>21</td>
<td>61.4% (SD = .1740)</td>
<td>76.7% (SD = .1461)</td>
</tr>
<tr>
<td>Co-ed</td>
<td>30</td>
<td>60.7% (SD = .1388)</td>
<td>67.3% (SD = .1552)</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>61.0% (SD = .1526)</td>
<td>71.2% (SD = .1570)</td>
</tr>
</tbody>
</table>

*Note.* N = Number of students. SD = Standard Deviation

**Preselected Roles Based on Gender**

Table 3 has student pre-selection of roles based on reflections on Lab 1 posttest. All male and female students, regardless of section, are represented in pre-selection choices.

Table 3

*Pre-selection Choices for Posttest Inquiry Lab 1*

<table>
<thead>
<tr>
<th>Roles</th>
<th>N</th>
<th>%</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Collector</td>
<td>17</td>
<td>31%</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Presenter</td>
<td>6</td>
<td>11%</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Leader</td>
<td>12</td>
<td>22%</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Monitor/Observer</td>
<td>19</td>
<td>35%</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>99%</td>
<td>23</td>
<td>31</td>
</tr>
</tbody>
</table>

*Note.* N = Number of students. % = Percentage
Monitor/observer ranked the highest in role pre-selection (35%) and was predominately a male choice for group role (63%). Data collector ranked second (31%) and was a female preferred role (76%). Males and females split the remaining roles with strong preference exhibited, females chose leader roles (83%) and males chose presenter roles (83%).

Difference in role pre-selection by gender within sections is shown in Table 4. Gender specific selection of role showed male preference of monitor/observer role 52% (12 students of 23) over other role selections. Males selected the role of leader 9% (2 students of 23) and data collector 17% (4 students of 23). The role of data collector was selected 17% of the time (4 students of 23) by males in co-ed groupings.

Table 4

<table>
<thead>
<tr>
<th>Roles</th>
<th>N</th>
<th>Male</th>
<th>Females</th>
<th>Co-ed Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Collector</td>
<td>17</td>
<td>4</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Presenter</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Leader</td>
<td>12</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Monitor/Observer</td>
<td>19</td>
<td>12</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>23</td>
<td>21</td>
<td>10</td>
</tr>
</tbody>
</table>

*Note. N = Number of students.*

The role of leader was the second highest in female pre-selection, with 60% (6 students of 10) of females in co-ed groupings choosing to be leaders, and 19% (4 students
of 21) in the all-female groupings. Females in the co-ed groupings selected the role monitor/observer 20% (2 student of 10) and 24% (5 students of 21) in all-female groups.

The role of presenter was least favored group role by all students, although males more frequently selected the presenter role, 22% (5 students of 23). One female chose the role of presenter from co-ed and all-female groups.

Assigned roles for Lab 1 and posttest means are reflected in Table 5. Role assignment and percentages for both females and males in all cooperative groups indicate specific role assignment increased learning. Posttest means were highest for leader (81.8%) with data collector (77.5%), presenter (78.3%), and monitor/observer (72.9%) scoring within 1% of role mean. Unequal assignment of roles indicates overall population restricts equal distribution of roles (16 4-member groups, N = 64). Student absence, behavior, and section population affected role assignment. Role of data collector was assigned to every cooperative group, with group leader role assigned (filled) the least.

Table 5

*Lab 1 Posttest Means and Standard Deviations for Assigned Roles*

<table>
<thead>
<tr>
<th>Roles</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Collector</td>
<td>16</td>
<td>77.5%</td>
<td>.1915</td>
</tr>
<tr>
<td>Presenter</td>
<td>12</td>
<td>78.3%</td>
<td>.1337</td>
</tr>
<tr>
<td>Leader</td>
<td>11</td>
<td>81.8%</td>
<td>.1471</td>
</tr>
<tr>
<td>Monitor/Observer</td>
<td>14</td>
<td>72.9%</td>
<td>.1899</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>77.4%</td>
<td>.1689</td>
</tr>
</tbody>
</table>

*Note.* N = Number of students. SD = Standard Deviation
Table 6 reflects role selection and posttest percentages for both females and males in all cooperative groupings. Posttest scores for selected roles are close in average (3%), with monitor/observer scores the highest at 75.8%. Females chose roles of data collector and leader more often than males. In all-female section groupings, 52% (11 students of 21) selected role of data collection, compared to 20% (2 students of 10) in co-ed groupings.

Table 6

*Lab 2 Posttest Means and Standard Deviations for Selected Roles*

<table>
<thead>
<tr>
<th>Roles</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Collector</td>
<td>11</td>
<td>72.7%</td>
<td>.1618</td>
</tr>
<tr>
<td>Leader</td>
<td>13</td>
<td>70.8%</td>
<td>.1847</td>
</tr>
<tr>
<td>Monitor/Observer</td>
<td>12</td>
<td>75.8%</td>
<td>.1564</td>
</tr>
<tr>
<td>Materials Manager</td>
<td>15</td>
<td>69.3%</td>
<td>.1335</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>72.0%</td>
<td>.1562</td>
</tr>
</tbody>
</table>

*Note.* N = Number of students. SD = Standard Deviation

**Student Reflections on Role Selection**

Students had an opportunity to reflect on assigned roles, selected roles, and state preference of a favorite role of the year (Appendix E). Normal conditions existed during completion of assessments, and expectation of student reflection did not ensure compliance. Most students answered assessment items and reflected as normal conduct in
this classroom. Favorable or unfavorable reflections were coded to show percentages of
student reflections on assigned and selected roles.

Males reflecting on assigned roles were favorable 57% (13 of 23 students) and
unfavorable 43% (10 of 23). Percentages changed slightly for selected roles. Males
reflecting on selected roles were favorable 59% (13 of 22 students) and unfavorable 41%
(9 of 22 students). Female reflections on assigned roles were 59% (19 of 32 students) and
unfavorable 41% (13 of 32 students). Selected roles by females were favored 61% (19 of
31 students) and unfavorable 39% (12 of 31 students). It is important to note students’
selected roles were not always first choice for students.

Males and females equally commented on a role giving them confidence, practice
at an important skill and reflected their learning as important to school (life) success.
Several females in the co-ed groupings reflected on completing roles other than the one
assigned or chosen for that lab. Females in co-ed groups also commented that they felt
they “no choice” when the opportunity to choose a role was presented.

Reflections varied in content and length. Students were encouraged to write
reflections in complete sentences, as is the practice, and to answer the prompts
thoughtfully, knowing an interested adult would be reading them. A female reflection on
data collection role selection was “I like to measure and write down observations”. Role
selection reflections for leaders revealed the need for females in co-ed grouping to be “in
charge”, and one student stated, “I like to have people actually listen to me”. Similar male
reflections regarding leader role selection identified the desire to be “in charge” and
“keep the group focused”.

38
Reflection of one male student of monitor/observer role selection was “I think it would be fun to collect data about stuff”. Males stated they preferred to observe, manipulate tools and materials, and have minimal writing tasks. Male reflections on presenter role included the following: “I like to talk in front of people and it helps with stage fear (fright)” “I think I do a good job of presenting”. The only female to choose the presenter role reflected, “I like to create a good presentation”. All students wrote at least one positive reflection about their experience with group members or the labs.

Figure 1 has the Lab 1 pretest and Lab 2 posttest means for both sections, which demonstrated significant learning from pretest to posttest.

![Figure 1](image)

Figure 1. All-female and co-ed class pretest and posttest assessment results on Lab 1 and Lab 2.
Significant differences in difficulty between Lab 1 and Lab 2 occurred between
the pretests and the posttests. Figure 2 has Lab 1 and Lab 2 pretest and posttest quiz score
means from the all-female and co-ed classes combined.

Figure 2. All-female and co-ed combined assessment results for Lab 1 and Lab 2.

Summary

Repeated measures ANOVA was used to determine if differences occurred in
student responses on pretest and posttest measures. Descriptive statistics compared
pretest and posttest means between all-female and co-ed sections and role selection.
Student reflections on group roles and percentage of role selection per inquiry lab were
discussed. Chapter 5 presents a discussion of the results in Chapter 4 within the strengths and weaknesses of the study.
Chapter 5: Discussion and Conclusion

Cooperative groups offer an opportunity for building social and communication skills, interaction and problem solving through inquiry. In his book, *Boys and Girls Learn Differently*, Gurian (2001) identifies features of “The Ultimate Middle School Classroom” which includes using gender-based groups and classes whenever possible. Within a typical co-ed section, gender-based groups are an option for any classroom. Middle school students can be a difficult population to instruct, with distraction from the opposite sex a main factor. Gender-based grouping may allow males and females an opportunity to gain skills and knowledge at a greater level, preparing them to work together with confidence, without distractions of attractions and flirting, typical of this age group.

The questions addressed in this study investigate the composition of cooperative groups affect on student role choice in an inquiry-based science lesson. Does choice or assignment of group role have an effect on academic achievement? The results show this study had no significant differences between the roles and performance on the pretest or posttest for preferred role on the last reflection. No statistical differences existed. In this sample of students, the researcher found that science achievement scores did not reflect a difference when roles were either assigned or selected.

**Strengths and Weaknesses**

Strengths within this study include cooperative grouping, which is a well-researched strategy to promote student learning while working together to accomplish shared goals, gender-based groups that allow students to learn and interact with students
with similar learning styles, and action research as conducted by a classroom teacher to inform instruction in science. Weaknesses of this study include the small sample size of students participating, difficulty of inquiry labs when compared, the changing of group roles between Lab 1 and Lab 2, and inconsistent group size in each section, related to participants.

**Cooperative Grouping**

Students that are involved in cooperative learning achieve many social and academic benefits. Cooperative classrooms are classes where students group together to accomplish significant cooperative tasks. They are classrooms where students are likely to attain higher levels of achievement, to increase time on task, to build cross-ethnic friendships, to experience enhanced self-esteem, to build life-long interaction and communication skills, and to master the habits of mind (critical, creative and self-regulated) needed to function as productive members of society.

Cooperative learning techniques are used in the author’s classroom to help students become active in constructing, discovering, and transforming their knowledge and understanding. Using cooperative learning groups in science allows students to be social, creative and see a skill or a concept as relevant for the task. For science inquiry, cooperative group strategies mirror what is expected in the real world, and much of what school tries to do is prepare students for life beyond the classroom.

**Gender-Based Groups**

This study used cooperative group composition (i.e., all-female and co-ed groups) to understand the interaction of young women and the effect working together in an all-
female group had on role choice and achievement. The author had several years of experience observing gender-based groups in science through gender-based programs at a middle school. This study used all-female groups as a condition of the gender-based program. The all-female class was compared to traditional, co-ed gender groups during science inquiry labs. The results of this study showed no statistical differences between all-female and co-ed groups. Female and co-ed groups showed similar liking or dislike for their roles.

Group composition was not consistent in the co-ed class in this study. Co-ed groups were predominately male (i.e., most groups included only one female), but one co-ed group included two females.

As teacher-leaders of a classroom, we recognize an immense overlap between the genders. Students should have an opportunity to learn in a variety of methods, including cooperative groupings that are single gender, as well as mixed gender.

**Action Research**

Action research is intentional and systematic study conducted by teachers for the intent of improving their practice and performance. Like an inquiry-based lesson, action research begins with a question, leading to research and ultimately, a method of studying the problem. This study is the author’s first action research and the results had two essential benefits to students. First, students benefitted from having a teacher as a researcher, who modeled the very behaviors teachers hope to inspire in our students. Students experienced new strategies and current practices that come because of the research focus of the teacher. Second, the teacher benefited from new knowledge,
strategies, and a paradigm shift to include new understandings in science literacy. Confidence is contagious. Teachers who feel successful share their experience and success with students. Conversely, students who see their teacher as a lifelong learner gain understanding and respect for learning and growing.

Participants

The participants in this study attended a small, public school in a rural setting. Grade level population of 59 seventh grade students created smaller than normal class sizes for the co-ed sections, and average for all-female section. For this school, population shifts occur often as students enter and leave the district throughout the school year. Class size and stability has an effect on daily learning, in particular when cooperative groups are used in the classroom. The participant population fluctuated during this study and caused students to shift roles more often than the author considered average.

Inquiry Labs

Inquiry based science labs used in this study were well tested and could be used to fulfill part of Michigan Grade Level Content Expectations for seventh grade science. The sequence of curriculum, reviewing the water cycle and introducing concept of ocean currents, is a repeated structure throughout the school year. The curriculum enables students to build on previous knowledge and connect new learning as expectations rise.

Results from pretests and posttests demonstrated students had equal and modest science achievement, which should be viewed as only a part of a larger assessment for the unit. In future research, specific group compositions and equal difficulty in labs would serve as a check on the consistency of the research results.
**Group Roles**

Perception of the monitor/observer role within cooperative groupings may have affected the selection of role. Monitor/observer was viewed as a passive role, one of watching and waiting, rather than actively observing using senses, manipulating materials and equipment, and keeping track of time on task. Conversely, in the all-female groupings, the leader role may have not carried as much “power”, as females in same-gender groups throughout tended to be more focused and to complete more tasks. Presenter role posed problems in Lab 1 as students felt nothing was asked of them until the end of the lab. Although combining presenter and leader was a realistic solution, within this study group role choice was impacted. The preselected role was the role students’ chose through reflection of posttest for Lab 1. Students did not necessarily get *that* role, resulting in inconclusive role preferences for Lab 2.

**Future Research**

Working collaboratively is required in many workplaces and creating opportunities for students to practice cooperative skills in our classrooms is important. Increasing the effectiveness of a group effort should be explored in terms of gender-based groups within a traditional coeducational setting. As part of an action research project in the future, gender groups (male and female) will be used, but consistent of difficulty of inquiry labs would be controlled for comparison and perhaps an instrument for coding interactions and reflections could be utilized.

**Summary**

The focus of this thesis was to examine the effect of group roles on achievement. Results included no significant differences between the roles and performance on the
pretest or posttest. The current study broadened this area of research and included an examination of the cooperative group strategies, gender grouping and action research by teachers. Limitations included sample size, use of selected inquiry labs, and group role changes during research. Despite these limitations, gender grouping within cooperative learning groups and the effect of role choice on student learning merit further exploration, but a larger and more diverse sample is needed to test this claim definitively.

**Author’s Reflection**

The researcher’s experience within this study has changed forever the way a classroom full of students is approached. Action research in the classroom has informed my teaching practice in ways not conceived of prior to the research. The process of designing and conducting research within the Master’s of Science program has allowed both my students and me to appreciate what it means to be a life-long learner.

At the beginning of this research, my rudimentary knowledge of conducting scientific research was restricted to the same stereotypical views as my students. White lab coats, sterile environments, and microscopes with the hum of special machinery in the background completed my idea of research. Research within a classroom of robust, hormone-laden middle school students is a far different scenario. Teaching science by “doing” scientific research has evolved as the ultimate professional development for this scientist/teacher. My experience through researching gender groupings, role selection, and achievement in my students will continue to inform and enrich my teaching practice for years to come. Watching their teacher struggle, question, and persist in her learning has served to give students a real life model of what it means to be a scientist.
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doi.:10.1207%2Fs1532690xci0104_3


doi:10.1111%2Fj.1467-9620.2004.00404.x

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Appendix A: IRB Approval Letter

May 5, 2009

TO: Maria Affalter
   Education

FROM: Cynthia A. Prosen, Ph.D.
      Dean of Graduate Studies & Research

RE: Human Subjects Proposal # HS09-270

"Effect on Achievement and Self-reflection in Same-sex and Co-ed Seventh Grade Classrooms for Inquiry-based Science Labs"

The Internal Review Board (IRB) has reviewed your proposal and has given it final approval. To maintain permission from the Federal government to use human subjects in research, certain reporting processes are required. As the principal investigator, you are required to:

A. Include the statement "Approved by IRB: Project # (listed above) on all research materials you distribute, as well as on any correspondence concerning this project.

B. Provide the Internal Review Board letters from the agency(ies) where the research will take place within 14 days of the receipt of this letter. Letters from agencies should be submitted if the research is being done in (a) a hospital, in which case you will need a letter from the hospital administrator; (b) a school district, in which case you will need a letter from the superintendent, as well as the principal of the school where the research will be done; or (c) a facility that has its own Institutional Review Board, in which case you will need a letter from the chair of that board.

C. Report to the Internal Review Board any deviations from the methods and procedures outlined in your original protocol. If you find that modifications of methods or procedures are necessary, please report these to the Human Subjects Research Review Committee before proceeding with data collection.

D. Submit progress reports on your project every 12 months. You should report how many subjects have participated in the project and verify that you are following the methods and procedures outlined in your approved protocol.

E. Report to the Internal Review Board that your project has been completed. You are required to provide a short progress report to the Internal Review Board in which you provide information about your subjects, procedures to ensure confidentiality/anonymity of subjects, and the final disposition of records obtained as part of the research (see Section II.C.7.c).

F. Submit renewal of your project to the Internal Review Board if the project extends beyond three years from the date of approval.

It is your responsibility to seek renewal if you wish to continue with a three-year permit. At that time, you will complete (D) or (E), depending on the status of your project.

kjm

E-mail: contedu@nmu.edu  ■ Web site: www.nmu.edu/ce
### Appendix B: Data

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The asterisk indicates a student fills both roles of leader and presenter by choice (e.g., only 3 to a group) or by need (e.g., student absent).
## Appendix B: Data Page 2

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<td>Keep your group on task, help others with jobs.</td>
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<td>Data Collector</td>
<td>3</td>
<td>You need good listening skills and to watch and write down what is happening</td>
</tr>
<tr>
<td>30-M</td>
<td>Materials Manager</td>
<td>5</td>
<td>I like to get the materials</td>
</tr>
<tr>
<td>31-F</td>
<td>Materials Manager</td>
<td>5</td>
<td>You need to follow directions and get the right stuff</td>
</tr>
<tr>
<td>32-M</td>
<td>Materials Manager</td>
<td>5</td>
<td>Steady hands so you don't drop things and you have to know what to get.</td>
</tr>
<tr>
<td>33-M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34-M</td>
<td>Data Collector</td>
<td>1</td>
<td>Write neatly and understand what's happening to write it down.</td>
</tr>
<tr>
<td>35-M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36-M</td>
<td>Data Collector</td>
<td>1</td>
<td>Watch what is happening and write it down.</td>
</tr>
<tr>
<td>37-F</td>
<td>Leader</td>
<td>3</td>
<td>Stay focused to lead and understand the lab.</td>
</tr>
<tr>
<td>38-M</td>
<td>Materials Manager</td>
<td>5</td>
<td>You need to be responsible to get all materials when needed and be careful.</td>
</tr>
<tr>
<td>39-F</td>
<td>Leader</td>
<td>3</td>
<td>I like to motivate people so you have to have order, organization, and a way of helping others.</td>
</tr>
<tr>
<td>40-M</td>
<td>Materials Manager</td>
<td>5</td>
<td>You have to get the right materials and follow directions.</td>
</tr>
<tr>
<td>41-M</td>
<td>Data Collector</td>
<td>1</td>
<td>Carry a lot of stuff.</td>
</tr>
<tr>
<td>42-F</td>
<td>Leader</td>
<td>3</td>
<td>Reading and following directions, listening to your group, keeping everyone organized.</td>
</tr>
<tr>
<td>43-M</td>
<td>Monitor/Observer</td>
<td>4</td>
<td>You have to see what happens in the lab.</td>
</tr>
<tr>
<td>44-M</td>
<td>Monitor/Observer</td>
<td>4</td>
<td>You got to pay attention.</td>
</tr>
<tr>
<td>45-M</td>
<td>Materials Manager</td>
<td>5</td>
<td>I got to use the materials a lot.</td>
</tr>
<tr>
<td>46-M</td>
<td>Materials Manager</td>
<td>5</td>
<td>I liked getting the materials.</td>
</tr>
<tr>
<td>47-F</td>
<td>Leader</td>
<td>3</td>
<td>You need to be responsible and have everything caught up in class.</td>
</tr>
<tr>
<td>48-F</td>
<td>Leader</td>
<td>3</td>
<td>You need to understand and take full responsibility.</td>
</tr>
<tr>
<td>49-M</td>
<td>Monitor/Observer</td>
<td>4</td>
<td>Watch closely and take down notes and study them.</td>
</tr>
<tr>
<td>50-F</td>
<td>Monitor/Observer</td>
<td>4</td>
<td>Good eyesight, being quiet, legible handwriting.</td>
</tr>
<tr>
<td>51-M</td>
<td>no preference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52-F</td>
<td>Leader</td>
<td>3</td>
<td>Skills to point out mistakes, explain what is going on in lab.</td>
</tr>
<tr>
<td>53-M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54-M</td>
<td>Monitor/Observer</td>
<td>4</td>
<td>Good paying attention, not writing skills.</td>
</tr>
<tr>
<td>55-M</td>
<td>Data Collector</td>
<td>1</td>
<td>Take notes on what is happening.</td>
</tr>
<tr>
<td>56-M</td>
<td>Leader</td>
<td>3</td>
<td>You need to be able to control your group.</td>
</tr>
<tr>
<td>57-M</td>
<td>Materials Manager</td>
<td>5</td>
<td>Listen, and read directions.</td>
</tr>
<tr>
<td>58-F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>59-M</td>
<td>Materials Manager</td>
<td>5</td>
<td>Use the materials correctly and good eye-hand coordination</td>
</tr>
</tbody>
</table>
Appendix C: Ocean Currents Inquiry Lab

SALINITY AND DEEP OCEAN CURRENTS

OVERVIEW
Ocean currents arise in several different ways. For example, wind pushes the water along the surface to form wind-driven currents. Over larger areas, circular wind patterns create hills and valleys on the ocean surface. In these areas, the balance between gravity and Earth’s spin causes geostrophic currents to flow.

Deep ocean currents are caused by differences in water temperature and salinity. In this experiment, the students will hypothesize the cause of ocean currents and then develop a model to explain the role of salinity and density in deep ocean currents.

CONCEPTS
• Salt water is more dense than fresh water, and is therefore heavier.
• When ocean water evaporates, the water becomes more dense because most of the salt remains in the water. In some regions of the ocean, circulation is based upon the mixing between more dense surface water and less dense layers of deeper water.

MATERIALS
• 4 Baby food jars
• 2 Laminated index cards
• Table salt
• 2 Colors of food coloring
• Stir stick
• Dish pan (for spills)
• Towels
• Map of deep ocean currents
• Map of sea surface temperature
• Map of surface salinities

PREPARATION
It is important to do this activity before your students do it. This will give you a chance to see and work out any potential problems beforehand. Be sure that your jars have flat lips, and have the students add a lot of salt to the salt water jar.

Gather the supplies or send a supply list home with the students. Make sure that the students mark their names on anything they bring to class that will be returned home.

Set up one activity station for each group of four students. Provide each group with a check list of supplies and a copy of the setup procedures. Make sure that the students complete this activity over a tray or dish pan; it can be very messy.

Divide the class into groups of four. This allows for participation of all members. You may wish to assign each student in the group a job. One student could be the equipment and setup monitor. Another student could be the recorder. The third student could be the group spokesperson. The fourth student could be responsible for the clean-up of the activity.
PROCEDURE

Engagement
Display the maps of wind-driven ocean currents, sea surface temperature, and surface salinities of the oceans [Figs. 1, 2, 3]. Have the students look for relationships between sea surface temperature, salinity, and the locations of warm and cold currents. Ask the students to write a hypothesis that explains these relationships, if possible.

Conduct the following experiment to learn more about the relationship between salinity and deep ocean currents.

Activity
1. Fill both baby food jars with water. Dissolve the salt in one of the jars and add blue food coloring. Make sure to mark the jar “Salt Water.” Add a drop of red food coloring to the other jar and label it “Fresh Water.”

2. Place a 3 x 5 index card on top of the salt water and carefully invert it. Place the salt water jar on top of the fresh water container and have someone carefully remove the card. Observe the results.

3. Use the second set of jars to repeat the experiment. This time, invert the fresh water jar over the salt water jar. Remove the card, and observe the results.

4. Take both sets of jars, turn horizontally, remove the card and observe the results.

5. Is salt water heavier or lighter (higher or lower in density) than fresh water? Make sure that you explain your answer in terms of the results that you obtained from your experiment. If evaporation causes surface water to be salty, where would you expect ocean water to be very dense? Does this correspond to where deep ocean currents originate? If not, can you explain why? Does the density of ocean water have any relationship to the temperature of ocean water?

Explanation
Thermohaline circulation is the name for currents that occur when colder, saltier water sinks and displaces water that is warmer and less dense. In this activity, you examined the relationship between salinity and deep ocean currents without changing the water’s temperature.

In Earth’s equatorial regions, surface ocean water becomes saltier as the water, but not the salt, evaporates. However, the water is still warm enough to keep it from sinking. Water that
flows towards the poles begins to cool. In a few regions, especially in the North Atlantic, cold salty water can sink to the sea floor. It travels in the deep ocean back towards the equatorial regions and rises to replace water which is moving away at the surface. This whole cycle, called the global conveyor belt, is very important in regulating climate as it transports heat from the equatorial regions to polar regions of Earth. The full cycle can take a thousand years to complete.

**Extension**

Have students compare the map of sea surface temperature to the map of surface salinity. They should also view the animation of the “global conveyor belt.” Based on what they’ve learned from the animation and this activity, what combination of temperature and salinity favors the sinking of ocean water? Think about the parts of the ocean where cold salty ocean water tends to sink. Can fresh water from nearby land masses affect the salinity there? How might the influx of fresh water affect the “global conveyor belt?”

Could global warming and associated melting of polar ice affect “the global conveyor belt”?

**Links to Related CD Activities, Images, and Movies**

Map of *Geostrophic currents* Map of *Wind-driven ocean currents* Image of *Sea surface*

**Vocabulary**

<table>
<thead>
<tr>
<th>current</th>
<th>density</th>
<th>displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>geostrophic</td>
<td>hypothesis</td>
<td>model</td>
</tr>
<tr>
<td>salinity</td>
<td>temperature</td>
<td>thermohaline circulation</td>
</tr>
<tr>
<td>wind-driven current</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*temperature* Image of *Surface salinity of the oceans* Image of *Global conveyor belt*

Animation of *Global conveyor belt* Activity *Temperature and Deep Ocean Circulation*

**Source**

Adapted from Kolb, James A. Marine Science Center. Marine Science project: For Sea. p. 88 - 90.
Figure 1. Wind-driven surface current.
Visit to an Ocean Planet

Sea Surface Temperature

Figure 2.

Degrees Centigrade
Appendix D: Water Cycle Bag Inquiry Lab

Water Cycle Bag
Grades 5-8

Overview:
During this activity, students will witness evaporation, condensation, and precipitation by enclosing water in an airtight bag and leaving it in a warm area.

The student will:
• research the water cycle;
• construct a model water cycle;
• recognize that water changes from one state to another; and
• learn the stages of the water cycle.

GLEs Addressed:

Science
• [5-8] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.
• [6] SA1.2 The student demonstrates an understanding of the processes of science by collaborating to design and conduct simple repeatable investigations.
• [7] SA1.2 The student demonstrates an understanding of the processes of science by collaborating to design and conduct simple repeatable investigations, in order to record, analyze (i.e., range, mean, median, mode), interpret data, and present findings.
• [8] SA1.2 The student demonstrates an understanding of the processes of science by collaborating to design and conduct repeatable investigations, in order to record, analyze (i.e., range, mean, media, mode), interpret data and present findings.
• [6] SD1.2 The student demonstrates an understanding of geochemical cycles by identifying the physical properties of water within the stages of the water cycle.
• [6] SD3.1 The student demonstrates an understanding of cycles influences by energy from the sun and by Earth’s position and motion in our solar system by connecting the water
cycle to weather phenomena.

Materials:
- Gallon-size resealable plastic bags (one per student)
- Permanent markers (5 per class)
- Clear plastic Dixie cups (one per student)
- Water
- Pitcher
- Red food coloring (1 bottle)
- Duct tape (1 roll)
- Global Climate Change CD-ROM • STUDENT LAB PACKETS: “Water Cycle Bag”

Activity Preparation:
Fill a pitcher with water, add several drops of red food coloring, and stir. Water should be noticeably pink.
Activity Procedure:

1. **Day one:** Build a water cycle bag (see steps 4-6) in front of the students and ask them what will happen to the water in the cup if the bag is left in the sun or near a heater vent. Students may know that the water will evaporate. Point out that the cup is sealed inside the bag. Ask students where the water vapor will go. Facilitate discussion of student hypotheses.

2. Distribute the STUDENT LAB PACKETS. Provide students with an opportunity to research the water cycle on the Global Climate Change CD-ROM, or other materials in the classroom or library to help them develop a hypothesis. Ask students to complete the hypothesis portion of their lab packet.

3. Distribute supplies and ask students to build their own water cycle bags. Make sure students write their names on the bags with permanent markers before placing the cup of water into the bag.

4. Ask students to fill a clear plastic cup half full with colored water from the pitcher, and mark the level of the water in the cup (with a marker on the side of the cup). The cups of water represent oceans, rivers and lakes.

5. Ask students to place the cup in the bag, taking care not to spill the water into the bag. Demonstrate how to hold the bag by one corner so the cup nests into the bottom corner of the bag. The bag represents the atmosphere and air.

6. Ask students to seal the bag, leaving some air inside the bag.

7. Using a piece of duct tape about three inches long, ask students to affix their bags to a south-facing window (or near a heat source) with the cup nested upright in the lowest corner. Leave the bag overnight. Ask students to complete question #1 in the Data section of their lab packets.

8. **Day two:** Some water from the cup should evaporate and condense on the bag, and will then roll down and pool in the bottom of the bag. Look to see if the level of water in the cups is lower. The water on the sides and in the bottom of the bag represents rain.

9. Explain that the water from the cups (representing lakes, rivers, oceans) evaporates into the air in the bag and condenses on the bag (representing clouds). It then runs down inside the bag to the bottom of the bag (representing rain, snow or other precipitation).

10. Ask students to complete their lab packets.
Answers to Student Lab Packets:

1. 

(Heat source will vary)

2. 

(Heat source will vary)

Water on sides of bag

3. On day 1, all the water was pink and in the cup. On day 2, some pink water remains in the cup, but there also is clear water in the bottom of the bag and on the sides of the bag.

4. a

5. d
6. **Conclusion/Explanation**: evaporate into the air in the bag, then condense on the sides of the bag and run down into the bottom of the bag. Explanations will vary.

7. **Further Questions**:
Testable Question:
What will happen to water in a cup if the cup is placed inside a sealed bag in a warm area and left overnight?

Background Research:
Research Earth’s water and the water (hydrologic) cycle on the Global Climate Change CD-ROM, or other resources in your classroom. Use what you learn to help you write your hypothesis.

Hypothesis:
Complete the statement below:
If a cup of water is sealed inside a plastic bag and left overnight in a warm area, then the water in the cup will:
________________________
________________________
________________________
________________________

Experiment:
Materials:
• 1 gallon-size resealable plastic bag
• Permanent marker
• 1 clear cup
• Pink water
• Duct tape

Procedure:
1. Write your name on the bag with a permanent marker.
2. Fill a clear plastic cup half full with colored water from the pitcher, and mark the level of the water in the cup (with a marker on the side of the cup).
3. Place the cup in a bottom corner of the bag, being careful not to spill any water. Hold the bag by one corner so the cup nests into the bottom corner of the bag.

4. Next, seal the bag, making sure to leave some air inside.

5. Using a piece of duct tape about three inches long, affix the bag to a south-facing window with the cup nested upright in the lowest corner. Leave the bag in the sun until tomorrow.
Name: __________________________________

Water Cycle Bag
Student Lab Packet

Data:
1. Hang up your water cycle bag and draw a picture of it in the box labeled Day 1 below. Label the bag, cup, water and heat source on your drawing.

   DAY 1:
   

2. Leave your water cycle bag hanging overnight, then draw a picture of it in the box labeled Day 2 below. Label the bag, cup, water and heat source on your drawing.

   DAY 2:
Name: ______________________________

Water Cycle Bag
Student Lab Packet

Analysis of Data:

3. What differences do you see between your drawing for Day 1 and your drawing for Day 2? Look at the location and color of the water.
4. Where is the water located on Day 1?
   a. In the cup
   b. In bottom of the bag
   c. On the sides of the bag
   d. All of the above
5. Where is the water located on Day 2?
   a. In the cup
   b. In bottom of the bag
   c. On the sides of the bag
   d. All of the above

Conclusion:

If a cup of water is sealed inside a plastic bag and left overnight in a warm area, then the water in the cup will:

   Explain how you reached this conclusion.
Name: ______________________________________

Water Cycle Bag
Student Lab Packet

Further Questions:

Draw arrows to indicate the path of the water in the water cycle bag below. Label evaporation, condensation and precipitation in this model of the water cycle.

Draw arrows to indicate the path of water in the picture below. Label evaporation, condensation, and precipitation on this drawing of Earth’s water cycle.
Appendix E: Pretests and Posttests for Inquiry Labs

Solar Energy and the Water Cycle

Pre Lab-Assessment

1. Water droplets in a cloud collide and form larger droplets until they are pulled to the ground by
   a. Solar energy  
   b. Thermal energy
2. Warm air in the atmosphere has added energy, with molecules moving faster, which causes
   a. Molecules to move together  
   b. Molecules to rise
3. What type of system allows energy to move in and out, but not matter?
   a. open system  
   b. cool system
4. What shape best represents the water cycle?
   a. Square  
   b. Circle
5. Energy that heats the Earth’s surface, both land and water, is called
   a. Kinetic energy  
   b. Radioactive energy
6. Water as a gas in the atmosphere is called
   a. Water vapor  
   b. Carbon dioxide
7. A process by which liquid water changes into a gas is called
   a. Condensation  
   b. Transpiration
8. When water vapor collects together and changes back into a liquid, becoming a part of mist, dew, 
fog or clouds it is called
9. The ________ temperature in the atmosphere causes water vapor to change state and condense as a liquid.
   a. warmer       c. cooler
   b. Faster       d. slower

10. The water cycle is the continuous movement of water on the Earth.
    a. no, it is not continuous       c. no, only some of the time
    b. yes, only in the oceans       d. yes, including land, water and air
Solar Energy and the Water Cycle

Post Lab-Assessment

11. Energy that heats the Earth’s surface, both land and water, is called
   c. Kinetic energy  c. Electrical energy
d. Radioactive energy  d. Solar energy

12. Water droplets in a cloud collide and form larger droplets until they are pulled to the ground by
   c. Solar energy  c. atmospheric energy
d. Thermal energy  d. gravitational energy

13. Warm air in the atmosphere has added energy, with molecules moving faster, which causes
   c. Molecules to move together  c. molecules to change state
d. Molecules to rise  d. molecules to sink

14. A process by which liquid water changes into a gas is called
   c. Condensation  c. precipitation
d. Transpiration  d. evaporation

15. When water vapor collects together and changes back into a liquid, becoming a part of mist, dew, fog or clouds it is called
   c. Condensation  c. precipitation
d. Transpiration  d. evaporation

16. Water as a gas in the atmosphere is called
   c. Water vapor  c. oxygen
d. Carbon dioxide  d. precipitation

17. What shape best represents the water cycle?
   c. Square  c. rectangle
d. Circle  d. triangle

18. The ________ temperature in the atmosphere causes water vapor to change state and condense as a liquid.
   c. warmer  c. cooler
d. Faster  d. slower
19. What type of system allows energy to move in and out, but not matter?
   a. open system    c. closed system
   b. cool system    d. weather system

20. The water cycle is the continuous movement of water on the Earth.
   a. no, it is not continuous    c. no, only some of the time
   b. yes, only in the oceans    d. yes, including land, water and air

Reflection: What your role was in your lab group? (Leader, Data collector, Monitor/Observer, Presenter)
Respond to the following questions with complete thoughts.

My role in the lab was ________________________________

I liked my role because _________________________________________________________________

I did not like my role because __________________________________________________________

Which role would you choose for the next lab experience and why?
   _________________________________________________________________________________

How did your role help you learn the information?___________________________________________

Any additional comments about your group work?
Ocean Currents Lab

Pre-Assessment

True or False: Place a “T” for true statements and “F” for false statements.

1. _____ Oceans cover nearly two thirds of the Earth’s surface.
2. _____ Land heats up quicker than water and retains the heat for longer periods.
3. _____ Heat from the sun is transferred by ocean currents to Polar Regions.
4. _____ Surface currents are mainly wind-driven and occur in all of the world’s oceans.
5. _____ The Coriolis Effect states that deep ocean currents spin in a clockwise direction.
6. _____ Gigantic ocean currents that come into contact with continents are called gyres.
7. _____ The downwelling of water is the opposite of upwelling of water.
8. _____ Salinity is the measure of “saltiness” of ocean water.
9. _____ Density-driven circulation of ocean water caused by temperature and salinity is called thermohaline circulation.
10. _____ A slowly flowing (over 1,000 years) dense, cold current is called “the ocean conveyor belt”.

**Indicate below the “roles” and the number of times you have had in the past marking period.**

Leader _____ Monitor/Observer _____ Materials Manager _____ Data Collector ______

**What role would you most like to have?** ______________________________

**Why?** ______________________________________________________________

**What role would you least like to have?** ______________________________

**Why?** ______________________________________________________________
True or False: Place a “T” for true statements and “F” for false statements.

11. ____ The downwelling of water is the opposite of upwelling of water.
12. ____ Oceans cover nearly two thirds of the Earth’s surface.
13. ____ Heat from the sun is transferred by ocean currents to Polar Regions.
14. ____ A slowly, flowing (over 1,000 years) dense, cold current is called “the ocean conveyor belt”.
15. ____ Surface currents are mainly wind-driven and occur in all of the world’s oceans.
16. ____ The Coriolis Effect states that deep ocean currents spin in a clockwise direction.
17. ____ Gigantic ocean currents that come into contact with continents are called gyres.
18. ____ Land heats up quicker than water and loses heat faster than water.
19. ____ Salinity is the measure of “saltiness” of ocean water.
20. ____ Density-driven circulation of ocean water caused by temperature and salinity is called thermohaline circulation.

Please answer completely the questions below.

What role were you assigned for this lab?

Leader ______ Monitor/Observer ______ Materials Manager ______ Data Collector ______

What did you like about this role? _____________________________________________
__________________________________________________________________________

What did you not like about this role? ___________________________________________
__________________________________________________________________________

List your favorite role this year and explain what skills are needed to do this job well.

____________________________________________________________________________