



A study of cooperative learning group dynamics in an inquiry-based physics course  
by Meredith Jennings Wills-Davey

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science Physics  
Montana State University

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Abstract:

We consider the nature of group dynamics in small cooperative learning groups in the inquiry-based physics course Physics 201: Physics by Inquiry. Our study was motivated by observed changes in the behavior of some students as they participated in various groups during the Spring 1998 semester. In order to understand the origin of these behavior changes, approximately half of the class was interviewed concerning their group experiences.

The results of these interviews suggested that students could be categorized into five different group learning styles, and that certain combinations of learning styles led to positive' productive group dynamics, while other combinations led to internal group friction. The strongest predictor of group interaction appeared to stem from a student's previous experience with the course subject matter; students with some background in physics had extreme difficulty working with novice learners. A less strong but noticeable predictor related to the students' self-confidence as learners. Students without previous physics knowledge could be classified into four levels of confidence, and it was found that extremely confident students had difficult working with extremely insecure students.

We formed hypotheses for organizing cooperative learning groups with successful group dynamics based on this categorization scheme, and applied them to two sections of Physics by Inquiry in the Fall 1998 semester. Students from this semester were then also interviewed. We found that, when our grouping strategies were implemented, group success rates increased from 36% in the Spring 1998 semester to 75% in the Fall 1998 semester.

However, data from the Fall 1998 semester revealed several secondary problems. Non-traditional students were observed to conflict with traditional students in certain circumstances. When students with previous physics experience were grouped together, problems with the curriculum became apparent. Finally, assigning multiple groups throughout the semester was found to have negative effects on student interactions. Our original hypotheses were modified to help rectify these problems.

We conclude that our cooperative grouping strategies are extremely effective for creating groups with positive and productive dynamics. We compare them to grouping techniques used in other studies, and we discuss the potential for wider implementation.

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IN AN INQUIRY-BASED PHYSICS COURSE

by  
Meredith Jennings Wills-Davey

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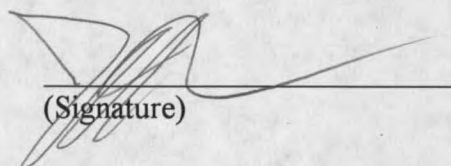
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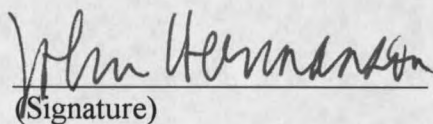
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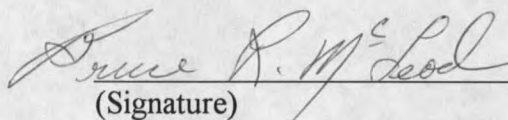
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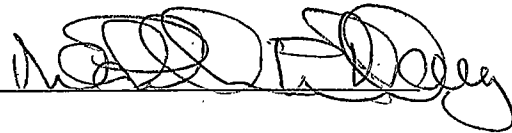
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## ABSTRACT

We consider the nature of group dynamics in small cooperative learning groups in the inquiry-based physics course *Physics 201: Physics by Inquiry*. Our study was motivated by observed changes in the behavior of some students as they participated in various groups during the Spring 1998 semester. In order to understand the origin of these behavior changes, approximately half of the class was interviewed concerning their group experiences.

The results of these interviews suggested that students could be categorized into five different group learning styles, and that certain combinations of learning styles led to positive, productive group dynamics, while other combinations led to internal group friction. The strongest predictor of group interaction appeared to stem from a student's previous experience with the course subject matter; students with some background in physics had extreme difficulty working with novice learners. A less strong but noticeable predictor related to the students' self-confidence as learners. Students without previous physics knowledge could be classified into four levels of confidence, and it was found that extremely confident students had difficulty working with extremely insecure students. We formed hypotheses for organizing cooperative learning groups with successful group dynamics based on this categorization scheme, and applied them to two sections of *Physics by Inquiry* in the Fall 1998 semester. Students from this semester were then also interviewed. We found that, when our grouping strategies were implemented, group success rates increased from 36% in the Spring 1998 semester to 75% in the Fall 1998 semester.

However, data from the Fall 1998 semester revealed several secondary problems. Non-traditional students were observed to conflict with traditional students in certain circumstances. When students with previous physics experience were grouped together, problems with the curriculum became apparent. Finally, assigning multiple groups throughout the semester was found to have negative effects on student interactions. Our original hypotheses were modified to help rectify these problems.

We conclude that our cooperative grouping strategies are extremely effective for creating groups with positive and productive dynamics. We compare them to grouping techniques used in other studies, and we discuss the potential for wider implementation.

## CHAPTER 1

### INTRODUCTION

#### A Brief Description of Physics Education Research

Physics has a reputation as a difficult academic subject, both to learn and to teach. As one of its main goals, the burgeoning field of physics education research strives to make physics more accessible to students. This is being done largely through a reexamination of the nature of subject material, the effectiveness of teaching techniques, and the appropriateness of assessment procedures. Progressive instructors are moving towards more conceptual – rather than formula-based mathematical – understandings of physics concepts. The more didactic methods of instruction, such as large-enrollment lectures or recitation sessions, are giving way to classrooms in which students are more actively involved. Student discussion is encouraged, with students often being challenged to question and justify results. Laboratory activities are moving away from exercises that merely verify well-known experiments, and instead are focusing on creating cognitive conflicts which challenge students to confront and resolve their own non-Newtonian preconceptions.

One teaching environment that has gained popularity in the physics education community is the small cooperative learning group. These groups typically consist of 3-4 students, and are organized with the expectation that the students within the groups will

work collectively toward some common goal, such as solving problems, producing a group project, or learning designated subject material. The use of cooperative learning groups is not new. There are relevant and compelling sociological studies dating back to the mid-1950s. However, with the recent onset of physics education research as a recognized field within the discipline of physics, the physics community has renewed interest in this style of learning in the hope of improving student understanding.

Myriad studies have examined the effectiveness of cooperative learning groups for teaching physics. Since laboratory work already has a history of using small groups, many of the recent studies (Cottle & Lunford, 1995; Emkey, 1979; Heller & Hollabaugh, 1992; Heller, Keith, & Anderson, 1992; etc.) have used cooperative learning groups as a supplement to more traditional lecture-based teaching methods, using the discussion format to focus on problem-solving skills. In most of these cases, students were organized to work quantitative problems individually with help from fellow group members. In some other cases, the group was assigned to work collaboratively on a single solution to a posed problem.

Other research (Shaffer & McDermott, 1992, for example) examined cooperative groups as a potential format for all instruction, with a strong focus on conceptual understanding. Here, rather than the more free-form discussion of problem-solving sessions, instructors would interact with the students through Socratic dialogue, providing an environment of guided inquiry. At least two curricula have been created that take students through the guided inquiry process: McDermott's Physics by Inquiry and Laws'

## Workshop Physics.

### The Motivation for our Study

This study was inspired by an instructor's observation of student behavior during the Spring 1998 semester in a non-lecture-based physics course using cooperative group learning and guided-inquiry techniques to teach physics. This particular physics class was *Physics 201: Physics by Inquiry*, a course offered at Montana State University - Bozeman primarily for pre-service elementary school teachers using curricula derived from McDermott's *Physics by Inquiry*. The population of the section under study was predominantly female – seventeen women and two men – and included many students who were extremely unfamiliar with, and in some cases even “phobic” of, physics. Students were for the most part of traditional age, and with the exception of one Native American student, all were Caucasian.\*

While cooperative group learning had been used since the inception of the course in 1995, effective techniques of student grouping were not considered before this study. Students created self-formed groups on the first or second day of class<sup>†</sup> and remained in those groups throughout the semester. In the Spring 1998 semester, the instructors implemented mandatory group switching to allow students to interact with members of the class outside their initial groups. The initial groups were still self-formed, but the three

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\* Because of the lack of gender and ethnic diversity, we did not consider these variables separately in our study.

† For some semesters, the first day of class is devoted to social activities, so that students can have some interaction with all of the other members of the class before choosing groups.

subsequent rounds of groups were instructor-assigned. There was no particular instructor motivation behind grouping assignments.

When the instructors reassigned groups, they noticed obvious changes both in individual student behavior and in overall group dynamics. Some students appeared more dominant or passive depending on their group composition. Others seemed engaged and interactive in one group, only to instigate conflict in another. To understand these observed "personality" changes, nine students were interviewed from the Spring 1998 semester. Surprisingly, the information provided in these interviews proved more useful as a diagnostic of group dynamics than as a window into the temperaments of individuals. Unmistakable patterns emerged, which suggested that the nature and success of dynamics in small cooperative learning groups was not only understandable, but often predictable.

The aforementioned informal observations motivated the principle research question for this study: Based on limited initial student-provided data, is it possible to organize cooperative learning groups in which all students will be engaged, productive contributors and learners? The following chapters present the results of this study. Chapter 2 offers data and conclusions derived from the interviews of the Spring 1998 students. Chapter 3 compares our results with those of other studies of cooperative learning groups, and discusses similarities and differences. For Chapter 4, we implement the hypotheses derived in Chapter 2 in two sections of the Fall 1998 offering of Physics by Inquiry and discuss our findings. Chapter 5 offers our conclusions and implications for use of our findings by other instructors.

## CHAPTER 2

### EXAMINING STUDENT BEHAVIOR

#### Procedure

Our study was motivated by observations of changes in student behavior as groups were reorganized. Nine undergraduate students – out of a class of nineteen – were interviewed about their group learning experiences in Physics 201. Six of the interviewees were selected because the instructors noted their behavior changed from group to group. The other three students appeared to behave consistently in all groups, and were chosen to function as a quasi-control group. The interviewers had no contact with the students before or after their interviews. The interviews were performed individually with the interviewers working from a script. Students were prompted to describe their personal experiences in their first three learning groups. They were asked specifically about how they interacted with other students in their groups. The interviewer focused the questions on the various roles each student played, their subsequent behaviors, and on the hierarchy that formed within each group. Students were also asked to describe positive or negative experiences within each group.

The interviews were audio-taped and transcribed. The investigator organized quotes from the interviews into three overarching categories: participation, hierarchy, and group dynamics. These categories often overlapped and were used mainly to group

comments about similar topics. The "participation" category focused on the level of involvement of each student in a group; the "hierarchy" category discussed issues such as leadership and general group organization; and the "group dynamics" category regarded the social interactions between group members.

Because the investigator was interested in changes in students' roles from group to group, students' personality traits were cross-referenced. If two interviewees provided radically different descriptions of a particular student's behavior in different group settings, the motivation for these personality changes would be considered; if not, it would suggest that group organization alone led to changes in a student's behavior.

## Data

### Personality Descriptions

In most cases, student descriptions of fellow group members' behavior were consistent, regardless of group or personal relationship. Negative traits received more attention than positive ones, and most interviewees had the same negative reactions to the same students. Thus, there were considerably more data on some students than others. In such detailed cases, no external descriptions proved incongruous, and the only inconsistencies in self-reports arose where students were not aware of their own negative characteristics. As an example, one student is described by members of her three different groups:



*The girl that liked to ask the teacher the answers to questions, she liked to stop us a lot, just for the fact that she didn't really like to think for herself, and so we'd say, "Well, think about it. This is..." and she'd say, well, no, she wanted to ask the question.*

Member of student's first group

*[W]e would be trying to explain [a concept] to her... [b]ut it seemed like she always had to return to [the instructor], instead of asking, instead of a group discussion of what we all thought.*

Member of student's second group

*[I]f there wasn't something that she understood, she wouldn't confide in us so much, but would ask the TA [teaching assistant] more, rather than trying to work it out within the group or something.*

Member of student's second group

*She'd ask a question, and we'd set out to try and explain it, and we'd get the first couple sentences out and she'd like, "[Instructor's name]!" .... And that kind of irritated me a little bit because she wouldn't let us get our ideas out.*

Member of student's second group

*[I]f it's [the interviewee's answer] not what she got, then she doubts herself. You know, she'll be like, "That can't be right,"...and then usually calls for a third opinion.*

Member of student's third group

Even her self-description was consistent, albeit somewhat more charitable:

*I think the only way I ran into problems was when they felt like they knew the answer, like, they knew that they had the right answer, and I doubted. I was kind of, like, edgy, and so other people in the group were kind of edgy, so I'd usually ask, and I think that would frustrate some of them when they were right. They're like, "Just listen to me. I have the answer." So that was kind of frustrating to them, that sometimes it would help to ask the teacher, 'cause they'd put it into different terms.*

Self-description

When student descriptions diverged, it stemmed from a lack of detailed description on the part of some interviewees. In particular, this seemed to occur when a student had

failed to leave an impression. In one instance, some interviewees offer personal descriptions of a student:

*Our other group member kind of played the passive role, but she thought of questions that we never asked, really deep thought questions maybe? She would come up with a question out of the blue sometimes.*

Member of student's second group

*AS\* kind of works at a pace between the two of us. She'll be with BA as far as moving at the same pace, but then she and I work similarly in how we get our answers. We think real similarly.*

Member of student's third group

while others discuss her only in vague, generalized terms:

*Mostly, they [the other group members, which included this student] did all the questions.*

Member of student's first group

*[E]verybody else [the other group members, including this student] kind of watched, mostly because they liked to chat.*

Member of student's second group

### Hierarchy Descriptions

Interviewees were asked to describe themselves and fellow group members in the context of group roles and, specifically, a group hierarchy. Two repeating themes emerged. In most groups, a specific hierarchy was present and students described it as static:

INTERVIEWER: *Do the roles change very often, or do you guys all kind of do the same thing all the time?*

STUDENT: *I would say, well, in the three groups I've had, they probably don't change much.*

---

\* When students refer to each other by name in interviews, a two-letter anonymous representation of the student's name has been used. Two-letter representations were assigned randomly to each student, such that they have no relation to the student's actual name, and are used self-consistently throughout this paper.

In these cases, all the interviewees in a given group identified the same student(s) as the leader(s). Although the actions of the leader varied from group to group, he or she was considered the "smartest," or most knowledgeable in the group:

*ND, I guess, would be kind of the leader in that group, because she was more boisterous in her ideas, and the rest of us were kind of, like, holding back, because none of us had had any of that in our school.*

*I would say that RS was probably the leader. She would go out and get everything and just start putting things together. It just clicked for her.*

It is interesting to note that the person students named as the leader didn't necessarily contribute positively to the group, and in some cases, serious problems emerged:

STUDENT: *They [the leaders] were so fast-paced, and I kind of got it. They just kept working and I felt like I had to work extra-fast to keep up...*

INTERVIEWER: *Do you think they knew this?*

STUDENT: *Yeah. It didn't matter.*

*[Y]ou'd say one [an opinion], but she'd never think that yours was right, even if yours actually was, so it was hard to convince her. The other three got along a lot better, because we would, like, talk about it, whereas she'd just like, "No, it's this way." You're like, "No, really, it isn't."*

*HC, in this group, went ahead of everyone. I guess he'd look at the question and say, "Well, that's easy!" and write down two things, and raise his hand and ask [the instructor] or a TA [teaching assistant] to check us off. And he was getting us into trouble for a couple classes 'cause they would say, "Well, your group's not ready."*

*There was a definite leader who always was leading everything and just took control, didn't really give anyone else a chance to do that.*

*ND would already know it. She'd just write down an answer, just right away, but to me it felt like she knew everything and her answer was "the word," and so she'd write it down. That's where she would get into trouble a lot; she wouldn't discuss it and stuff, and [the instructor] would come over and say, "Well, how did you get this answer?" and it was not the right way of doing it.*

In fact, students more often reported negative experiences with group leaders than positive ones.

Beyond group leader, other student roles were more difficult to classify. Some students described themselves as skeptics or questioners and some acknowledged their limited contributions to group discussion:

*I was always considered the quiet one.*

*[S]ometimes I'd just kind of sit there, and then they'd notice that I didn't know what was going on, and they'd help me.*

On the whole, however, no group roles consistently stood out other than the group leader.

In two of the groups, a distinct lack of leadership was present. In these cases, students failed to fall into definite roles and no hierarchy emerged:

STUDENT: *At any given time, we all contributed pretty well. I think, if one person started doing too much, the others would take part more. And that happened, I think. One person maybe setting it all up at one time, but then another would try to get involved more.*

INTERVIEWER: *And it could have been anybody? It wasn't sort of one person kind of running the show?*

STUDENT: *No, no. Right, right.*

INTERVIEWER: *So you took on more of a leadership role in the second group?*

STUDENT: *It was definitely more shared.*

INTERVIEWER: *So, is there any hierarchy you would give to that second group?*

STUDENT: *No, not in that group.*

In groups that lacked hierarchy, students instead described group roles as moving naturally between members:

*I thought it [the leadership hierarchy] changed quite a bit. Sometimes people would initiate different activities. I'd come in, one person would get it going one day and we would start following along, and there might be another person the next day.*

*We all took turns depending on what section we were working on. In one section, MW would have been more of a leader...*

It is important to note that students consistently described these non-specific role groups as their favorites.

### Types of Students Observed

In interviewees' descriptions of themselves and others, clear learning and participation styles<sup>†</sup> emerged. Even if students' own roles changed from group to group, their basic attitudes towards learning and their interactions with other people did not vary significantly. Based on descriptions from our nine interviewees, we found that the nineteen students in the course displayed five distinct sets of traits. We named them as: previously-knowledgeable, aggressive-confident, cooperative-confident, cooperative-uncertain, and passive-uncertain. These categories were derived more from group personality than academic prowess. In fact, we found no relation between academic achievement and group confidence.<sup>‡</sup>

Previously-knowledgeable Two interviewees and one non-interviewee stood out due to their previous knowledge of and comfort level with physics. In this case, all three had had positive experiences in high school physics courses. The two interviewees saw

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<sup>†</sup> Our use of the term "learning styles" refers to the way in which students seem to learn within the cooperative learning group environment. We do not consider it related to similar terminology – such as the "cognitive styles" used by Miller, Wilkes, & Cheetham (1993) – although possible correlations between our observed "group learning styles" and other type of learning styles may exist.

<sup>‡</sup> A natural bias seems to exist, especially in group learning, that people who are outgoing and self-confident are naturally higher achievers; a lack of talking conveys a lack of understanding. In fact, the instructors found that it was not unusual for a particularly withdrawn student to be academically successful (perhaps due to overzealous studying stemming from insecurity with the subject matter) or an outgoing student to perform poorly (perhaps due to overconfidence with the material).

themselves as more knowledgeable and, in some cases, smarter than their fellow group members:

*With my first group, it was currents and electric circuits and stuff, and I understood that... I know how some things should function and how they should not, just from that knowledge, and then my other group members pretty much didn't have a clue.*

Previously-knowledgeable student

*I think the reason, mostly, that I assume the leadership role is that I have the most science background.*

Previously-knowledgeable student

*[M]aybe I'm just a little bit quicker on the draw...*

Previously-knowledgeable student

*I've basically done balances and stuff like that since elementary school, so it's ingrained in me. I know what's going on; I know what's supposed to happen and there's a couple members of my group that I'm not sure have had that much experience...*

Previously-knowledgeable student

These comments suggest that "previously-knowledgeable students" encountered no new material in the course at all. One student went so far as to make the statement:

*Usually, not everyone would know the answer to the question when it was asked...*

Previously-knowledgeable student

This statement is interpreted to mean that the activity questions were there to probe the knowledge of other group members and not his own.

Other students indicated that they were aware of the knowledge level of their previously-knowledgeable group members and more credibility was given to their opinions. Each of these students was the leader in every group he or she participated in and none of them were involved in groups that lacked a hierarchy<sup>§</sup>.

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<sup>§</sup> One previously-knowledgeable student described her third group as lacking a hierarchy by saying:

Previously-knowledgeable students were also characterized by the fast pace at which they completed tasks. This pace was often resented by other members in their groups:

*They both have so much physics background... That was my hardest group, probably...*

Aggressive-confident student

*There was one that, like, really knew it, and he just, like, whipped through it, and the rest of us would be like, "Huh?"*

Cooperative-uncertain student

No interviewee described a previously-knowledgeable student as retarding his or her work pace; however, in some cases, previously-knowledgeable students demonstrated patience with the work of other students and occasionally served as resources.

*[He] helped us through some stuff we didn't understand.*

Aggressive-confident student

*And then sometimes, it was good, because he knew so much, he could explain it a little better, because you really didn't get much explanation – well, you do when you're trying to check it – but most of the time it's just your own group, and so it was good to have someone who knew a little more...*

Cooperative-uncertain student

---

*With this group, there's probably an equal balance. There's no one leader. We all take turns setting up, we all take turns, you know, just "Hey, let's do this."*

Previously-knowledgeable student

However, descriptions of that same group by another interviewee and in the instructor's report painted a very different picture:

*ND really took on a dominant role. She felt like she knew everything. She would explain concepts to us; it was like she would talk down to us. And she wouldn't give us time to discuss...*

Passive-uncertain student

*ND was very domineering in dealing with her other groupmates. While a level of organization can be productive, ND controlled virtually all of the work done and conclusions drawn by this group.... She felt the need to run all aspects of the experiments, sometimes preempting work already done by her fellow group members.*

From instructor's report

In this case, we concluded a hierarchy was present despite the student's self-report.

*Well, she tried to help us, 'cause she would say, "What do you understand, FF?" and I'd say, "Yeah," or else if I didn't understand, I'd say, "Well, I don't understand how you're getting this answer here," and she'd explain it to me...*

Passive-uncertain student

In general, previously-knowledgeable students functioned as group leaders, and tended to dominate the hierarchy.

Aggressive-confident Two interviewees who possessed no physics background nonetheless emerged as strong and dominant students. They stood out largely because of their self-confidence as learners. Although they had never encountered any of the physics concepts, they felt they had a better grasp than other group members and saw themselves as resources:

*[L]ike, in circuits, that was my strongest area, and I felt like other people would look to me.*

Aggressive-confident student

*I guess I explain things, and if she has a question, I'll step up and try to give her an example that she'll understand or relate it to something else.*

Aggressive-confident student

Like the previously-knowledgeable students, they also were comfortable working at a faster pace than the rest of the group. They expressed frustration with students who did not quickly grasp concepts:

*[W]hen we start doing stuff, she'll say, "Well, I don't understand." I'm like, "It says it right there. We're going to measure this and measure that." I would say it's a little frustrating.*

Aggressive-confident student



*She'd always have to maybe ask a question that's maybe not needed? I suppose every time we come up with an answer, or at the end of an experiment, she's like, "Well, that doesn't make sense," or "That can't be." And we'll say, "Well, what's wrong?" or "Why?" and she kind of doesn't know, but she just doesn't think that could be the right answer.*

Aggressive-confident student

It appears that most other students failed to differentiate between previously-knowledgeable and "aggressive-confident students," but these students themselves were keenly aware of their more experienced classmates. Aggressive-confident students clearly felt hurried and intimidated by previously-knowledgeable students. More than others, these students perceived the previously-knowledgeable students as impeding their learning process:

*I don't know if I felt... I was maybe a little intimidated, but maybe I was thinking that he is so smart, why should I open my mouth? I might say the wrong thing. And then after - you know, like, in the first group, I understood circuits really well, and then we started going into voltage and all that, and so I understood it just as well, but he kind of put a cap on everything we had to say, just because he was already two steps ahead of where we were thinking then.*

Aggressive-confident student

Their comfort with the physics concepts led aggressive-confident students to initiate group discussions and handle equipment more often than their peers. However, they expected fellow group members to behave similarly and they expressed some dismay at the apparent lack of participation:

*It's not even a race, because you all leave at the same time. ...I think the people that are maybe slower at it, they feel like, in the past, they've always had to keep up, so they're trying to add as much as they can, so when they come up with the answer, they just have to fill in the blank.*

Aggressive-confident student

*I suppose I learn better...if I'm talking or I'm active, when I'm doing stuff with my hands, or if I'm actually measuring. And in most of my groups, everyone says, "Well, here, you do it. I don't want to do it." They'll push it to someone other than themselves.*

Aggressive-confident student

Unfortunately, attempts to motivate other students often did not prove successful. One interviewee describes her efforts to increase group discussion:

*I'd usually try and make little comments, like, "What are you writing?" or "What do you guys think?" or "We should talk about this," or "Do you guys want to go over it?" You know, just kind of subtle little hints.*

Aggressive-confident student

However, another member from the same group saw the prior student's questioning as hurried, answer-driven, and unproductive:

*[S]he'll go so fast that she'll get off on her own thing. And she'll be like, "Well, did you get the same thing I did?" And I'm like, "Well, I'm still a couple pages behind you there. I'll tell you when I get there." And she does so much thinking out loud that I just kind of block her out...*

Cooperative-uncertain student

It would seem that the motivations and actions of aggressive-confident students were at cross-purposes; in their attempts to generate greater participation among group members, their behavior often frustrated their peers or was misinterpreted.

Cooperative-confident We classified students as "cooperative" if they seemed to be comfortable in group settings. Unlike aggressive-confidents, "cooperative-confident" students accommodated themselves to any pace; they could keep up with previously-knowledgeable and aggressive-confident students, but they were willing to slow down for less confident group members. These students used their comfort with the material to move the group forward, but they dealt with less able students more magnanimously than

their more aggressive counterparts. While they still functioned as leaders in some cases, individual participation increased in groups lead by cooperative-confident students:

*Everyone discussed and put input in, and then there was RC and BC [both cooperative confident students] that mainly discussed, and me and LA followed somewhat, and then we set up things, and it was, everybody was putting everything in kind of equal; everybody had an equal share of what was going on. When there was time to write an answer, everyone would discuss what the answer was, so everybody would be clear what it was, and then we'd all write our answer down.*

Passive-uncertain student

The behavior of cooperative-confidents depended largely on who they were grouped with. They easily kept up with faster paced students. On the other hand, they were not afraid to speak up when problems arose. For instance, one cooperative-confident described her third group experience, which included a previously-knowledgeable student:

*[This group was] a lot more fast-paced than my other two groups, but that's okay, because I feel comfortable enough to say, "I don't know. We need to stop this and someone explain it," or "Let's talk it through, and tell me how you think you got it this way."*

Cooperative-confident student

When grouped with more unsure students, cooperative-confidents saw themselves as teachers or motivators. Unlike the aggressive-confidents, however, they did not seem to classify themselves as "better" students and their attempts at helping were often more successful:

*DM works slower than all of us, and AS [a cooperative-confident] and I, we help her out a lot as far as helping her figure out which way she needs to go, not by giving her the answers but by asking her questions to make her think of where she needs to be.*

Cooperative-uncertain student

Cooperative-uncertain\*\* These students were very similar to cooperative-confidents in their work style and understanding of the material. However, they differed in their level of participation. While cooperative-confidents were comfortable speaking up and even controlling groupwork, "cooperative-uncertain" students rarely initiated discussion and relied on more outgoing group members to seek them out. This meant that cooperative-uncertains could be left behind in group discussions and sometimes had trouble with more complex topics:

*[V]oltage confused me, so I just kind of learned on that one, because I didn't really understand it. Occasionally, if I did understand it, I could help the other ones in the group that didn't, but that one I didn't really understand so I just learned from the group.*

Cooperative-uncertain student

*She [a passive uncertain] let other people run the show, and I did to some extent too. They wanted to take on the leadership role like that, and I wanted to be involved and so forth, but I didn't want to do it my way all the time.... At times, we'd feel a little bit left behind too, some of us; we'd still be writing our data, [and they'd be] getting the experiment ready, going on ahead.*

Cooperative-uncertain student

In spite of their decreased participation, cooperative-uncertain students worked very effectively one-on-one with passive-uncertain students. They were comfortable acting as mentors and offering encouragement when not the focus of the entire group. In several instances, a cooperative-uncertain student served as a liaison between a passive-uncertain student and the rest of the group:

*There was one girl [a cooperative-uncertain]. I think she, like, could have stayed with us, but she helped the other one [a passive-uncertain] a little more because she knew she was a little slower and took a lot more time to figure it out.*

Cooperative-confident student

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\*\* "Uncertain" refers to the students' self-perceived group roles. Uncertain students were less comfortable initiating group discussions and tended to isolate themselves from more outgoing group members.

*He [a cooperative-uncertain] was like the people that was [sic] in the first group [in which she had a positive experience], because he'd say, "Did you understand?" and I'd say, "Yeah," and if I didn't, I'd ask him. I felt really comfortable working with him.*

Passive-uncertain student

*I think I'm kind of more of a teacher to DM [a passive uncertain student]. If she'll be working on homework and she doesn't get it, I'll work with her after class, to figure it out and help her with it.*

Cooperative-uncertain student

While cooperative-uncertain students were not active group participants, they were better than passive-uncertains about voicing complaints or opinions, especially in relation to focus or group pace:

*[S]he'll ramble on about what she thinks the answer is, and then she'll be like, "Well, what did you get?" "Well, I'll tell you when I get there." I just kind of block her out until I've done the work to where I'm happy with what I've got.*

Cooperative-uncertain student

*We'd do an experiment, and often times each of the individuals would write down their own conclusions without sharing them, so I would try to slow the project down that way and ask them some questions about it...*

Cooperative-uncertain student

Cooperative-uncertain students were aware of their limits and were less willing than most to be rushed through an activity.

Passive-uncertain Students who exhibited quiet and withdrawn group behavior were considered "passive." These students might develop a relationship with a single student within a group, but spoke very little and spent most of their time writing or observing. "Passive-uncertain" students were the least comfortable working in groups. Although most ultimately developed an understanding of the material, they avoided

contact with the equipment and had to be dragged almost forcibly into discussions. The one passive-uncertain student interviewed described her quiet behavior as ingrained:

*I should learn to speak out more, but I've just been raised where speaking out isn't right, that it's wrong...<sup>††</sup>*

Passive-uncertain student

Other students felt this behavior stemmed from a lack of self-confidence, and expressed frustration at such passiveness:

*Some people don't like to do stuff in fear of messing it up...*

Previously-knowledgeable student

*We wanted to at least make sure she would participate... I actually ran into her and said, "No, just go for it. Who cares if it's dumb? Just, you know, throw it out there, and we'll talk it through. It doesn't matter." You just have to participate. No question is a dumb question.*

Cooperative-confident student

Passive-uncertain students also seemed to require additional time to learn concepts. The behavior of passive-uncertain students led to faster, more vocal students creating upsetting stereotypes. In one instance, a previously-knowledgeable student saw quietness as negative and related it to a lack of understanding:

*There's quiet people in the group, and if you've got a loud person, that's going to draw them out. That's better for the quiet person. And the loud person is practicing skills of communication, going, "She's really quiet. I need to make sure she's understanding this."*

Previously-knowledgeable student

But, when a passive-uncertain student describes a scenario similar to the one above:

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<sup>††</sup> It should be noted that this student was of Native American descent, and her passive nature appears to stem from a strong cultural background. Future studies will offer a broader sample of self-reports from passive-uncertain students.

*ND really took on a dominant role. She felt like she knew everything. She would explain concepts to us; it was like she would talk down to us. And she wouldn't give us time to discuss...*

Passive-uncertain student

Such student reactions serve as an important reminder of the distinction between ability and personality.

### Problems Uncovered by the Interviews

Although the interactions among these five types of students led to several successful groupings, these were overwhelmed by students' negative experiences. Two broad categories emerged from analysis of the interview transcripts:

#### Group Pace

Virtually every student complained about the pace of at least one group. In fact, the instructor noted that all groups appeared to work fairly evenly. Tasks were assigned for each day, and only rarely did a group fail to finish within the two-hour time limit. This is not to say that all groups finished simultaneously; typically, a group would take between 75 and 120 minutes to complete a module. However, even within this narrow time frame, students felt pressured to work at a pace with which they were uncomfortable.

Most students complained of feeling rushed. Their complaints were consistently directed towards previously-knowledgeable or aggressive-confident students:

*[T]hey moved very fast and I just kind of tried to keep up with them... just, "Come on, let's keep going." We were usually finished an hour before the rest of the class every time, and that was a hard pace for me to keep.*

Aggressive-confident student discussing two previously-knowledgeable students

*It can be frustrating sometimes, because BA will get done on her own so quickly, and she's so loud, and she'll keep "What'd you get? What'd you get? What'd you get?" and I'm still behind her, and she doesn't wait for us.*

Cooperative-uncertain student discussing an aggressive-confident student

*I wanted more time to explore experimentally a bit more in depth, and we didn't get to do that at times. I wanted a bit more time to actually look at things, instead of coming in, performing it, writing down the numbers, and getting out of class.*

Cooperative-uncertain student

Most of the previously-knowledgeable and aggressive-confident students accepted a slackened pace, albeit unhappily. Unfortunately, their groupmates seemed to sense this hostility, and this often led to tension within the group:

*It feels like, if I could go at my own pace, I'd go, go, go and get done a lot faster.*

Aggressive-confident student

*[A] lot of the time I think he thought, "Gee, this is pretty simple and I wish I could just get it done and leave," and the rest of us were like, "Well, we don't really know it, so we want to go a little slower."*

Cooperative-uncertain student discussing a previously-knowledgeable student

In some cases, a pace dichotomy formed, either of an individual functioning separately from the rest of the group, or the group splitting into two pairs:

*There's one gal in there [a previously-knowledgeable student]... she's pretty quick with things too. She goes ahead quite a bit, and often times myself and another gal in there, PM, feel that we're always playing a catch-up game.*

Cooperative-uncertain student



STUDENT: *[W]e work together, but we work separately at the same time. We'll do the work, and then we'll kind of get together, and see who got what, and if we're the same, then we're happy, we go on, and if we're different, then we'll break it down to see where [the problem is]. We'll all help each other out along the way.*

INTERVIEWER: *I'm getting the impression that it doesn't always operate as a group. You do things separately and then you just talk for a few minutes.*

STUDENT: *Uh-huh. Real separate.*

Cooperative-uncertain student

Two pairs working separately produced more positive results than the psychological tug-of-war produced in groups where a single member forged ahead. However, the instructors had hoped to develop successful groups of four, and these groups failed to accomplish that.

### Extreme Heterogeneity

The work pace of a given student related to how quickly he or she grasped the material. Unfortunately, most students took work pace as a proxy for ability; faster students were perceived to be more intelligent and vice versa. Previously-knowledgeable students expressed frustration with slower group members, but they attributed a slackened work speed to laziness or lack of intelligence:

*We [two previously knowledgeable students] would really fly through it, because we really helped each other out a lot. The girl that liked to ask the teacher the answers to questions, she liked to stop us a lot, just for the fact that she didn't really want to think for herself...*

Previously-knowledgeable student

In one glaring example of the dichotomy that developed between slower- and faster-paced group members, two students – one previously-knowledgeable and one passive-uncertain – described an incident where they worked on an assignment together at

the end of a class period. The instructor observed conflict between the students, and after the encounter, the passive-uncertain student approached the instructor, unconvinced of the methodology used by the previously-knowledgeable student. It was discovered that the passive-uncertain student had an accurate understanding of the material and the previously-knowledgeable student had completed the assignment incorrectly.

In her interview, the previously-knowledgeable student recounted the incident. She did not recall that her work was incorrect. Instead, she remembered her disagreement with the passive-uncertain student as stemming from a deficiency on her group member's part:

*One of the girls in the group, I guess she has not had a great math background, and most of the members of my group left, and I stayed there to make sure she understood what was going on... And you know, if she doesn't understand the math, she needs help of some sort. And I was willing to do that, but there are times when you just go, "Oh! Here's a calculator! Go!" But it's a matter of, I don't think she had the math skills to be able to do this, or the math learning skills inside her head to be able to do some of this stuff quick like the rest of the group.*

Previously-knowledgeable student

It never occurred to the previously-knowledgeable student that she herself could be incorrect.

Such excessive self-assurance unfortunately led to decreased cooperative learning. Two scenarios emerged. In one case, a previously-knowledgeable student would see him- or herself as a "teacher:"

*They looked to me going, "Oh, hey, you have experience in this." And I'm going, "Okay." So that was interesting because I could teach, and I could learn some more to make sure my past knowledge was what it should be.*

Previously knowledgeable student

In groups which are organized to produce an end product – a report or a problem set – such “group teaching” is usually a goal of the instructor. In the case of inquiry-based learning, however, instructors wish to achieve maximum participation on the part of all group members and such “teaching” is generally viewed as detrimental.

Remembering that the present course is designed for pre-service elementary school teachers, it could be argued that, for this particular group of students, self-teaching would be an acceptable approach. Unfortunately, the “teaching” techniques used by previously-knowledgeable students were suspect:

*[I]f she didn't understand, I would, you know, "Here, you need to do this and you need to do this. You get this number so you can do this with it."*

Previously-knowledgeable student

This previously-knowledgeable student has failed to make a distinction between teaching a concept and giving an answer. In other cases, previously-knowledgeable students had trouble communicating with their fellow students, who expressed frustration:

*[H]e knew how it would go, and we were like, "Maybe it's supposed to go this way," and he'd try and explain. I think he, like, knew more than what you need to know for the class. Like most of the people in the class haven't really had much physics, and I think he had, so he was really more advanced, and so it was harder for him to explain it, because he almost knew too much.*

Cooperative-uncertain student

*If we were trying to understand something, instead of just trying to explain it, she'd try and teach it.... And there was [sic] times when we started a new concept, and it was really basic, so she'd try and make it harder than it was... She was really hard to deal with.*

Passive-uncertain student

In spite of the fact that the students were all future teachers, previously-knowledgeable students unilaterally failed to demonstrate productive teaching methods.

Alternatively, previously-knowledgeable students who weren't trying to function as instructors tended to dissociate from the groups altogether:

*We all worked, us three, and then HC [a previously-knowledgeable student] was kind of over there, doing his own thing.*

Aggressive-confident student

Since students were graded on the success of their group dynamic, with all students in a group receiving the same score, this became a source of genuine concern, albeit one that presented no easy solution:

*I think he really didn't like the group thing. He kind of said that now and then, 'cause you know you get graded on your group, and when he would move ahead, he would get a lower grade for his group, but it's really not his fault, because he just knew more, and so I think it was harder for him, 'cause it's hard, when you know a lot more than the other people, to slow down.*

Cooperative-uncertain student

In a single instance, a group managed to incorporate a previously-knowledgeable student by what appeared to be sheer force of will on the part of a cooperative-confident student<sup>††</sup>. She focused on their future roles as teachers:

*[B]ecause when we teach elementary school kids, we're not just going to say, "This is the answer." There's got to be a process.*

Cooperative-confident student

At the other end of the spectrum, more advanced students (not necessarily previously-knowledgeable) occasionally expressed frustration at working with passive-

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<sup>††</sup> This particular group contained a previously-knowledgeable student, a cooperative-confident student, and a cooperative-uncertain student. It should be noted that, while the previously-knowledgeable student was a traditional-age college student, both remaining group members were returning students above traditional age. Our follow-up study (see Chapter 4) finds that in some cases, students above traditional age function similarly to previously-knowledgeable students, and provides a reasonable explanation for the successful dynamic of this group.

uncertain students. Complaints stemmed from an observed lack of confidence and the resulting diminished participation:

*I'd say, "Oh, well, why don't you do it this time?" ... because it would be a lot of "Well, what do you think?" and it would drive my nuts. "Well, okay, what do you think it is?" you know, so that some people would participate more and give an answer. That was pretty frustrating, and it lead to a lot of, "Let's take a break."*

Cooperative-confident student

In some cases, the passive-uncertain students were genuinely more comfortable letting more confident students handle the equipment:

*I wasn't very comfortable with the setting up when we did voltage. I had missed a day..., but there was setting up the circuit using the amp and the volt. I wasn't very comfortable about it, but him and ND would set things up.*

Passive-uncertain student

Most passive-uncertains, however, did not see themselves as less capable. Rather, they felt pushed aside by faster students:

*[S]he always wanted to be the one that measured, like found out how much it weighed. Like if anyone else would do it, she'd like, "No, no, no, no, no," and she'd take over and do it but not really show you. I think she had more of a math background, so she'd come up with all of these equations, and we're like, "Hold on, we don't really have to do that. You've just got to weigh it."*

Passive-uncertain student

One passive-uncertain student, relating a particularly negative group experience, said:

*[I]n the third group, it just shut me down. I didn't want to try because the person was so dominant.*

Passive-uncertain student

If this is the sort of response generated by students as a reaction to cooperative learning, we must seriously re-examine our approach as instructors and our criteria for successful group composition.

### Group Success Rate

A summary of the group compositions and their success rates is shown in Table 1. Of the fourteen groups examined in this study, five demonstrated a "successful" group dynamic. A successful group was one about which interviewees generated positive reports, characterized by a high degree of participation on the part of all group members. All groups that lacked a hierarchy performed well, but several groups with a distinct group leader still allowed the participation of all members. In these situations, the leader functioned more as an organizer than a source for information. Successful groups seemed to draw from more limited, adjacent classifications, and most of them lacked an aggressive-confident or a previously-knowledgeable member. It is interesting to note that all but one successful group<sup>§§</sup> contained students from consecutive student classifications (for example, a passive-uncertain is not grouped with a cooperative-confident without also being grouped with a cooperative-uncertain). This probably stems from the tendency of slightly more confident students to act as "mediators" between the group and less confident students (as demonstrated specifically with cooperative- and passive-uncertains).

Two groups were labeled "partially successful." These were groups in which three of the members worked well together and produced a productive and cooperative dynamic. The fourth member voluntarily withdrew from group participation. In both these cases, the outside group members were previously-knowledgeable students, and no negative effects could be found from their lack of participation.

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<sup>§§</sup> This is the group mentioned in the previous footnote. See Chapter IV for more discussion.

| Successful                | Partially Successful  | Unsuccessful              |
|---------------------------|-----------------------|---------------------------|
| CC, CU ( $\times 2$ ), PU | AC, CC, CU, <i>PK</i> | AC, CU ( $\times 2$ ), PU |
| CC ( $\times 2$ ), CU, PU | CC, CU, PU, <i>PK</i> | PK, CC, CU, PU            |
| CC, CU ( $\times 2$ )     |                       | PK ( $\times 2$ ), AC     |
| AC, CC ( $\times 2$ ), CU |                       | PK, AC, CU, PU            |
| PK, CC, CU                |                       | CC, PU ( $\times 3$ )     |
|                           |                       | AC, CC, CU, PU            |
|                           |                       | PK CU ( $\times 3$ )      |

**TABLE 1:** A breakdown of group composition in relation to group success. The student categorizations have been abbreviated as follows:

PK - previously-knowledgeable

AC - aggressive-confident

CC - cooperative-confident

CU - cooperative-uncertain

PU - passive-uncertain

Most of the groups are four-member groups, but three groups consisted of only three students. Students in italics indicate scenarios where three of the four members functioned as a successful group, and the fourth member worked individually, with no real impact on the group.

A group was considered unsuccessful if students reported predominantly negative experiences about it, or if group members were unable to function in a reasonably cooperative manner. The seven remaining groups fit these criteria. Problems within these groups were ultimately derived from extreme group heterogeneity. The most pronounced difficulties involved previously-knowledgeable students – either a previously-knowledgeable student tried to assume “command” or worked at a pace that was intolerable for most of the other group members. Even without previously-knowledgeable students, problems developed between faster- and slower-paced students; no successful groupings were observed that placed aggressive-confident students with passive-uncertain students. Here, problems manifested themselves mostly as pace dichotomies within a group. In one case, outright conflict resulted.

In two cases, groups were created in which three students were in the same "uncertain" classification and the fourth student was in a more "confident" classification. These groups were formed with the intent that the more confident student would serve as a natural leader. In one case, the group faltered because the three passive-uncertain students failed to participate, leaving the cooperative-confident student to carry the group single-handedly. In the second case, the previously-knowledgeable student refused to let the three cooperative-uncertain students participate adequately and assumed an almost dictatorial role.

We were puzzled that the groups that demonstrated the most difficulty seemed to be of the type most highly advocated by conventional literature recommendations – extremely diverse groups, in which higher ability students have the opportunity to "teach" those of lower ability. In our next section, we examine the justification for previous conclusions on group learning, and see how well those goals match our own.



## CHAPTER 3

### OUR RESULTS VERSUS RESULTS OF PREVIOUS STUDIES

Previous research on collaborative small-group learning has typically produced results different from those found in this study. Many previous studies (Cottle & Lunford, 1995; Emkey, 1979; Heller & Hollabaugh, 1992; Heller, Keith, & Anderson, 1992; Lunetta, 1990; Miller, Wilkes, & Cheetham, 1993; Peterson *et al.*, 1984; Rau & Heyl, 1990; and Webb, 1985, for example) have examined similar examples of group learning. A typical study looked at an introductory physics courses where students, working in groups of three to four, were presented assignments that they were meant to approach as a group. As with our Physics by Inquiry course, instructor participation was mostly through Socratic dialogue. Several variations of student grouping were used. Cottle & Lunford (1995) allowed students to form their own groups for each class period in which cooperative groups were used. There was no instructor input, and groups were not expected to stay together from one class period to the next (although no evidence is presented as to whether students actually rotated groups or if they mostly remained in the same group throughout the course). Two studies (Heller, Keith, & Anderson, 1992; Miller, Wilkes, & Cheetham, 1993) rotated groups several times each quarter, allowing the first round of groups to form randomly and then forming subsequent groups. Heller, Keith, & Anderson (1992) placed students into academically heterogeneous groups, and

Miller, Wilkes, & Cheetham (1993) first organized homogenous ability groups before proceeding to heterogeneity. The remaining studies carefully organized students into their groups from the beginning. In most cases, these groups were composed of students displaying maximal academic heterogeneity (Emkey, 1979; Heller & Hollabaugh, 1992; Rau & Heyl, 1990); however, Webb (1985) compared groups of heterogeneous ability to more uniform groups.

Most of these studies concluded that a cooperative group environment was beneficial to all of the students involved. Furthermore, studies that examined group composition argued that groupings of maximal heterogeneity demonstrated the strongest "positive" results. The consensus interpretation for collaborative group learning advocated by these investigators is that more advanced students will assist novice group members with difficult concepts. The truism is that the more advanced student is forced to organize and clarify his or her knowledge by teaching, while the novice student benefits from an additional source of information. As Lunetta (1990) states: "The less-skilled student profits from the insights and explanations of the more talented student. The more talented student can enhance learning by talking through the material with others and responding with questions."<sup>1</sup> All students come away enriched.

Our results, in contrast, strongly suggest that maximal heterogeneity was actually related to the greatest problems in this type of learning environment. Moreover, it appears that the most advanced students were even detrimental to the overall group

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<sup>1</sup> V. N. Lunetta, "Cooperative Learning in Science, Mathematics, and Computer Problem Solving," in *Towards a Scientific Practice of Science Education*, ed. M. Gardner (Hillsdale: Lawrence Erlbaum Associates, Inc., 1990), 239.

learning experience, hindering both the learning of more novice students and failing to advance their own understanding. In this chapter, we highlight how our data differs from traditional norms and suggest some causes based on interviews.

### Reviewing Comparable Physics Education Group-work Research

Attempts to study group learning tend to start from the assumption that interaction with other classmates will draw students into the learning process and ultimately allow students to internalize more of the course material than they might in a more detached setting, such as a lecture environment (Emkey, 1979). There is also the hope that active discussions and encouraging cooperation will improve problem solving skills (Heller, Keith, & Anderson, 1992; Heller & Hollabaugh, 1992).

Many group learning efforts start with three basic premises: 1) maximal heterogeneity provides the most productive work environment, 2) the learning of group members can be determined by comparing the highest score of an individual in the group to the score given to the group as a whole, and 3) group success can be adequately assessed on purely academic grounds. This assessment is easy to administer widely and definite results can be obtained without the same time expenditures that might be required in using focus groups or interviews. However, reviewed research studies tend to ignore the assumptions behind these premises.

Consider the justification for maximal heterogeneity. Most studies cite Johnson *et al.* (1984), who state: "More elaborative thinking, more frequent giving and receiving of explanations, and greater perspective in discussing material seems to occur in

heterogeneous groups..."<sup>2</sup> No evidence from specific research results is offered to support this statement. Instead, their academic justification for heterogeneity is based on the claim:

"It is obvious that low- and middle-achieving students have much to gain from working in cooperative learning groups with high-achieving peers. In terms of motivation and actual achievement, the largest gainers from working in heterogeneous cooperative learning groups are the struggling, low-achieving; the next largest gainers are the middle-achievers." [underline added]<sup>3</sup>

It is interesting to note that the idea of heterogeneous grouping has become so ingrained that its validity as an effective teaching strategy is rarely questioned. As Good & Marshall (1984) state:

The heterogeneous-homogeneous question [is] typically approached as a one-variable problem. This is, much of the research is based on the belief that there is a single answer to the question, Is homogeneous or heterogeneous grouping better? This belief has probably led many investigators to study class heterogeneity without carefully considering the types of students involved, the community being served, the quality of instruction, and many other variables.<sup>4</sup>

In fact, it is this consideration of other variables which has generally been neglected in physics education research. Most of the studies we considered either started with the premise that heterogeneous groupings were preferable, or they used assessment strategies that did not directly reflect group dynamics (discussed on pages 38 and 39). However, in studies which make more direct observations of internal group functions, investigators have found that heterogeneous groupings are not necessarily the most favorable. Good

<sup>2</sup>D. W. Johnson and others, *Circles of Learning: Cooperation in the Classroom* (Edina: Interaction, 1984), 27.

<sup>3</sup>Ibid, 74.

<sup>4</sup>T. L. Good and S. Marshall, "Do Students Learn More in Heterogeneous or Homogeneous Groups?" in *The Social Context of Instruction: Group Organization and Group Processes*, eds. P. L. Peterson, L. C. Wilkinson, and M. Hallinan (Orlando: Academic Press, Inc., 1984), 17-18.

and Marshall (1984) give evidence that more "homogeneous grouping increased participation and involvement in academic and social activities for most students, especially slow learners."<sup>5</sup> Similarly, Webb and Kenderski (1984) observed that "[s]tudents in high-medium or medium-low groups [showed the most interaction], on the average, and students in high-medium-low groups [showed the least interaction], on the average."<sup>6</sup> These results suggest that extremely heterogeneous groups may be less productive and positive group learning environments than more homogeneous ones.

The second premise, that the learning of individuals within the group can be determined by assessing group achievement, makes some very broad tacit assumptions. Johnson *et al.* (1984), like many subsequent studies (Cottle & Lunford, 1995; Heller & Hollabaugh, 1992; Heller, Keith, & Anderson, 1992, etc.), seem to imply that the work produced by the group accurately reflects the retained individual knowledge of each student in the group, and that all group members are able to reach the same level of achievement as the highest ability students within the group. For example, Heller & Hollabaugh (1992) state that, "[a]n examination of written problem solutions indicated that instructor-assigned groups of mixed ability (e.g., a high, medium, and low ability student) performed as well as groups consisting of only high-ability students...."<sup>7</sup>

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<sup>5</sup> Ibid, 20.

<sup>6</sup> N. M. Webb and C. M. Kenderski, "Student Interaction and Learning in Small-Group and Whole-Class Settings," in *The Social Context of Instruction: Group Organization and Group Processes*, eds. P. L. Peterson, L. C. Wilkinson, and M. Hallinan (Orlando: Academic Press, Inc., 1984), 162.

<sup>7</sup> P. Heller and M. Hollabaugh, "Teaching Problem Solving through Cooperative Grouping. Part 2: Designing Problems and Structuring Groups," *American Journal of Physics* 60 (July 1992): 641.

However, these same studies base their results on outcomes produced by the group as a whole. The group assessment techniques used say nothing about individual student understanding. The assumption seems to exist that, as a result of their group experiences, all come away with comparable grasps of the material.

If we reexamine the hypotheses researchers pose about interactions within such heterogeneous groups, this reasoning may be inconsistent. As Johnson, Johnson, & Smith (1992) state that:

... **oral discussion** of relevant information has at least two dimensions: oral explanation and listening. Both benefit the giver and receiver. The **giver benefits** from the cognitive organizing and processing, higher level reasoning, insights, and personal commitment to achieving the group's goals derived from orally explaining, elaborating, and summarizing information and teaching one's knowledge to others. The **receiver benefits** from the opportunity to utilize others' resources in their goal accomplishment efforts.<sup>8</sup>

The Johnson, Johnson, & Smith (1992) hypotheses of interactions between "givers" and "receivers" are borne out by Heller & Hollabaugh (1992), who observe that "the higher-ability student typically supplied the leadership by generating new ideas and approaches to the problem, [and] the low or medium ability student kept the group on track by pointing out obvious, simple ideas..."<sup>9</sup> While explaining may help solidify understanding, it seems unreasonable to expect that the "giver" can raise the "receiver" to a comparable level of cognition, since the "receiver's" learning is largely second-hand. When we consider a further statement by Johnson, Johnson & Smith (1992), it becomes

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<sup>8</sup> D. W. Johnson, R. T. John, and K. A. Smith, *Active Learning: Cooperation in the College Classroom*, (Edina: Interaction, 1992), 6.

<sup>9</sup> Heller and Hollabaugh, 641.

difficult to justify in what context a consistent "giver-receiver" relationship can constitute effective group learning:

The critical issue in understanding the relationship between cooperation and achievement is specifying the variables that mediate the relationship. Simply placing students in groups and telling them to work together does not in and of itself promote higher achievement. It is only under certain conditions that group efforts may be expected to be more productive than individual efforts. Those conditions are clearly perceived positive interdependence, considerable promotive (face-to-face) interaction, felt personal responsibility (individual accountability) to achieve the group's goals, frequent use of relevant interpersonal and small groups skills, and periodic and regular group processing.<sup>10</sup>

If students are placed in groups where higher ability students are expected to function as teachers or helpers to lower ability students, it seems that many of these expected behaviors (for instance, positive interdependence or personal accountability) may fail to materialize, in light of the unequal status that group members may perceive amongst themselves. The supposed "contributions" by low- and middle-ability group members may not be the independent thinking that Heller & Hollabaugh (1992) assume. Webb (1982) has evidence that "less proficient members [tend] to conform to the judgment of more proficient members, regardless of the quality of their judgments."<sup>11</sup> This suggests that higher ability students may possess an extremely dominant intellectual role, and that the lower ability students are more likely to be receivers than contributors of knowledge.

There is even evidence that group members are more likely to defer to perceived rather than actual proficiency. Steiner (1972) describes a study in which B-26 bomber

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<sup>10</sup> Johnson, Johnson, and Smith, 14.

<sup>11</sup> N. M. Webb, "Student Interaction and Learning in Small Groups," *Review of Educational Research* 52 (Fall 1982): 432.

crews were presented with problems in cooperative group situations.<sup>12</sup> Pilots, which tended to have the highest status within crews, were the most successful in swaying groups to their opinions, regardless of how correct their answers were. On the other hand, gunners, which tended to have the lowest status, were least successful. They also had the most difficulty swaying groups to their opinions when they *were* correct. The experience Steiner (1972) describes is not unlike the conflict discussed on pages 23 and 24, in which a previously-knowledgeable student with an incorrect understanding of a problem refused to even consider the correct explanation of a passive-uncertain. Both of these examples suggest that the dominance higher ability students experience in heterogeneous groups may not only encourage lower ability students to function as passive learners, but if higher ability students possess an incorrect understanding of the subject matter, they may be more likely to influence their groupmates. Conversely, lower ability students with correct views may not only have problems convincing their fellow group members, but may actually be dissuaded from these views by higher ability students. Neither situation is desirable.

None of the physics education studies clearly demonstrate that work in groups of maximal heterogeneity ultimately leads to gains for all students. This would require assessment of individual students grouped in heterogeneous groups in relation to a control of students who learned by a more traditional method. Peterson *et al.* (1984) did perform such a study, and found a significant *negative* correlation between performance on achievement tests and receiving explanations in groups. "One obvious hypothesis,"

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<sup>12</sup> I. D. Steiner, *Group Processes and Productivity*, (New York: Academic Press, 1972), 25.



Peterson states, "is that low-ability students were being given the answers by others in the group, and they wrote down the answers without having a clear understanding of how to work the problems themselves."<sup>13</sup> Such a result might be overlooked by studies that considered a final group outcome as the only evidence of student gains.

The third premise – that assessment of a group project provides evidence of group success – is even harder to justify. Beneath this assumption lies the idea that group success can be measured academically – a group which solves problems correctly or produces a report which receives a high grade has therefore functioned successfully – and that high-scoring group outcomes can only be produced by groups that interact successfully. Most studies ultimately take this "end justifies the means" approach. Heller, Keith, & Anderson (1992) assess their groups solely on outcomes, with the justification that:

"In well-functioning cooperative groups, students can share conceptual and procedural knowledge and argument roles, and request clarification, justification, and elaboration from one another, so a better solution emerges than could be achieved by individuals working alone. The results of this study suggest that this type of collaboration did occur."<sup>14</sup>

While a successful group will function as described above, no evidence is offered that a group with a poor dynamic will produce outcomes which score poorly. In fact, in their study of group dynamics, Miller, Wilkes, & Cheetham (1993) found that "[t]here is no correlation between group performance and group conflict, or between group

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<sup>13</sup> P. L. Peterson and others, "Merging the Process-Product and the Sociolinguistic Paradigms: Research on Small-Group Processes," in *The Social Context of Instruction: Group Organization and Group Processes*, eds. P. L. Peterson, L. C. Wilkinson, and M. Hallinan (Orlando: Academic Press, Inc., 1984), 146.

performance and group satisfaction.”<sup>15</sup> Although the focus of our study does not consider academic criteria in general, our data also found no appreciable difference in academic achievement between students who participated in successful groups and students who participated in unsuccessful ones. This implies that, while outcomes-based assessment can be a good judge of group academic prowess, it is not necessarily reflective of successful group interactions.

It appears that the assumptions made by Heller, Keith & Anderson (1992) are reflected in many group learning studies. They believe that a good group will not only share knowledge but will also participate equally and enthusiastically. However, when many studies describe actual group interactions, myriad scenarios emerge which did *not* typify good group dynamics. In some cases, groups exhibited distinct hierarchies:

“Some groups had a dominant student who railroaded the group into an approach or problem solution. At the other end of the personality spectrum, a timid student would be reticent of participating and often became the silent record-keeper for the group...”<sup>16</sup>

In other situations, students dissociated from the group entirely:

“[S]ome students do not interact with their peers. These individuals tend to work alone and do not contribute their ideas to other members of the group. Those who work outside the group could not be identified based on their performance in the course...”<sup>17</sup>

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<sup>14</sup> P. Heller, R. Keith, and S. Anderson, “Teaching Problem Solving through Cooperative Grouping. Part 1: Group versus Individual Problem Solving,” *American Journal of Physics* 60 (July 1992): 635

<sup>15</sup> J. E. Miller, J. Wilkes, and R. D. Cheetham, “Tradeoffs in Student Satisfaction: Is the ‘Perfect’ Course and Illusion?” *Journal on Excellence in College Teaching* 4 (1993):43.

<sup>16</sup> Heller and Hollabaugh, 641-642.

<sup>17</sup> W. L. Emkey, “A Small Group Approach to Introductory Physics,” *American Journal of Physics* 47 (August 1979): 696.

"In groups with four members, one student was invariably left out of the problem-solving process. Sometimes this was the more timid student who was reticent to ask for clarification. At other times, the person left out was the most knowledgeable student who appeared to tire of continually struggling to convince the three other group members to try an approach, and resorted to solving the problem alone."<sup>18</sup>

Finally, some groups suffered from a distinct lack of cohesion, especially in situations where the group's main focus was problem-solving:

"[S]ome of the groups do not seem to 'gel.' Here individuals tend to work by themselves showing little or no participation within the group...."<sup>19</sup>

To try to eliminate such problems, Rau & Heyl (1990), as well as Heller, Keith, & Anderson (1992) and Johnson *et al.* (1984), advocate the assigning of roles within a group "to prevent more vocal, aggressive, or precocious students from dominating group discussion."<sup>20</sup> In these studies, role rotation seemed to enhance group dynamics somewhat. However, evidence presented by Skala, Slater, & Adams (1999) and Steiner (1972) showed that role assignments may not necessarily serve the purpose intended by Rau & Heyl (1990). Skala, Slater, & Adams (1999) conducted focus groups of students participating in group learning activities within a large-enrollment (200 students per section) lecture-based course and found that, unless closely monitored, students often deviated from their prescribed roles. Specifically, "students did not always rotate the position of leader. The student with the most dominant personality usually emerged as

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<sup>18</sup> Heller and Hollabaugh, 640.

<sup>19</sup> Emkey, 696.

<sup>20</sup> W. Rau and B. S. Heyl, "Humanizing the College Classroom: Collaborative Learning and Social Organization among Students," *Teaching Sociology* 18 (April 1990): 146.

the leader and remained the leader through the whole semester.”<sup>21</sup> Similarly, Steiner (1972) describes a study in which students were given personality tests and students were grouped in pairs in which one student had a more dominant personality than the other. Pairs were then given a task, and roles were assigned such that one student was given a more dominant, directorial position. When the role of director was given to the less dominant student, pairs experienced a failure rate 27% higher than when more dominant students were assigned to direct, and 18% higher than control groups in which no roles were assigned.<sup>22</sup>

Both of these studies suggest that attempts to assign roles may be counter-productive. Not only is there evidence that students have difficulty conforming to roles – especially students with dominant personalities – but findings show that role assignments may lead to less productive interactions. In addition, students in our interviews described that, in their own successful groups, group roles seemed to move naturally from person to person, depending on the activity at hand:

STUDENT: *[In my favorite group], some people would set up the equipment right away...and another person was interested in the questions in the text more, and I always felt like I wanted to coordinate it a bit, get it all going. But...sometimes other people would set up the equipment too and the person usually doing it was accepting of that. It was no big deal if somebody else did it too, so it was good that way...*

INTERVIEWER: *[It] was...fluid?*

STUDENT: *Yeah, I thought so.*

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<sup>21</sup> C. Skala, T. F. Slater, and J. P. Adams, “Qualitative Analysis of Collaborative Learning Groups in Large-Enrollment Introductory Astronomy,” *Proceedings of the Astronomical Society of Australia* (in press): 6.

<sup>22</sup> Steiner, 56.

If roles had been assigned, students would have been expected to function in a particular way within the group for some arbitrary period of time, and such intuitive role-taking and switching might have been suppressed.

### Towards the Implementation of Successful Cooperative Groups in Inquiry-based Learning

Upon carefully examining previous studies, we feel we possess a better understanding of observed differences between our conclusions and others. It is important to remember that, while previous studies have focused on collaborative small-group learning, they have been assessing traditional – rather than inquiry-based – physics courses. The physics courses in question have also typically been directed towards science and engineering majors, while Physics by Inquiry concerns itself with a unique audience – the pre-service elementary school teacher. This creates two challenges that may not be concerns in other courses: 1) students will probably enter Physics by Inquiry with a far greater range of backgrounds, fears, and expectations, and 2) if the students come away from the course with a less than positive and successful experience, they might choose not to incorporate similar activities into their own classrooms. The instructors are put in the delicate position of trying to challenge the students intellectually while ensuring their success.

Therefore, rather than assess knowledge solely through exams or graded problem sets, instructors work very closely with all students and assessment takes place continuously. Groups are not allowed to advance more than a page or two in any one module without participating in a discussion with the instructor. With a student-to-

instructor ratio of about 7-to-1, this environment also draws instructors much closer to the group experience. Instructors are able to focus more closely on how students interact with one another, but are also more acutely aware of tension and lack of productivity.

Where group learning is often used to supplement more didactic physics instruction, the outcomes-based assessment used by cited studies might be entirely adequate. Students who intend to focus on science and engineering at the college level might be more likely to enter courses with similar backgrounds, eliminating the problems presented by previously-knowledgeable students. If students are grouped to work quantitative problems with a single correct solution, the "teacher-learner" relationship can undoubtedly be more productive than students working individually. Unfortunately, when all of the learning takes place in small groups and there are many intellectual paths to a correct understanding, as in our environment, we have found that the traditional approaches to group learning can fail.

Therefore, for the remainder of this study, we grouped two sections of Physics by Inquiry, from the Fall 1998 semester, drawing on the hypotheses developed in Chapter 2. In order to implement our grouping strategy, we presented the students with a instrument (discussed in the Appendix) on the first day of class which allowed us to categorize them. Using the results of this instrument, we then segregated previously-knowledgeable students into separate groups which were not rotated into groups containing non-previously-knowledgeables. Because of the advanced understanding previously-knowledgeable students already possessed, we expected to move these students through a different, slightly accelerated curriculum to keep them challenged.

After the previously-knowledgeable students were segregated, the remaining students were organized in moderately heterogeneous groups, making sure to only group adjacent categories and include no more than two students from one category. We avoided grouping students in any way that we felt might produce negative outcomes. It was felt that placing students in detrimental situations solely for the sake of a control group would be unacceptable teaching practice; therefore, groupings from the Spring 1998 semester were the closest we considered to a control group.

At the end of the Fall 1998 semester, we conducted interviews similar to those conducted with the Spring 1998 students. In this case, however, we attempted to interview all of the students in both sections, providing us with thirty to forty interviews. We determined that our grouping strategy would be successful if we saw a drop-off in conflicts and pace dichotomy, and a distinct increase in student enjoyment and participation. Our results are discussed in Chapter 4.

## CHAPTER 4

### IMPLEMENTATION AND FOLLOW-UP

To test the validity of our conclusions, we used our results as a basis for formally assigned group composition in both sections of the Fall 1998 *Physics by Inquiry* course. A classification instrument (discussed in the Appendix) was created, which was administered to students on the first day of class. The instrument was designed to be simple enough that previously-knowledgeable students could be identified immediately.\* Two out of sixteen students in one section and eight out of eighteen in the other were identified as previously-knowledgeable.

Previously-knowledgeable students were grouped together exclusively, and an accelerated curriculum was designed for these groups to accommodate the faster pace that was expected to emerge. At the outset, all previously-knowledgeable students were consulted individually about the implementation of a dual-pace curriculum, and all agreed to participate. Due to slight changes in the curriculum, students participated in three groups during the course of this semester rather than the four different groups<sup>†</sup> used in the Spring 1998 semester.

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\* It was important that previously-knowledgeable students be identified quickly, as they were asked to stay after the first class meeting to obtain their permission to carry out the grouping experiment.

<sup>†</sup> In the first section, the two previously-knowledgeable students functioned as a single group throughout the semester. These are the only students who did not participate in group reorganization.



The distribution of student types identified by the categorization instrument in each section is shown in Table 2.

| <b>Student Type</b>             | <i>Number of Students<br/>in Section One</i> | <i>Number of Students<br/>in Section Two</i> |
|---------------------------------|----------------------------------------------|----------------------------------------------|
| <b>Previously-knowledgeable</b> | 2                                            | 8                                            |
| <b>Aggressive-confident</b>     | 2                                            | 3                                            |
| <b>Cooperative-confident</b>    | 9                                            | 4                                            |
| <b>Cooperative-uncertain</b>    | 3                                            | 3                                            |
| <b>Passive-uncertain</b>        | 0 <sup>†</sup>                               | 0                                            |

**TABLE 2:** Distribution of students in each section according to their cooperative group learning categorization.

Groups were then arranged according to the following criteria:

1. Previously-knowledgeable students were grouped together and in separate groups from other students.
2. Non-previously-knowledgeable students were grouped with people from similar or adjacent categorizations.<sup>§</sup>

This strategy led to the twenty-eight combinations of student learning groups shown in Table 3. These groups were the focus for this portion of the study. In all, 34 students were impacted, and 31 of these students were interviewed<sup>\*\*</sup> concerning their group experiences using a script similar to that used in the interviews of the Spring 1998

<sup>†</sup> According to the responses given on the instrument, no student identified him- or herself as a passive-uncertain. While it may be that no passive-uncertains enrolled in the Fall 1998 sections of Physics by Inquiry, we must acknowledge the possibility that the instrument was flawed. This is discussed in detail in the Appendix.

<sup>§</sup> By the time some later groups were formed, some cooperative-uncertain students had matured into cooperative-confidents. This led to one grouping of technically non-adjacent types.

<sup>\*\*</sup> Two students (a cooperative confident from each section) withdrew from the course before the end of the semester, and one aggressive confident from Section Two was not interviewed. The behavior of each of these students is therefore inferred from information provided by fellow group members.

students. As before, interviewers were not known to the students and had no contact with them before or after the interviews.

### *SECTION ONE*

|                    |                      |                   |                   |            |            |
|--------------------|----------------------|-------------------|-------------------|------------|------------|
| <b>Round One</b>   | PK(x2) <sup>††</sup> | CC(x2),<br>CU(x2) | CC (x3)           | AC, CC, CU | AC, CC(x3) |
| <b>Round Two</b>   |                      | AC,<br>CC(x2), CU | AC,<br>CC(x2), CU | CC(x2), CU | CC(x3)     |
| <b>Round Three</b> |                      | AC,<br>CC(x2), CU | AC, CC(x2)        | CC(x2), CU | CC(x2), CU |

### *SECTION TWO*

|                    |                   |            |            |        |        |
|--------------------|-------------------|------------|------------|--------|--------|
| <b>Round One</b>   | CC(x2),<br>CU(x2) | CC(x2), CU | AC(x3)     | PK(x4) | PK(x4) |
| <b>Round Two</b>   | AC, CC, CU        | AC, CC, CU | AC, CC, CU | PK(x4) | PK(x4) |
| <b>Round Three</b> | AC, CU(x2)        | AC, CC, CU | AC, CC(x2) | PK(x4) | PK(x4) |

**TABLE 3:** Student organization in each of their cooperative learning groups according to their groups learning classification. Group learning types have been abbreviated according to the same system used in Table 1 in Chapter 2.

The follow-up study differed from the original in that a larger number of students and groups were considered, and a larger percentage of the students (91% versus 47%) were interviewed, allowing for greater cross-correlation. In addition, the 16 interviewees and 13 groups of Section One were taught by an instructor other than the researcher, in a deliberate attempt to remove instructor impact as a predictor.

<sup>††</sup> The previously-knowledgeable students in Section One constituted a single group which lasted the entire semester. For purposes of the clarity in Table 3, they are only listed once.

### Results of the Follow-up Study

The follow-up study was designed to deal with the problems revealed in the initial interviews that appeared to stem from extreme group heterogeneity, for example, lack of student participation or stress caused by diversity in group pace. By limiting heterogeneity (and more specifically, segregating previously-knowledgeable students), the researcher hoped to create a group learning environment in which all group members contributed to discussions and students were motivated to ask questions and learn actively through their group members, as opposed to using fellow group members as repositories of knowledge, or conversely, failing to interact productively with other students because they felt their classmates lacked relevant knowledge. In light of the fact that all class members were pre-service elementary school teachers, the researcher felt that criteria for success should stem from active engagement in groups and perceived self-fulfillment on the part of the students. Therefore, course grades were not taken into account<sup>††</sup> and, for our purposes, a group was considered successful if most of its members described positive and productive interactions.

### Group Success Rates

Group success rates were determined by taking combinations of each member's rating of that group and determining an average. Student responses were divided into

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<sup>††</sup> There is some debate over the reliability of grading as representative of successful group dynamics anyway. For our Physics by Inquiry class, only a small percentage of the grade considered group participation at all, and there was no component that was dependent on group problem solving. Most of the grading was determined by written individual criteria, such as homework assignments, essays, and exams, and any effect of group dynamics on grades is therefore difficult to determine.

three categories: positive (+), negative (-), or neutral (0).<sup>§§</sup> Responses were interpreted as positive if the student related his or her group experience as being good and described behavior consistent with cooperation and active learning. Examples of positive responses include:

*We all seem to, if somebody's having a problem with something, then another person can help out, and if they can't help that person, then another person can think of another way and help them out that way. So it was like different kinds of thinking; even though someone might understand all the ways, you know, they could explain it to someone else so they could understand it. That was really nice.*

*I felt valued. I felt like whatever I needed to ask or question or talk about was worthwhile. I never felt like they thought I was behind or anything like that. It was really nice, just because we kind of established a nice casual sort of atmosphere; whatever question you had, that was fine. We went over stuff to make sure we all understood it. It was really nice in all of them. I didn't feel too different about any of them, just working with different people. It was good.*

*If one of us didn't get it, everybody else would stop and say, "Okay, this is how I thought through it, and this how I did it," and pretty much everybody always had an idea...*

A response was considered negative if the student related extremely negative experiences when interviewed. These tended to involve animosity towards other students, expressions of frustration, and the like. For instance,

*Well, I know that IT liked to be in control of the group and that kind of frustrated me personally, and I think TC also, and we just, you know, when we really didn't know the answer, it was difficult for us to actually, like, come together and figure it out...*

*They would be kind of lacking and lagging behind. We'd spend too much time on one thing or something and I'd be... I know that at times I would get frustrated and just kind of work ahead a little bit, and then come back when they were ready to go ahead, and that was a little bit frustrating.*

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<sup>§§</sup> As we had access to responses from a much larger percentage of students, this method was slightly more rigorous than that used to determine group success in the Spring 1998 semester.

*They both completely understood what we were doing, and I was going a little slower, but it wasn't slowing them down at all. They just kept going ahead of me, and I was just finding myself falling behind and I was so uncomfortable with both of them. Like, our personalities didn't seem to click. ...I felt just like an idiot, 'cause they were just like flying, and I'd ask the two questions all the time and they'd kind of give me this answer, like, that was so obvious, just the answer, like, not how they got to it, stuff like that. So I found myself just skipping over sections to get caught up with them. I couldn't wait to get out of that.*

STUDENT: *It [the group] gives me a headache a lot of the time.*

INTERVIEWER: *And why is that?*

STUDENT: *They talk about what they're going to do after class and "da-da-da-da-da" and then they're like, "Come on, we've got to get this done!" And I'm like, "Hey, I'm already passed you guys." You know, I work a lot on my own on this one, just 'cause they sit there and they talk and they talk and talk, and if I try and say, "Hey, you guys..." they're like, "Hey, we're just talking for two seconds." And then when you try and do something, they're like, "No, no, no. It's not like that," and they never are willing to look at it from somebody else's perspective.*

A neutral response was characterized by more ambiguous or unclassifiable opinions. In these cases, students described slightly negative situations that they tolerated but were willing to accommodate, or spoke positively of interactions that they knew did not contribute to a positive learning environment. Most students had an intuitive grasp of what constituted positive and productive group dynamics, and neutral responses seemed to be characterized by attempts to rectify partially dysfunctional groups, or at least self-awareness of what types of behaviors would correct the problem:

*I guess FN always kind of stepped up and'd say, "This is the way it's gonna work out," and SS always questioned – she had to see everything for herself before she'd believe that it was true – and, I don't know, ML and I just kind of sat back. I always had my ideas. I always felt like I knew what was going on. I didn't always voice my opinion, just because I'm not real sure of myself all the time.*

*It seemed everyday – well, not everyday, a couple of days – that somebody would move ahead, or two people would move ahead and two people would be behind. [The problem was] just lack of everybody staying together.*

STUDENT: *I felt that FH worked on her own a lot... I'd look up and she'd be ahead three sections, and then I'd be behind and I would have to keep asking questions about where we were...*

INTERVIEWER: *So did you ask her to slow down, or how did you handle that?*

STUDENT: *Well, I have to talk with her about it, ask her questions about it, and that would make her slow down, and after that, she would realize she was far ahead and stop.*

STUDENT: *[W]e, like, didn't really work as a group. We worked, like, more individually until we had a question...*

INTERVIEWER: *What do you mean? I'm not sure I understand.*

STUDENT: *Like, we didn't really, like, work through the stuff together; we kind of worked each of us at our own pace, and if any of us had a question, we'd ask someone, like, "What'd you get for this one?"*

*I don't think it was quite the same [as the first group]. I think DU and I were always on the same level, but I think KS was at a very different level, and we never knew if she really was just having a bad day, or if that's just how she was. ... I didn't feel like we [PN and DU] were rude to her [KS] in any way. I think she felt closer to her first group, and I felt like she didn't want to get to know us very well.*

*I think she feels that... I don't why she does, but she's thinking she'd like to do most of the work. If [the instructor] comes over and there needs to be explaining, you know, she'll speak up right away... And that's kind of hard, because... you feel the tension there and you don't really know what to do... I mean, just because we're not jumping to speak up, it doesn't mean that we're quiet ones and we're not understanding or we need self-confidence or something.*

Classifying neutral responses proved difficult. The ultimate criteria used was one of "acceptability:" whether the nature of the group interactions was considered tolerable by the researcher. It seems unlikely to expect that all group learning situations, no matter how ideal the grouping criteria, will result in perfectly positive situations. Variables, such as outside-of-class interactions or a student's temperament on the day of her interview,

may result in an emotional response that is not entirely reflective of the classroom situation. Therefore, only overtly positive or extremely negative responses were considered to be significant.

A success index of a group was determined by summing the judged values (+ - or 0) of the responses given by each group member. Any group whose combined responses led to non-negative outcome was deemed successful, with the exception of four-member groups where the responses were split evenly between positive and negative. It was decided that a group where at least half of its members were unhappy was unsuccessful. The results appear in Table 4:

### SECTION ONE

|                    |                 |                     |                      |                   |                     |
|--------------------|-----------------|---------------------|----------------------|-------------------|---------------------|
| <b>Round One</b>   | +,+<br>total=+2 | +,-,0,0<br>total=0  | +,+,Ø<br>total=+2    | +,-,0<br>total=0  | +,+,+,+<br>total=+4 |
| <b>Round Two</b>   |                 | +,-,0,0<br>total=0  | +,+,0, Ø<br>total=+2 | -,,-<br>total=-3  | -,0,0<br>total=-1   |
| <b>Round Three</b> |                 | +,+,+,0<br>total=+3 | +,+,0<br>total=+2    | +,+,+<br>total=+3 | -,0,0<br>total=-1   |

### SECTION TWO

|                    |                     |                   |                    |                     |                          |
|--------------------|---------------------|-------------------|--------------------|---------------------|--------------------------|
| <b>Round One</b>   | +,+,+,+<br>total=+4 | -,0,Ø<br>total=-1 | +,0,Ø<br>total=+1  | +,+,+,+<br>total=+4 | +,+,+,+<br>total=+4      |
| <b>Round Two</b>   | -,0,0<br>total=-1   | +,+,Ø<br>total=+2 | -, -,0<br>total=-2 | +,+,+,+<br>total=+4 | +,+,+,+<br>total=+4      |
| <b>Round Three</b> | +,+,0<br>total=+2   | +,+,Ø<br>total=+2 | +,+,+<br>total=+3  | +,+,+,+<br>total=+4 | +,+,-,-<br>total=0 (neg) |

**TABLE 4:** Success indexes of the 28 groups considered in the follow-up. Each cell shows the success index as determined by student responses. The response of each student is symbolized by a +, -, or 0. Success indexes were computed by summing student responses within a group. Groups with a non-negative outcome were considered successful. Groups with a negative outcome (shown in italics) were considered unsuccessful. The symbol Ø is used to denote individuals who did not participate in interviews.

Of the 28 groups studied, 21 (75%) demonstrated characteristics of successful groups when the selection criteria was applied. This is a considerable increase compared to 5 of the 14 groups (36%) discussed in Chapter II.

### Demonstrations of Improved Group Dynamics

It retrospect, we determined that the following major problems contributed to group dysfunction in the Spring 1998 class:

1. Extreme heterogeneity
2. Diversity in group pace
3. Presence of a distinct leader (lack of general student participation)

The new and deliberate grouping strategy used for the Fall 1998 students was able to greatly reduce the group dynamics problems caused by each of these factors.

### Extreme Heterogeneity

It appears that actively segregating the previous-knowledgeable component of the class virtually eliminated tension due to perceived differences in scientific background. Both previously-knowledgeable and non-previously-knowledgeable students were delighted with being able to "connect so well" with other group members. Non-previously-knowledgeable students seemed relieved that they were working with people who possessed an equally weak physics background. In fact, grouping students with similar deficiencies in scientific background seemed to enhance the course for some students:



*We worked pretty well. We were all basically on the same kind of level of understanding, and so we all, like, when we didn't understand something, we all didn't understand it, which was nice, because then we could work through it together. Or if one person got it, then they could help the other...*

Cooperative-uncertain student

*I think we worked really well together. With the circuits section, it was really fun. And we were all kind of learning together, 'cause none of us had a clue about circuits.*

Cooperative-confident student

*It made such an impact on me. I was really afraid of physics. I didn't have any physics in high school, and I'm thirteen years out of high school and haven't had sciences since then, and I was really nervous on how I would understand or react to how this class was being taught. But with them there, it was wonderful.*

Cooperative-confident student

Similarly, the previously-knowledgeable students expressed enjoyment at working together. The interactions reported by the Fall 1998 previously-knowledgeable students were strikingly different from those in the Spring 1998 class. There are many more descriptions of general group discussion, and, unlike the Spring 1998 component, these previously -knowledgeable students describe experiences in which they learned from their fellow groupmates:

INTERVIEWER: *What did the interaction look like? Was it almost all the time, or did you kind of work on your own and then just come together as you needed to?*

STUDENT: *No. It was all the time. I don't think we ever did it by ourselves. Maybe a little bit, you'd help somebody with it as went along, but never by ourselves and then come together and discuss it. We'd discuss it as we went.*

Previously-knowledgeable student

STUDENT: *We were really, really... you know, argued about – not argued, you know, in the negative sense – took things apart, took concepts apart, and we really picked at 'em.*

INTERVIEWER: *So it was a little more analytic?*

STUDENT: *Mm-hmm.*

Previously-knowledgeable student

There also is evidence to suggest that a segregated cooperative group learning style proved more beneficial to the learning of the previously-knowledgeable students. Unlike the students in the Spring 1998 class, who saw themselves more as helpers or teachers than learners, and who professed to not gaining a great deal of new understanding, some of the Fall 1998 previously-knowledgeable students reported that their understanding of physics increased dramatically. A comparison with a response from a previously-knowledgeable student from the Spring 1998 semester suggests just how much the situation of previously-knowledgeables improved:

*Like, physics in high school, I don't remember a lot of it, because it was more, "Here are the formulas you memorize," and you memorize what, when, and where, and then you got the answer, but I couldn't tell you the formulas now. But this stuff, I remember how we did it, and how you got there, so I could explain it. I mean, it forces you to be able to explain the concept to someone who knows nothing about it. And us, it was like we had to work backwards; we knew the concept, but we had to get back to where it actually began, and work up to that. So that was good.*

Previously-knowledgeable student  
Fall 1998

*[My understanding of circuits] is just inherent, I guess. I've seen it done so many times, I can probably do it almost in my sleep. I know how some things should function and how they should not..., and then my other group members pretty much didn't have a clue.*

Previously-knowledgeable student  
Spring 1998

Due to minor problems with the initial grouping instrument<sup>\*\*\*</sup>, one group did end up with a situation of extreme heterogeneity, and as with the situations observed in the Spring 1998 class, this group turned out to be unsuccessful. In this case, a cooperative-uncertain student had taken an introductory astronomy course, and thus functioned as a previously-knowledgeable student during a section studying the phases of the moon. As a fellow group member recounted, the previously-knowledgeable student's experience with the subject was more confusing than helpful, and ultimately this groupmate was forced to seek outside assistance in understanding the topic:

INTERVIEWER: *Did [IT's astronomy experience] help or hurt to kind of give you hints as to how it [the phases of the moon] worked, or you wish that you had been able to do it without that input?*

STUDENT: *You know, I thought it was going to help, but I never really understood, and I know she tried, and she was real patient... I never really quite understood.*

INTERVIEWER: *What about now? Do you feel like you have a model...?*

STUDENT: *Yeah. Now I've had a different person explain it to me, and that made all the difference in the world.*

This example serves to further substantiate the need to separate students with different levels of experience.

### Diversity in Group Pace

Reported group pace problems were much less common among the groups in the Fall 1998 class. Several students commented that they appreciated not being rushed, and the comfort with the group pace seemed to relate closely to the level of understanding students believed they had achieved:

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<sup>\*\*\*</sup> One student failed to identify that they possessed previous experience in astronomy. A solution to such a problem would be to specify course topics on the grouping instrument, so that students can be considered

*This group actually seems to be the best group I've had, because there's nobody that has one particular role, and it occurs to me that everybody, like they're with each other – we don't have one person that we're trying to bring up to speed and then we don't have one person that's trying to push everybody to go further – you know, we all work well together and we all work at the same pace and all seem to have the same level of understanding.*

INTERVIEWER: *What was the best attribute of this group? What worked really well?*

STUDENT: *I think the pace that everybody was able to set... Some days we went faster, some days slower, but everybody was on top of things, everybody was interested in the topic, it seemed like.*

*I think that we're all working about the same pace. We all have pretty equal understandings. Like we all did really well on the last test, and I think that was a big part of being able to work well.*

Of course, not all students felt comfortable with the pace of the group. One cooperative-confident student explained problems she encountered with her first group:

*It was very fast-paced. I always felt like, "Oh, I gotta keep up with everyone else," and it was like I always felt, like, really rushed, and there was people in the group [sic] tend to be really fast with their work. Whether they got it right or wrong, they wanted to go ahead, 'cause it was, "This is an answer to this. Whether it's right or wrong, well, we'll just move on." So there was a lot of that...*

Cooperative-confident student

However, in this particular instance, the student who complained of a fast-pace was also remembered by her fellow group members as quite often being tardy:

*She [SS] would come late, and we'd explain things to her several different ways, and she still didn't get it, and it was frustrating, 'cause the three of us were ready to go on, but we couldn't...*

It could be that the perceived pace dichotomy had less to do with the student not being able to work at the pace of the group and more to do with the fact that her group often

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selectively previously knowledgeable. This is covered in the Appendix.

devoted time and effort to help her catch up. That could explain the frustration on SS's part at generally being told the answer and not necessarily participating in the reasoning process.

More often, pace problems presented themselves when a minority of students worked faster than the rest of the group. Rather than coming from a difference in understanding, however, many students reported that pace problems stemmed from social interactions. In some particularly chatty groups, one or more students would pull ahead while the other students socialized:

*I felt that she, I don't know, just kind of jumped apart from the group, FH did, while me and PP were trying to work as a group, and I think that's what kind of lead to us just stopping our work and then socializing and stuff...*

*Because of the fact that we were more social, it was harder to focus from one experiment to the other, 'cause we'd kind of jump into social things – so I'd kind of, you know, WP and I, the boy in the group, we would kind of move ahead and read through it, and then maybe the other girls would come along with us.*

STUDENT: *I know FN was frustrated with AD and I 'cause we would talk so much, and he would just go on and do the work himself.*

INTERVIEWER: *Is that right? So he just kind of operated independently?*

STUDENT: *Yeah, it wasn't more like a group effort. It was more an independent effort when it came down to that.*

A deliberate attempt to eliminate the pace dichotomy also had an unfortunate, but not surprising, side effect. Because students were now being grouped with people that didn't rush them along or slow them down, it became more difficult for some groups to stay on task during class, especially when they were not overtly interested in the topic at hand.

*[S]ince we knew each other so well, or we felt like we got along so much better, we talked a lot more, and we got distracted a lot easier. So, like, we didn't keep up with the agenda so well....*

*Sometimes we just didn't want to work, so we would, like, talk about our weekends or something like that. But we got everything done, but sometimes we just didn't want to work.*

*It didn't work out very well, actually, as far as learning and stuff like that. It was a lot more chatty about social issues and stuff like that. So we got our work done, you know, but it just didn't work out very well because we weren't focused. You know, as far as our learning styles and everything, that was completely fine, but socially, we decided we had more of an aptitude for that area.*

It is difficult to tell the extent to which these problems stem from the course versus the groups themselves. It is possible that students became more social as the material became too difficult, or not difficult enough. This is discussed further in the section Problems Arising during Implementation starting on page 62.

#### Presence of a Distinct Leader

The idea of a identifiable group leader emerged far less often in Fall 1998 groups. Many students described their groups as having no single leader, and even that the role of leader seemed to rotate naturally. A lot of interviewees remarked that a defining factor in their favorite group had been a lack of distinct hierarchy:

*This group actually seems to be the best group I've had, because there's nobody that has one particular role:*

*We all share an equal part within the group.... In this group, no one person takes the lead.*

STUDENT: *We all work together like that... I can't explain it. It's an equal...*

INTERVIEWER: *There's not really a leader? You all kind of pitch in, and no one's fighting?*

STUDENT: *I would say that we all take the lead when we need to, but it's not pushy...*

In the few groups where hierarchies did appear, the "leaders" seemed to be resented by students, rather than treated as authority figures as was done with the previously knowledgeable students in the Spring 1998 class.

*He'll, like, go off on his own little tangent and then come back as "Mister Authority," like, this is how I did it, you know, type of thing, which is totally contrary to team effort. I find myself more and more like, "We're a team here."*

*Sometimes I'm more of a follower in this group, but it seems like a lot of times TP's a leader, but she's not always right in what she's saying, so I have to, like, be a follower but at the same time I have to lead and tell all the group that, no, I don't think this is right.*

In cases where "leaders" were perceived, they seemed to be more a result of group dysfunction than experiential differences. The two situations mentioned above appeared to be the result of tension between students due to genuine personality conflicts. It should also be noted that both aforementioned situations involved non-traditional students, who presented an unexpected source of problems, which are discussed in the following section.

These are not, however, the only groups in which leaders attempted to emerge. In fact, none of these "leaders" refer to themselves as such in their interviews, so we must consider that the perception of unwanted "leaders" stemmed from conflict among group members. It is easy to see how a student might interpret disagreements with a groupmate as evidence of that person trying to "run" the group. This conclusion is supported to some extent by the fact that all of the groups containing "leaders" fell into the unsuccessful

category.

### Problems Arising during Implementation

It would be unrealistic to expect that all problems arising in cooperative group learning situations could disappear merely by grouping according to one or two characteristics. While segregating previous-knowledgeable students and creating groups from adjoining categories resulted in a dramatic improvement in success rate as determined by our criteria, other secondary problems presented themselves. While these problems were not nearly as dramatic as those demonstrated in the Spring 1998 semester, they appeared solvable with certain modifications to the classification instrument, and thus we choose to address them. Some, such as problems associated with non-traditional students, seem to be somewhat independent of our grouping techniques. Most of these secondary problems, however, likely occurred as a result of our grouping criteria. In this section, we will discuss the problems at hand and possible solutions.

#### Non-traditional Students

With the segregation of previously-knowledgeable students, tensions due to physics experience were generally eliminated. However, previously unobserved problems emerged between traditional and non-traditional students. "Non-traditional" here refers to students who have spent a significant time (several years) out of school. Most of the non-traditional students considered were married, had small children, and were employed full-time in addition to being full-time students. Some traditional students had similarly full



lives, but, in spite of marriage, children and work, had never left school, and thus viewed themselves differently than non-traditional students.

In the Spring 1998 semester, the class considered had three non-traditional students (16% of the class), only one of whom was interviewed. The Fall 1998 semester had one non-traditional student in the second section (6% of the class) and four in the first (25% of the class). Four<sup>†††</sup> of these students were interviewed.

All of the non-traditional students were quick to distinguish themselves as such. They demonstrated different priorities than their traditional counterparts, with a large part of their focus on their lack of recent experience, as well as outside commitments such as family. This was borne out both in their interviews and in the interviews of their more traditional group members:

INTERVIEWER: *So what was the worst thing about that group?*

STUDENT: *We had one partner – CD – who had... – and I don't even know if it would even classify as 'worst' – but it was tough when somebody came in late. She has children... You know just late, as far as the class. You know, like half hour, fifteen minutes, whatever, when everybody has started and we'd have to catch somebody up.*

Traditional Student

*[The two non-traditional students in my group] talk about each other's husbands, and one of them has a kid, and they talk about the kid, and who's going to watch the kid and stuff like that.*

Traditional Student

*Well, for myself, a lot of my physics experience...was twenty, twenty-two years plus, and all three of the other members in the group were pretty much fresh out of high school.*

Non-traditional student

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<sup>†††</sup> One of these students dropped the course halfway through the semester.

*I was really afraid of physics. I didn't have any physics in high school, and I'm thirteen years out of high school and haven't had sciences since then, and I was really nervous on how I would understand or react to how this class was being taught.*

Non-traditional student

*I'm so much older than a lot of the students in the class. I don't know... I go back and talk to my husband about it all the time...*

Non-traditional student

All of the interviewed non-traditional students displayed consistent opinions on two subjects: their interactions with traditional students and their attitudes towards cooperative group learning. It was clear that, in many cases, the non-traditional students questioned the intellectual priorities of their traditional groupmates. The non-traditional students took their roles as future teachers very seriously, and focused strongly on the context of the course material as part of their upcoming careers<sup>†††</sup>. As one non-traditional student put it:

STUDENT: *[T]he only thing that frustrated me was their youth not allowing them to look beyond the content material in the course, and to actually look at what the reason for the course was, and that would be to not necessarily pick up on content.... [T]hat's the thing that frustrates me in general.*

INTERVIEWER: *So the younger students had a really hard time seeing that perspective?*

STUDENT: *Yes. [A traditional student would say,] "Oh, I know this!" "Now wait a minute. That's not exactly what we're s'posed to be doing here. Okay? We're s'posed to be learning about presenting it to the students, and fully understanding the contents before we present 'em to the students." And a lot of 'em just, "Oh, yeah, yeah, yeah. I know that." Well, you might know that, but you need to know several different ways to present it. And that's one good thing about the groups was because there were so many different perspectives of how to*

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<sup>†††</sup> It could be said that their focus on course material in the context of teaching was overly strong, as Physics by Inquiry is intended to be a content, rather than a methods, course. Regardless, the difference in perspective proved a source of frustration for non-traditional students.

*look at what you were doing that it would give you an idea of, "Oh, hey! Well, I'm going to have students just like that in my classroom, so I need to know how to get the point across to each of them." So I look at it from that perspective.*

This particular non-traditional student found herself regarding group members more as future students and less as peers. In this case, the effects were benign, and some of her fellow group members expressed enjoyment with her relentless pursuit of method:

*She's going into her student teaching next semester, and she's got a science emphasis... The way she thinks is just amazing to me. I mean, her logic can just go through anything, and she can explain it to you logically so that I understand it.*

Unfortunately, the self-imposed differentiation by non-traditional students didn't always have such positive results. More often, the non-traditional students saw themselves as more worldly than fellow group members. This led them to somewhat devalue the intellectual contributions of more traditional students. In one particularly negative group interaction, a non-traditional student described her interactions with a traditional student:

*[W]e have a person who is total, like, traditional age for that class, and so maybe just in that she was feeling defensive at "These two older students just think they're going to come in. I'm going to give my ideas..." So it could be just an age issue, you know, a maturity level, you know, and I'm more apt to be vocal, and she was like, defending her right to be nineteen or whatever, you know.*

This comment expresses a great deal of frustration with the traditional student, and any contribution is disregarded as lacking maturity. The traditional student in question described the same interactions:

STUDENT: *She'd never taken it [physics] before, but she just took it upon herself to feel that she needed to be up with them [the previously-knowledgeable students] with us in the group. She acted very singularly. It wasn't a group with her. "Come on, let's rush through this. Let's get done with this." So I guess how I acted, I tried to fight my way back, you know, to find a place, 'cause CD and I would be trying to understand concepts together, and AD would just be like, "Come on, ladies," and then she'd be telling us about her weekend, you know, one second, and the next second she'd be rushing through.*

INTERVIEWER: *So how would you pull her back?*

STUDENT: *How would I pull her back? I'd say, "Listen, we're not even done with this problem, you know?" She'd be two ahead of us. So she'd close her mouth, you know, if she was frustrated with us, basically, close her mouth and just start working on her own, not help us, not work together as a group.*

It would appear that this traditional student was actively trying to contribute, but this non-traditional student had assumed a role similar to one seen in a previously-knowledgeable student from the Spring 1998 semester. In this case, traditional vs. non-traditional status served to promote a hierarchy within the group. Of the 28 groups, three suffered from this problem, almost half of the unsuccessful groupings. It would appear the life experience can create group tension in much the same way that physics experience does.

Fortunately, there were also groups containing non-traditional students that were successful. These groupings seemed to follow specific patterns. If non-traditional students were isolated within groups (6 groups), or if the entire group was composed of non-traditional students (1 group), the group was successful<sup>§§§</sup>. However, if a group had non-traditional students in the majority with traditional students in the minority (2 groups) – in these cases, two non-traditional students with one non-traditional student – the

<sup>§§§</sup> One case with a single non-traditional student was unsuccessful. However, the lack of success in this group seemed related to group coherence rather than the role of the non-traditional student; one group member virtually stopped coming to class and generated a great deal of animosity with her fellow group members.

groups were unsuccessful\*\*\*\*. In both the unsuccessful cases, the traditional students expressed frustration at the lack of group functionality:

*We had a lot of animosity. Like I don't even talk to AD now. It sounds so petty, but it was so frustrating to learn with her. I could not learn with her. I didn't learn anything.*

*This group, I might as well just be working on my own on this one. I'd have a lot less headaches.*

It is interesting to note that the one group which consisted of all non-traditional students contained a student who was continually behind, had trouble with the course material, and was one of the two students who ultimately dropped the course. In this case, though, one of the same non-traditional students who expressed frustration at a traditional group member in a previous quote described a far more positive experience:

*VN, I had just met then, that was the first time I had ever met him before, and I thought he was super in the group. You know, it didn't feel confrontational. Some people are very confrontational, and I thought we interacted really well, in terms of like my ideas, his ideas, or me questioning something that he had. You know, very comfortable. It didn't feel like I was challenging him on any ideas...*

It would appear that she was willing to consider a fellow non-traditional student as more of a peer than the younger, but more academically-capable, student she so actively conflicted with. This strongly suggests that non-traditional student status should be a deciding factor in our strategy of group organization.

Another somewhat unexpected outcome of the interviews with non-traditional students was their attitudes towards group learning. While they each advocated it as a good teaching style, they expressed reservations about participating in it personally:

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\*\*\*\* One successful group, containing two non-traditional students and one previously-knowledgeable student, was reported in the Spring 1998 semester. It is possible that physics experience can be

*I'm not a big group worker anyway, so when they said at the beginning of class that it was going to be group work, it was just kind of, "Oooh..."*

*I just go like, "Gosh, we have to be in groups," and I'm a non-traditional student. I could just do this stuff by myself. You know, other group projects that we have in our other classes too, that takes me away from my family. Well, this one doesn't, but just stuff like that. Being a non-traditional student, I don't like groups, but as a teaching strategy... I can see where it would work well...*

This is especially interesting when one considers that these same students each expressed at least one very positive group experience. It would seem that the students in question experienced more difficulties with the mechanics surrounding group work (commuting, making time for group projects, etc.) than many traditional students. A solution to this might be to take these problems into account as an instructor and try to minimize extraneous hassles (traveling great distances to meet with groups, scheduling difficulties, etc.) as much as possible.

#### Previously-knowledgeable Students and Expected Coursework

While the segregation of previously-knowledgeables improved their learning experiences, grouping students with previous physics experience did lead to an unexpected problem. Because students were able to start communicating at a more advanced level, quite often group discussions were much more in-depth than the course material anticipated. Previously-knowledgeable students often found themselves bored or foundering:

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considered equivalent to life experience in such a case.

INTERVIEWER: *Were there times in the curriculum when you or members of your group were bored or wishing you could skip ahead?*

STUDENT: *All the time.*

INTERVIEWER: *All the time? Pace felt too slow for you?*

STUDENT: *Yeah, it did. All of us had had physics before, so just the idea that we did it all in the tenth grade... [I]n the book, the questions are so repetitive that there's times, like if you look at my notes, I have like six things that say, "See four point one, ditto, ditto, ditto, ditto," 'cause I'm not writing it all out.*

*I think sometimes it would get a little long; the two hours would be long. That unit was real, kind of, basic, I think. We'd all done it before.*

The students generally traced their frustrations back to the text. Many found it too basic to accommodate their previous encounters with physics, and at the same time, full of seemingly "trick" questions:

*I didn't really like the book, and that I think contributed a lot to the frustration in the [second] group, because the book, it's supposed to be a college-level book, and I didn't think it was. I thought it was pretty basic. I think that was one of the major frustrations was the book, and how the book worded the questions or worded the experiments or what to do. ... You learn the concepts, and it's very basic, and that helps you, but it's like, some of the basic concepts that I did get out of high school I came in and I'm like, "Well, I thought I knew this," and I actually didn't know it. ... It was really frustrating, and I think the book really added to it. It was really frustrating, the book.*

In spite of previously-knowledgeable students' frustration with the basic nature of the course, they tended to move at the same pace as the rest of the class and expressed frustration with the instructor at being asked to learn material at an accelerated pace:

*In the particular groups that I was in – we're in this advanced group – we'd go faster than the rest of the class, and that really bothered me sometimes because we'd be given all this extra stuff to do and the rest of the class wouldn't do it, and I thought, "Well, if it's supposed to be beneficial, why aren't they doing it?" And so we'd feel frustrated with some of the extra stuff we had to do.*

The seeming contradiction of boredom and resentment towards an accelerated pace was difficult to reconcile. In one case, a previously-knowledgeable student in Section Two

became so frustrated with the banality of course material that she stopped coming to class, much to the frustration of her group:

STUDENT: *AT's attitude really bothers me, because, like, she doesn't care. She thinks it's way to basic for her, so she just doesn't care. She doesn't show up to class. I mean, she comes to class, and it's like, she'll go through it at home, and she doesn't expect us to catch her up because she already knows it, but I don't know. She doesn't like the class, she doesn't like [the instructor], and she doesn't want to be there and it shows.*

INTERVIEWER: *That unfortunately is hurting you, I guess.*

STUDENT: *Right, yeah. It's like, "Well, you're a part of our group, and our group depends on all of its members to work together." And lots of days she's never even there. And then when she is there, she's got a negative attitude about it.*

*What frustrates me is ... refusal to see beyond what was in front of, and that goes back to AT's, "Oh, I just don't see why we have to do this. This is just so stupid." Well, yeah, you may think it's stupid, but hey, to get out of this class, this is what we've got to do. ... I mean, we're going to make it out all right, but it's just frustrating to me to have to sit and listen to people like that, but I have to deal with it, because I know there's going to be students like that in my classroom.*

Unfortunately, in the process of complaining about this particular student, her fellow groupmates reveal their own similar frustrations with the course and the material.

It would appear that, by improving group dynamics for the previously-knowledgeable students, we have, in the process, diminished the effectiveness of the course for them. Group learning strategies appear to work best when the group members are challenged by the subject; that failed to happen here. This brings into question the motivation for previously-knowledgeable students to take a course so specifically designed for non-majors. Fortunately, one student revealed her motivation for being in Physics by Inquiry even as she expressed her disappointment:



*It just seemed like, for a college class, I'm learning more how to teach physics. It didn't do a very good job of that. That's I guess what I thought the class was about – you know, how to teach the basic ideas of circuits and math and things like that – and it just felt like we were doing the work, but we weren't really learning how to teach it better.*

Apparently, at least some of the previously-knowledgeable students approached this class as a methods, rather than a genuine physics, course. Given the negative reactions of the students to the content, *Physics by Inquiry* is inadequate on both counts.

These data suggest that improved grouping methods could have a drastic impact on curriculum structure. In this case, improved group dynamics led to frustration with the course material that, had students not been organized in this manner, probably would have manifested itself as frustration with other group members. Since going back to previous grouping strategies would contradict the findings of this study, the best remedy for such problems may lie in fundamental curricular changes aimed specifically at previously-knowledgeable students.

### Group-switching Backlash

Far and away, the initial student reaction to group-switching was negative. Some students eventually enjoyed the groups they switched into, finding that a change of pace helped their learning:

*I disliked it at first, after switching from the first to the second, because we were just starting to click. You could pretty much count on the first group, at least a few of the people in our group, being there everyday on time, and so you started to notice everybody's routines and kind of how they thought and whether you'd feel like a total dink if you asked a question of somebody else or asked somebody to help you out, and everybody was really helpful in that way. And then once we got going along the switching groups, it was great to get to know other people and be able to talk to other people.*

For the most part, though, students did not enjoy their personal experiences. As one student commented:

*Most of the people I've talked to in the class, their first group was their favorite group. You know? I mean, MD's first group was her favorite group, and RB's first group was her favorite group.*

Even for students who cited their second or third groups as their favorites, it was apparent that change was often more difficult than rewarding:

*I don't like it. I don't know... You get used to a group and you like staying in and finishing up, you know, 'cause you work so well together. I can understand somebody should maybe go talk to the professor or the TA [teaching assistant] or whatever and tell them that they're having a problem with their group, but we weren't having any problems, and PP and I were both begging [the instructor] to stay in our group the first time.*

*In general, I feel that if we [the first group] would've just kept together, and not had to have split up, that would've been the best.*

*If you think you don't understand something, you're afraid to ask 'cause it's a new group. You don't have the comfortableness [sic] yet.*

*I don't like it 'cause you have to get into a new group and... it's a whole new style, kind of like, you know.*

*I think that if you stay with the same group for a long time, you get so comfortable that it would be hard to work with other people. You just get so used to the role that you're in – I don't know if that makes sense – like, if you're the one that's always speaking up for your group, you might get so used to that it would be hard to work with another group...*

*I think it's really hard when you get thrown in with a bunch of people to try to get a foundation, and you finally get one – like in that first group, we started working well together, and started enjoying it 'cause we moved along quickly and I started, you know, understanding how it all worked, and it really jostled me, I think, to switch into a new group. Then you've got to start all over again, and I think that was a kind of struggle for me.*

The preference of dynamics within the first group is reflected by the success rates of groups at each round of changes. For the first round, nine out of ten groups were successful (90%)<sup>†††</sup>, compared to five out of nine (56%) for the second. The high success rate of the first round strongly suggests that the group-learning techniques students adopted were highly dependent on their initial group interactions. Many students described positive interactions with members of their first group, followed by subsequent problems within the second. This was often attributed to differences in personalities or learning styles. Just a small sample of the comparisons follow:

*I don't know if I would have changed anything. It seemed that was by far the most productive for me, as far as what I was learning, and everything seemed to go pretty smoothly.*

WP describing first group

STUDENT: *I don't know what it was, but our group didn't "click" maybe as well as say the first one did.*

INTERVIEWER: *Didn't click as well with the science, or didn't click as well with the social?*

STUDENT: *No. Social things were fine, and the science seemed to... we were just at a different pace maybe. People were learning differently...*

WP describing second group

\* \* \*

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<sup>†††</sup> It should be noted that the one unsuccessful first round group may have been due to factors beyond the instructor's control. Apparently, two students were grouped together who had conflicts previous and external to the class:

STUDENT: *I would've liked to have a different person besides EK. I think that that maybe would've mixed the group better, and EK was in every single one of my classes also, plus the physics and plus we were in the same group together, so that was kind of...*

INTERVIEWER: *Too much EK?*

STUDENT: *Too much EK.*

In the future, such problems could be avoided by including a question in the instrument which asks students if their are class-members they would prefer not to work with.

*That group worked really well together, so I wouldn't really say there was a leader. I think everybody pulled their own weight and did their own fair share, and I don't think there was really a leader or a follower.*

DB describing first group

*Probably the second group was [the least favorite.] Just personality... learning styles were different.*

DB describing second group

\* \* \*

*We all kind helped each other. We worked really well together. Like, we all were the same kind of people. We took a little longer to get it, but once we got it... You know, and if somebody else in the group didn't, then we'd keep changing the ways of explaining it to make sure that all four of us understood it.*

PP describing first group

*They both completely understood what we were doing, and I was going a little slower, but it wasn't slowing them down at all. They just kept going ahead of me, and I was just finding myself falling behind and I was so uncomfortable with both of them. Like, our personalities didn't seem to click.*

PP describing second group

The students attribute most negative interactions to personality conflicts, but a more plausible explanation might be that the students each developed distinct group learning styles in their initial groups. There was little disharmony in the first round simply because most students may have had little or no experience with intensive collaborative group learning, and thus were much more willing to compromise their learning styles in an effort to establish individual group equilibria. After switching groups, students probably expected to continue to interact in a manner similar to that of the first group. However, if group dynamics were tailored within each initial group (as appears to be the case), switching groups would instead lead to conflict as students were forced to quickly adjust to new learning styles. It would seem that this researcher's assumptions about the

innocuousness of switching groups proved incorrect, and successful grouping may only be compromised by group switching.

There was, however, one circumstance in which group switching proved ideal for students. This happened in situations where initially timid students (mostly cooperative-uncertains) demonstrated increased confidence as they moved to each subsequent group.

Some examples include:

INTERVIEWER: *How did you behave in this group?*

STUDENT: *I don't know. Kind of shy, I guess.*

DU describing first group

*I opened up a little more. Like I talked more in this group, I think, just 'cause I got more comfortable with physics, 'cause this is my first class, so I think I just got more comfortable with everything.*

DU describing second group

*Again, [I'm] more outgoing, 'cause I understand much better, and I'm getting more comfortable with it.*

DU describing third group

\* \* \*

*I did a lot of observing, I would say. I didn't feel that I could be a full participant, I guess.*

ML describing first group

*I was more interactive, I'd say, with that group...*

ML describing second group

*I'm actually interactive. I help with the problems. I feel like I'm doing this instead of, you know, kind of doing it and then having take it home and figuring it out. You know, I'm doing it in class and I'm figuring it out.*

ML describing third group

In these situations, group switching proved beneficial for the cooperative-uncertain students. We speculate that their increase in participation and confidence in the subject

would not have taken place had there not been group switching. These students were in the minority but still a noticeable percentage (6 out of 34 students) of the two sections. We are left with the dilemma of which scenario should take precedence: should group switching be avoided so that most students can remain in harmonious groups, or should we continue with group switching to promote increased confidence in science among a minority of the students?

### Improvements for Future Implementation

Based on the new problems encountered as part of the implementation of categorized grouping, this researcher recommends the following three guiding principles:

- ◇ **Deal with non-traditional students in much the same way as previously-knowledgeable students.**

Non-traditional students seem to function best in two situations: grouped exclusively with other non-traditional students or isolated entirely from other non-traditional students. If at all possible, groupings with other non-traditionals seems favorable. This allows for a more uniform frame of reference within the group, and students might find it easier to accommodate each other's schedules for meetings outside of class. However, this grouping of non-traditional students should be secondary; after previously-knowledgeable students have been segregated.

- ◇ **Provide a more challenging environment for previously-knowledgeable students.**

The problem of fully engaging previously-knowledgeable students as active learners is slightly more delicate in the context of this course. We must accommodate the fact that

previously-knowledgeables are not being challenged by the traditional course material, but feel that it is inappropriate to be presented with different expectations than the rest of their classmates. To avoid the in-class dichotomy altogether, it might be best that previously-knowledgeable students not be included in this particular inquiry-based physics course at all, and may benefit from a more advanced traditional course with weekly inquiry-based recitation sections<sup>+++</sup>. This would not only present the previously-knowledgeables with more challenging material, but it would avoid the expectation that *Physics by Inquiry* should function as a teaching methods course.

◇ **Reconsider the value of group-switching.**

The usefulness of group-switching is dependent on the expectations of the instructor. If group-switching does not occur, it seems more likely that categorically grouped students will end up in harmonious groups. Unfortunately, withdrawn students (such as cooperative-uncertains and passive-uncertains) may not develop the same level of self-confidence that they might if group switching occurs. In the context of a course such as *Physics by Inquiry*, which is geared towards future teachers, the benefits of group switching may outweigh the drawbacks. If these students are eventually going to present science to their own pupils as knowledgeable resources, it is important that they all develop confidence in themselves as scientific knowers and learners. If groups are not switched, the more withdrawn students may never reach this point.

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<sup>+++</sup> Montana State University does provide two semesters of such a physics course, which includes three hours of lectures with active discussion and demonstrations, and a two-hour inquiry-based recitation section similar to those used in Physics 201, but presenting material at a more advanced level.

With these modifications to our model of cooperative group organization, we are hopeful that group dynamics success rates may be improved even further. We will discuss the implications and possible uses of this more complete model in Chapter 5.



## CHAPTER 5

### DISCUSSION

#### Conclusions of our Study

This research project was initiated to better understand the nature of group dynamics in small cooperative learning groups in the context of an inquiry-based introductory physics course for pre-service elementary education majors. The ultimate goal was to determine the most relevant factors in creating groups where all students participated actively and enthusiastically in the learning process. The results of this study strongly suggest that positive group interactions for cooperative learning situations are not only possible, but can be predetermined with reasonable accuracy for this particular population.

The primary predictor of group success is relative previous experiences with the subject matter within the group. Students with similar backgrounds in conceptual physics worked together most effectively, and students with disparate backgrounds (a high school physics course versus no high school physics training) tended to experience conflict and animosity towards each other, often to the detriment of learning by all involved parties.

Within groups of students with similar physics backgrounds, a secondary predictor could be derived from students' self-confidence levels. Students could be classified into four categories:

- aggressive-confident,
- cooperative-confident,
- cooperative-uncertain,
- and passive uncertain,

which reflected their levels of confidence as physics learners. It was found that extremely outgoing and self-confident students (aggressive-confident) did not interact successfully with students who needed a great deal of patience and encouragement from their fellow groupmates (passive-uncertain). The most successful groups also possessed students in consecutive categories, so that, for example, a group containing a cooperative-confident, a cooperative-uncertain, and a passive-uncertain would be more successful than a group consisting of an aggressive-confident, a cooperative-uncertain, and a passive-uncertain.

When all of these factors are taken into account, our results show that successful groups can be orchestrated. Our original categorization instrument, which took into account previous physics experience and student self-confidence, enabled us to organize groups quickly and efficiently, and also produced a dramatically higher group success rate than observed in the Spring 1998 semester.

However, data from the Spring 1998 implementation also brought to light weaknesses in our model. We found that a student's "life experiences" produced results similar to, albeit less noticeable than, previous subject experience. Students with non-traditional status occasionally conflicted with more traditional students. However, this only occurred when traditional and non-traditional students were grouped together such that the number of non-traditional students in the group exceeded the number of

traditional students. In situations where there was only one non-traditional student in a group, the differences in "life experience" did not seem to impact the success of the group. Our original model did not take the "life experience" factor into account, but modifications to the instrument, such as questions concerning students' age, marital status, and self-classification as traditional or non-traditional status might allow us to create even higher group success rates when this technique is used in the future.

With factors associated with unsuccessful grouping better controlled, two problems with the nature of the *Physics by Inquiry* course structure became apparent. First, we found that when students with strong physics backgrounds (previously-knowledgeables) were grouped together, their group dynamics improved, but their interest in and satisfaction with the course decreased. They expressed boredom and frustration with what they saw as banality and repetitiveness within the course material. Furthermore, their main motivations for taking the course seemed to be an interest in the teaching methods rather than the subject material. Since *Physics by Inquiry* is designed to be a introductory content course for non-majors using cooperative group learning methods, rather than a teaching methods curriculum using inquiry-based physics as a vehicle, we believe that current course design is insufficient to further educate previously-knowledgeable students, and when the categorization instrument divines such students, they should be advised to take a higher-level physics course, and possibly automatically exempt from enrollment in *Physics by Inquiry*.\*

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\* As these students are primarily education majors, any change in curricular expectations must be discussed with and approved by Montana State University's School of Education. It is also possible that the problem of previously-knowledgeable students enrolling in *Physics by Inquiry* only exists because they

The second curricular problem stemmed from the implementation of group switching, first implemented in the Spring 1998 semester. Most students reacted negatively to group switching, feeling that their most comfortable and successful group experiences occurred in their first groupings. We believe that such strong first-group success may be attributed to the newness of the subject matter and the environment, and an inherent willingness to compromise learning styles in a effort to work together more effectively. However, by the time students first switched groups, they had become accustomed to the learning styles of their initial groupings, and found learning to function under new circumstances extremely stressful.

Such results suggest that, unless there is a specific motivation for it, group switching will for the most part be detrimental to students' group experiences. It should be noted, however, that we did observe a small proportion of students that appeared to benefit from group switching. In these cases, students who had originally lacked self-confidence as learners (here, cooperative-uncertains) gained confidence in their abilities with each group change. Many described themselves as active discussion and experiment instigators by the time they reached their third groups. In a course such as *Physics by Inquiry*, where virtually all of the students are training to be elementary school teachers, confidence in the course material and a student's ability to work within it are seen as vital components of the learning process. Therefore, it is likely that future instructors of *Physics by Inquiry* will prefer to sacrifice increased group success rates to provide a crucial opportunity for students to gain self-confidence as learners.

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are being advised to take it as a methods course. If this is the case, appropriate persons should be

### Implications for Use in Other Environments

Our study was limited to a single, narrowly-defined setting: a non-lecture, introductory, inquiry-based physics course for pre-service elementary school teachers. In our comparisons with other examples of group learning, we primarily compared studies using other physics or physics-related courses, with occasional references to studies examining group dynamics. However, we believe that our results suggest that our group organization strategies are more widely applicable.

It must be remembered that *Physics by Inquiry* is geared towards non-physics majors with extremely limited technical or scientific experience. The course is explicitly conceptual, and the group learning environment focuses on discussion and active learning rather than computational problem-solving. The instructors' main goals are to introduce students to hypothesis testing and the scientific method, and use these tools to build rigorous, self-consistent models. There is nothing about the course structure that is inherently subject-specific. It is also possible that courses using groups under less interactively intense conditions, such as in a problem-solving or creative discussion environment, can increase the likelihood of successful group dynamics using our grouping techniques.

Due to the highly interactive and self-regulating nature of the observed successful groups, we speculate that our group organization techniques would be ideal for large-enrollment courses (50 students or more) which use cooperative grouping as a teaching tool from time to time, but where instructors are not in a position to interact more than

briefly with any one group. In such situations, instructors generally organize students into groups to generate discussion and encourage active learning. If the success rates observed in the Spring 1998 semester are typical, it is possible that many, even a majority of, students have difficulty functioning within their groups. While group role assignments are used by some instructors, these may be difficult to enforce in a large-enrollment setting. Even if students could function successfully within their roles, such a teaching tool may prove limiting to discussion, since students will be locked into a given role throughout the assigned period, while a group functioning with good dynamics may, and according to our research, probably will naturally rotate roles as the discussion progresses.

We hope that our results and conclusions have proved sufficiently compelling that instructors opt to use the grouping techniques described here to facilitate their future employment of cooperative group learning. Successful application of this strategy will require the instructor designing an instrument – to be administered before groups are organized – that answers the following questions:

1. **What is the student's background in the subject matter?** The answer to this will most likely be dichotomous (the student has or has not previously taken a course in the subject), but it can go into as much detail as the instructor deems necessary. For instance, the instructor could ask about individual topics within the course if the scope is sufficiently broad.
2. **Is the student of traditional or non-traditional status?** This characteristic is easily covered with inquiries as to the student's age, marital status, and self-definition as traditional or non-traditional. In addition, inquiries into a

student's place of residence may facilitate group learning if the instructor wants to encourage groups to work together outside of class; it may be easier for students to meet if they live near each other, and would especially ease the burden for students who have long commutes.

3. **How does the student function in new situations or with groups of strangers? How comfortable does the student feel initially about the subject material?** Questions like these are designed to categorize the student's self-confidence as a learner. More than the other inquiries, these may be delicate and should probably be tailored to the course environment. This researcher's own first attempt at an instrument was somewhat less successful than hoped in these areas. This is discussed at length in the Appendix.

In addition to the three topics covered above, it may be useful to take a fourth into consideration. In our study, gender was not considered an issue, primarily because the students were almost entirely female. However, in mixed gender situations, Skala, Slater, & Adams (1999) found that in groups with uneven compositions of men and women (two or three of one gender grouped with one of another), at least one female student tended to dissociate from the group. On the other hand, groups with even gender compositions (two men and two women or single-gender) experienced far greater instances in which all members of the group interacted. The problems experienced by female students in groups of uneven composition are borne out in focus group interviews concerning students' group experiences.<sup>23</sup> Such results would suggest that gender should also be taken into

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<sup>23</sup> Skala, Slater, and Adams, 7.

consideration when groups are organized, especially in situations where an instructor is not in a position to closely monitor group activity. The most conservative approach would be to place students exclusively in single-gender groups; this would guard against group imbalances caused by student absences. However, it is difficult to predict how students would react to being assigned to such groups. For instance, might female students feel "singled out?" This aspect of group organization requires further study.

### Future Study

This research is only our first attempt at the understanding of group dynamics. Only with application of our techniques in a larger range of teaching environments can we see if our conclusions are generalizable. We are curious as to how widely applicable these grouping strategies truly are. For instance, they seem to work with older students and adults, but would they work with children? Are they even necessary or even appropriate among the sufficiently young? We have also derived all of our data from a course taught at a typical American college, as have all of the physics and physics-related studies we referenced. Would our techniques work in group learning situations in a sufficiently different cultural environment? Montana State University is associated with several Native American tribal colleges, some of which have offered the *Physics by Inquiry* course. Anecdotal evidence suggests that instructors have consistently had extreme difficulty interacting with these Native American students, and that active group learning has been difficult to motivate. These reports, as well as the interview provided by the



Native American student in the Spring 1998 semester, have made this researcher curious as to the impact of culture on cooperative group experiences.

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## APPENDIX

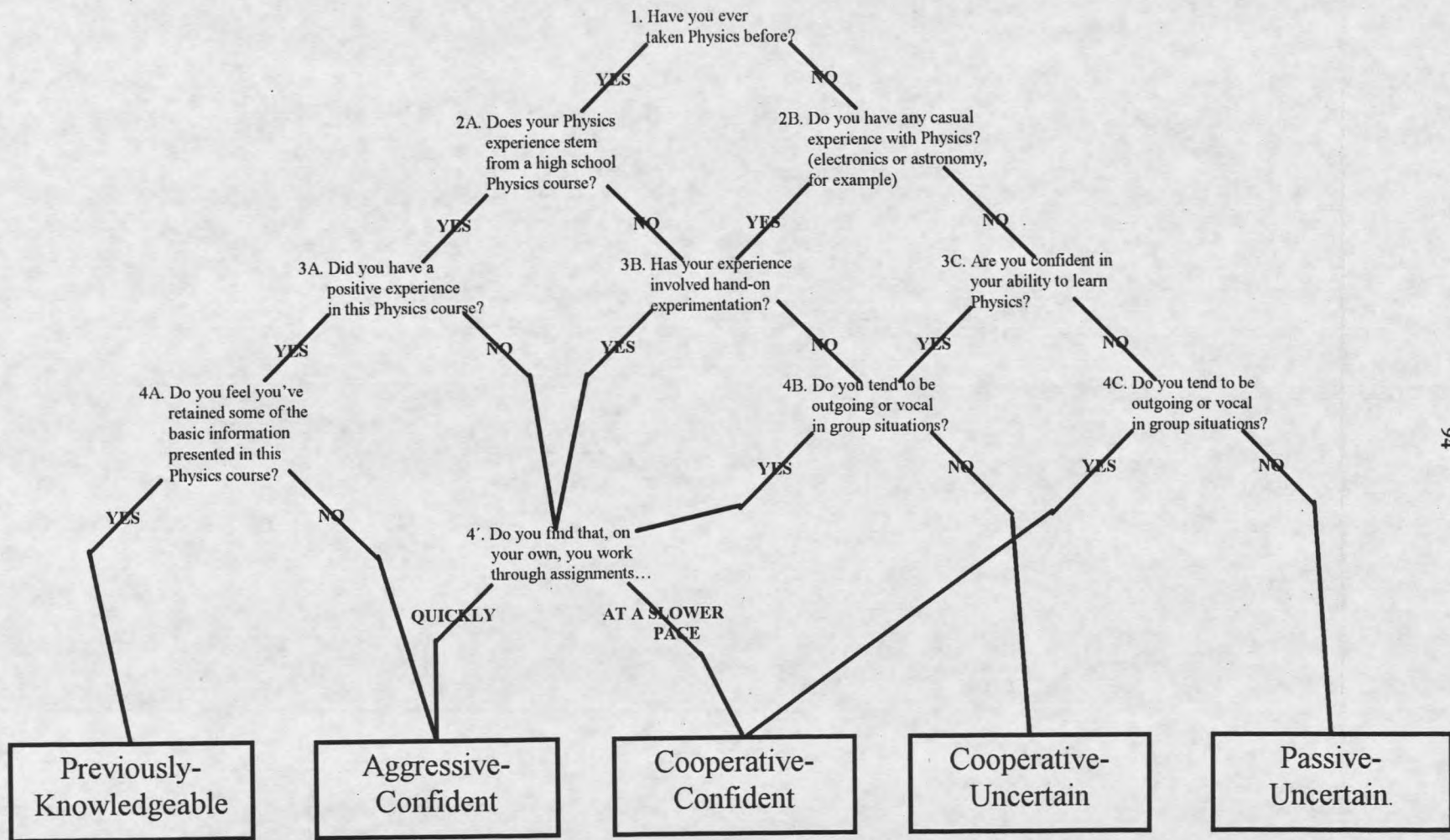
### DISCUSSION OF THE STUDENT CATEGORIZATION INSTRUMENT

### Instrument Development

Based on the responses from the Spring 1998 interviewees, we formulated a question tree, shown in Figure 1 on page 94. The question tree consists of a series of ten questions, each with a dichotomous response. Depending on the answer to a particular question, a student progresses to one question or another, so that a student actually answers only four or five of the available questions. The questions focus first on experience with physics, in order to distinguish previously-knowledgeable students. Remaining questions deal with students' behavior in group situations or on homework assignments. The path traced by student responses determines his or her group learning categorization.

For use in the Fall 1998 semester, the question tree was modified into a more easily administered survey, shown in Figure 2 on page 95. In an attempt to emulate the "tree" structure, any answer to a given question was accompanied with specific instructions that students proceed to another, often non-consecutive question. The instrument was designed so the number of questions to which a student answered "Yes" determined his or her categorization: four "Yes" answers constituted a previously-knowledgeable, three an aggressive-confident, two a cooperative-confident, and so on. This structure was created so that previously-knowledgeable students could be identified immediately upon submitting their responses.

## QUESTION TREE FOR PHYSICS 201



**FIGURE 1:** Question tree created to categorize student into group learning styles. This question tree was later formulated into the categorization instrument used in the Fall 1998 semester.



### Physics by Inquiry Introductory Questionnaire

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

Start with Question 1 and, according to your response, proceed to the next appropriate question. Don't worry. You'll only end up answering four or five questions.

- |                                                                               |               |               |
|-------------------------------------------------------------------------------|---------------|---------------|
| 1. Have you ever taken Physics before?                                        | Yes (go to 2) | No (go to 3)  |
| 2. Did you take a physics course in high school?                              | Yes (go to 4) | No (go to 5)  |
| 3. Do you have any casual experience with Physics (astronomy, for example?)   | Yes (go to 5) | No (go to 6)  |
| 4. Are you comfortable with fractions and ratio math, and have taken algebra? | Yes (go to 7) | No (go to 8)  |
| 5. Was your Physics experience hands-on?                                      | Yes (go to 8) | No (go to 6)  |
| 6. Are you confident in your ability to learn Physics?                        | Yes (go to 9) | No (go to 10) |
| 7. Do you think you've retained some of basic knowledge of Physics?           | Yes (stop)    | No (stop)     |
| 8. Do you tend to work through assignments quickly?                           | Yes (stop)    | No (stop)     |
| 9. Are you generally outgoing or vocal in group situations?                   | Yes (go to 8) | No (stop)     |
| 10. Are you generally outgoing or vocal in group situations?                  | Yes (stop)    | No (stop)     |

**FIGURE 2:** Categorization instrument used to determine student group learning styles in the Fall 1998 semester.

### Problems with the Categorization Instrument

When the instrument was administered to the students in the Fall 1998 semester, several problems were revealed. The most obvious problem seemed related to the instrument structure itself. Many students failed to pay attention to the instructions telling them to proceed to a specific, non-consecutive question, often answering all ten questions, regardless of their applicability. For instance, a student with no physics background answered questions asking about the experiences in the physics class(es) they had taken. This happened in spite of repeated explicit verbal instructions telling them to answer only the questions directed by their previous answers. Should this particular question tree structure be used again, a more successful approach might be to simply have students circle answers along the tree itself. A pictorial description might eliminate the propensity to answer all the questions.

A second, more subtle, problem appeared when it was discovered that none of the students had classified themselves as passive-uncertain. There are two potential sources for this discrepancy: either no passive-uncertain students enrolled in the Fall 1998 semester, or the nature of the questions precluded students from identifying themselves as such. Considering student descriptions of their own attitudes, as well as the behavior of their fellow group members, it is possible that neither section contained any passive-uncertains. However, we must consider the possibility that the instrument is flawed.

Further examination of the question tree in Figure 1 on page 94 and the instrument in Figure 2 on page 95 reveal two questions that may have presented problems. Question

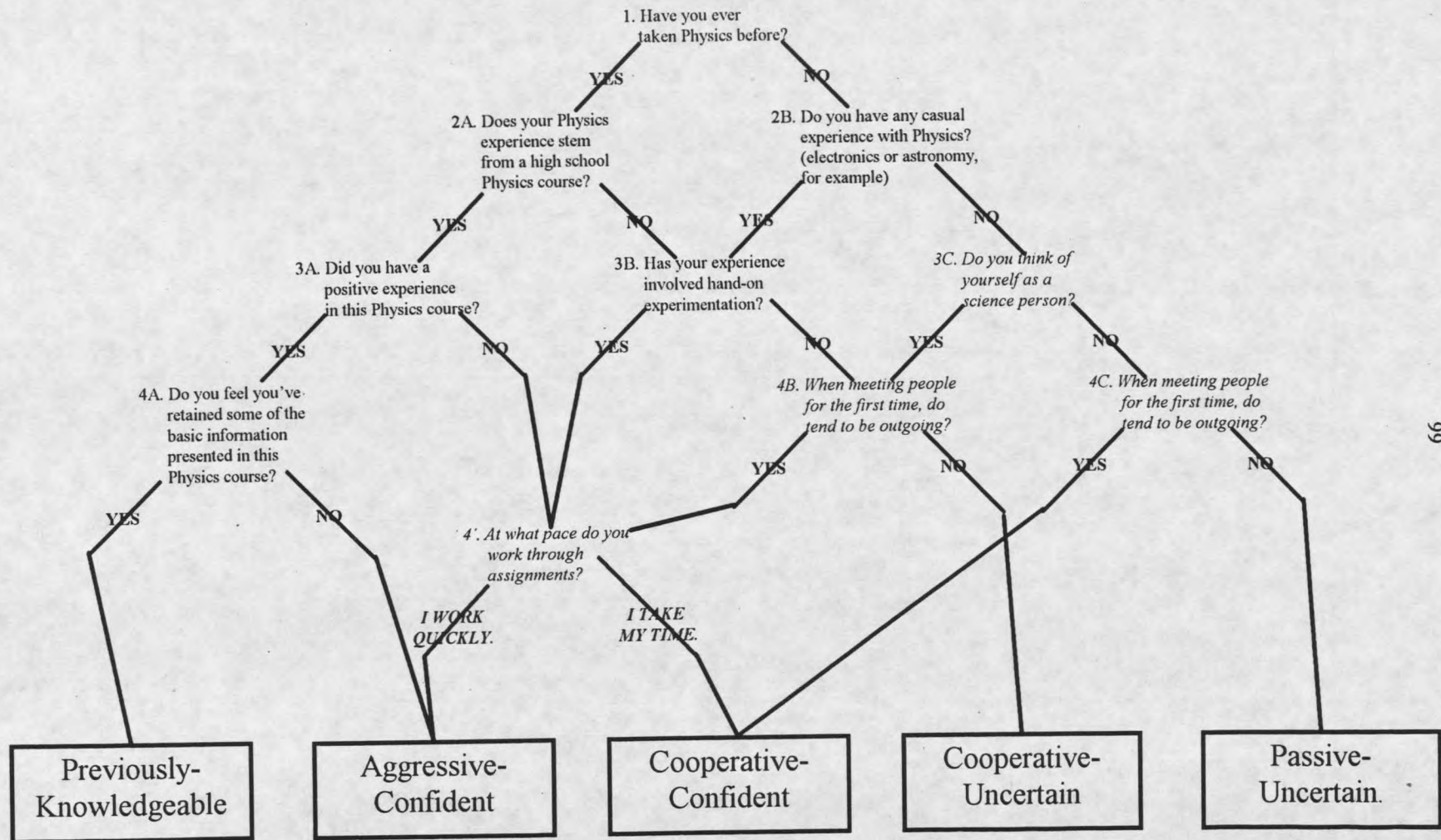
3C in Figure 1, "*Are you confident in your ability to learn Physics?*", may not be appropriate in this context. It is reasonable to assume that many students entering a physics course would only be there if they displayed some confidence in their ability to learn. If one notes the structure of the question tree, it can be seen that question 3C is along only one of two paths leading to a cooperative-uncertain categorization. Since no students who answered question 3B (the other path to a cooperative-uncertain categorization) answered it in the affirmative, it would appear that this one question not only eliminated all passive-uncertain categorization, but led to the categorization of all the cooperative-uncertains. The main purpose of this question was to ferret out students' self-confidence as science learners; it may not have accomplished this purpose. An improvement to the question might be "*Do you think of yourself as a science person?*" This wording should be tested, however, as it may make students with no science background overly prone to not classify themselves as cooperative-uncertains.

The other question which presents some difficulty is question 4B (also 4C) in the question tree: "*Do you tend to be outgoing or vocal in group situations?*". While there is no evidence to show that students felt primarily biased towards one answer, further consideration leads us to believe the question could be misinterpreted depending on how the student interpreted the phrase "group situations." In a close peer group, even an extremely shy student might be outgoing. More appropriate wording should emphasize the fact that students will probably not be grouped with close friends. Therefore, we feel the question might best be modified to read, "*When meeting people for the first time, do you tend to be outgoing?*"

In addition to the two questions mentioned above, it might be appropriate to also reconsider question 4' of the question tree: *"Do you find that, on your own, you work through assignments – quickly? – at a slower pace?"* In this case, though, the modification is derived from a greater desire for political correctness. It is possible that some students will interpret the word "slower" as mildly derogatory, even if it the concept is accurate in the context of the question. Therefore, an appropriate rewording of the question might be: *"At what pace do you work through assignments? – I work quickly. – I take my time."* This would eliminate the use of the word "slow."

A modified version of the question tree is shown in Figure 3 on page 99. We anticipate that the changes imposed will improve its accuracy and lead to more consistent categorization when it is used as an instrument in future classes.

## QUESTION TREE FOR PHYSICS 201 (MODIFIED)



**FIGURE 3:** Modified question tree derived from the discussion on the Appendix. Questions which differ from those in the original question tree are shown in italics.



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