Team study training in the college biology laboratory

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Students in college biology laboratory classes were grouped heterogeneously or homogeneously according to preferred cognitive learning style and were instructed using the cooperative learning method Student Teams-Achievement Divisions (STAD). In the first year of a two-year study students were given training in a team study strategy. No significant difference in achievement, as measured by the difference in pre and post-test scores, was detected for the students grouped homogeneously when compared with the students grouped heterogeneously. However there was a significant difference ($p < 0.005$) in score improvement between the year that students had training in the scripted team study strategy and the year they did not. In the first year of the study, when students had training in the strategy, the mean improvement in scores between pre and post-tests was 35.5%, but in the second year, when students did not have training in this strategy, the mean improvement was 18.6%.
Key words: Cooperative learning; Group composition; Learning style; STAD; Introductory biology

Introduction

Introductory level biology classes are usually the most challenging of all to teach due to the wide range of material to be covered and the wide span in prior knowledge levels among students. It is important to examine how various methods of structuring an introductory course can influence student achievement, because performance during this critical first year is likely to affect their attitude toward future science courses as well as their overall university experience. In this paper we discuss our examination of the effect that controlled grouping and team study training had on test scores in an introductory biology laboratory setting.

Our research was conducted in a number of laboratory classes over two years. *Biology 101: Fundamentals of Biology*, is an introductory course for students who are not biology majors. Because Salisbury University requires all students to take at least two science laboratory courses to fulfil their general education requirements, many non-science-oriented students enrol in Biology 101. The students in the course attended three hours of lectures per week, and one hour and forty minutes of laboratory in classes containing approximately 20 students each. The laboratory activities were structured for students to work cooperatively in groups of four. One of the authors, Maloof, taught all the laboratory classes included in this study.

The success of cooperative learning, and its effect on achievement, is so well confirmed that it stands as one of the most recommended educational methods (Johnson and Johnson, 1999; Slavin, 1990, 1995). While most of the research on cooperative learning has been done at the elementary school level, some research has demonstrated the effectiveness of cooperative learning in college biology and organic chemistry courses (Lord, 2001; Carpenter, 2003). The success of cooperative learning may depend, at least in part, upon the attention given to arranging students into groups. When assigning students to cooperative groups, controlled grouping is considered preferable to random grouping (Slavin, 1995; Howard, 1996). For instance, students clearly learn better overall in groups of different ability levels (Slavin, 1990; 1995) and tolerance for others is learned when groups are diverse in terms of gender, ethnicity and academic success (Johnson *et al*, 1991; Slavin, 1986; 1990). Far fewer studies have been done on the use of controlled grouping in college settings (but see Koppenhaver and Shrader, 2003). Bacon *et al* (1999) found that only 15% of university faculty staff assigned teams when grouping students. More commonly groups are formed informally or randomly (Bacon *et al*, 1999; Cooper and Mueck, 1990; Johnson *et al*, 1991; Koppenhaver and Shrader, 2003; Slavin, 1990; 1995). Johnson and Johnson (1999) point out that "seating people together and calling them a cooperative group does not make them one".

There are indications that the careful composition of cooperative groups will impact learning behaviour and achievement levels of college students (Bacon *et al*, 1999; Cooper and Mueck, 1990; Dansereau, 1988; Howard, 1996; Johnson *et al*, 1991). But to our knowledge no studies have been done on the effects of grouping by cognitive learning style in the college science laboratory. Our research was designed to examine that issue.

Learning styles are classified in many ways, but fall into three general categories: perceptual modalities, information processing, and personality patterns (Keefe, 1988). This study focused on the learner's perceptual modalities, or the way humans process information through auditory, visual, tactile and kinaesthetic senses. Perceptual modalities are also referred to as cognitive learning styles, and that is how they will be referred to here.

Understanding cognitive learning styles has powerful implications for education in general (Gardner, 1993) and may be useful for assisting in the structuring of effective cooperative groups. Most people retain a dominant and an auxiliary cognitive learning style (Keefe, 1988) and rely on these modes to process information at an unconscious level, yet may become consciously aware of the modes they prefer (Gardner, 1993; Keefe, 1998). We wanted to determine if students did better in groups where they shared the same learning style with their group mates (homogeneous for learning style) or where the groups were composed of members with different learning styles (heterogeneous for learning style).

Beyond the question of group composition, however, we also need to know what cooperative learning methods and strategies are most effective in improving achievement in the college science laboratory. The *Student Teams-Achievement Divisions* (STAD) method of cooperative learning (Slavin, 1986) is one of the most extensively researched cooperative learning methods (see Slavin, 1995, and references therein). Recently, at the college level, Carpenter (2003) found STAD decreased the failure and drop-out rate of students in organic chemistry courses. We modified the STAD method for the purposes of this study. See the box below for a comparison of the basic STAD methodology and how we implemented it in our setting.

Our second aim was a closer examination of the team study component within the STAD method of cooperative learning. We wished to examine whether explicit training in a team study strategy improved students' retention of biology concepts. For the purposes of this study, one of the researchers (White) designed a scripted team study strategy – including both organisational strategies and elaboration techniques – appropriate for teams of four members, and then trained students in its use (see Table 1). The term 'script' is used here as described by Howard (1996); meaning the formal directions used by a team to facilitate cooperative study. Hence a script in this sense is a study format and is not something read or repeated verbatim.

In summary, this research was designed to examine how grouping by cognitive learning style, and training in a scripted team study strategy, would affect achievement in the college biology laboratory. The questions we sought to answer with this research were:

1. Does grouping by preferred cognitive learning style affect academic achievement? If so, is it better to group students heterogeneously or homogeneously?

2. Does training in a scripted team study strategy affect academic achievement when compared with groups that have not been given specific training in the strategy?

Answers to these questions can make our limited time with students more productive.

Methods

During the first laboratory meeting students were given a presentation explaining the research study. After students' questions were answered they were briefed on their rights as research subjects. One hundred percent of the students (81 students divided into four lab sections in 2001, 50 students divided into three lab sections in 2002) opted to participate and signed a participation consent form. Preferred cognitive learning style – perceptual modality (auditory, kinaesthetic, visual, or tactile) – was determined by each student using the *Learning Styles Assessment* developed by Learnativity Inc. (Learnativity, 2001). This simple self-assessment allowed students to analyse their cognitive learning style, or modality, relative to their preferred behaviour in classroom learning situations.

Academic achievement was measured in this study as the difference between the score in a pre-test and that in the same test given at the end of the semester (post-test). An instructor-created test was developed, with accompanying scoring tool (see Appendix 1 and 2). Prior to receiving the test, students were given a detailed explanation of the test format and scoring tool. The pre-test was administered and students were instructed to work independently to the best of their abilities.

Before the second class meeting, we used pre-test score, gender, and ethnicity, to create diverse four member groups. Finally, while maintaining the above parameters, the preferred cognitive learning style of each student was used as criteria to rearrange the students into groups of similar learning styles (homogeneous) or groups of diverse learning styles (heterogeneous) depending on the laboratory section. This method of grouping allowed us to standardise certain criteria between all teams, while differentiating between learning styles.

In the first year of the study, in the second laboratory meeting, students were assigned to cooperative teams and were then trained in the use of the scripted team study strategy by White. A daily schedule was established to facilitate time management and to provide for extended team study during the laboratory session (see Box 1).

Box 1. Differences between standard STAD method and that used in this study

Student Teams-Achievement Divisions (STAD) method of cooperative learning	**Modified STAD method used in this study**
Criteria for composition of heterogeneous four-member teams includes ability level as determined by pre-test score; gender; ethnic group.	Criteria for composition of four-member teams includes ability level as determined by pre-test score; gender; ethnic group. These heterogeneous base teams were rearranged to include either students of similar preferred learning style or students of diverse learning styles.
Instructional cycle: Direct Instruction, Team Study, Individual Assessment, Team Recognition	Expanded instructional cycle: Team Study (10 minutes), Individual Assessment (10 minutes), Direct Instruction (10 minutes), Team Lab Experiment (60 minutes), Team Study (10 minutes)
General strategies recommended for student use during team study.	Detailed training in scripted team study strategy for first year of study only.
Improvement Points are awarded for each student's improvement in test score from week to week. These are averaged for all team members to place them in an achievement division for purposes of reward.	Improvement Points were not used. All teams were commended for their hard work weekly by the instructor.

Table 1. Scripted team study strategy

We recommend the following strategy to enhance your learning during the team study portion of each class. The script below will guide you through a process of explaining, justifying and elaborating upon the scientific concepts you worked with in each laboratory session. By rehearsing orally, not only will you have teammates to assist you in refining your responses, but also you will be prepared for the explanation section of your weekly quiz.

Procedure

- **Team member A** explains a scientific concept from the lesson using diagrams, models and charts (if applicable) then justifies why their response is correct.
- **Team members B, C and D** take turns clarifying, correcting and elaborating upon A's explanation. All listen for key vocabulary and encourage **member A** to respond using appropriate scientific terminology.
- **Team member A** quickly rehearses the revised or enhanced explanation for all team members to hear. Repeat as necessary.
- Repeat the process with **team members B, C, and D.** Each team member chooses another concept to rehearse from the lab objectives (found in laboratory manual). Include scientific concepts from previous lessons, as necessary.
- Repeat the entire process until all team members have demonstrated mastery of the concepts.

At the end of the semester, the students were given the post-test. It was identical, and scored identically, to the pre-test. The difference between pre and post-test scores was determined for each student.

In the second year of the study, identical techniques were used for learning style assessment, pre-test administration and scoring, and creating homogeneous and heterogeneous groups. Because there were only three classes in the study in the second year, one class was grouped heterogeneously and the other two classes were grouped homogeneously. Other than three classes versus four, the only difference between 2001 and 2002 was that White did not train the students in the scripted team study strategy. The same daily schedule was followed with time allowed for group study, and group study was encouraged; however, no specific study strategies were presented.

Results

If students did not take the pre-test or the post-test they were excluded from the analysis. A total of 81 students – in two heterogeneous sections and two homogeneous sections – were included in the analysis for 2001. For the second year of the study, a total of 50 students – in one heterogeneous class and two homogeneous classes – were included in the analysis. A two sample T-test of the 2001 results showed that there was no difference ($p = 0.370$) in the mean percentage of improvement in score when students in heterogeneous learning style groups ($N = 37$, mean improvement = 37.5%, SE = 3.3%) were compared with students in homogeneous learning style groups ($N = 44$, mean improvement = 33.75%, SE = 2.6%). Similar results were obtained from the 2002 data. Again, there was no difference ($p = 0.828$) in the mean percentage of improvement in score when students in heterogeneous learning style groups ($N = 17$, mean improvement = 19.5%, SE = 5.3%) were compared with students in homogeneous learning style groups ($N = 33$, mean improvement = 18.0%, SE = 3.9%). See Figure 1 for a graphical representation of this data.

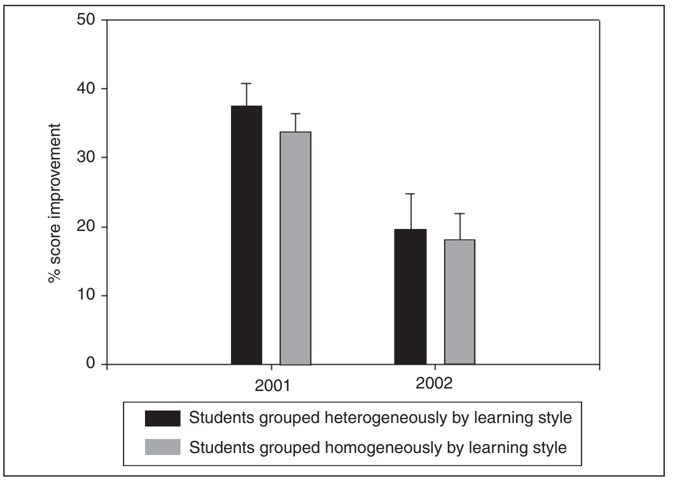

Figure 1. There was no significant difference in score improvement between students grouped with others of different learning styles (heterogeneous), when compared with students grouped with others of a similar learning style (homogeneous).

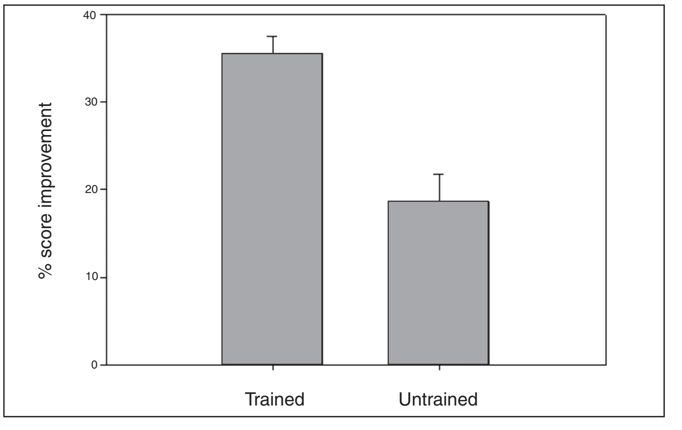

Figure 2. In the first year students were trained to use a scripted team study strategy to prepare for quizzes. In the second year an opportunity was given for team study, but students were not specifically trained in the scripted study strategy. The difference in score improvement with the training is significant ($p < 0.005$).

However, when we compared results between years, we found that the students who had been trained to use the team study strategy (2001; $N = 81$, mean improvement = 35.5%, SE = 2.07%) improved significantly more ($p < 0.005$) than the students who were not trained in the strategy (2002; $N = 50$, mean improvement = 18.57%, SE = 3.14%); see Figure 2. It is possible that there are reasons for this difference in achievement that are not related to training in team study; however, between the two semesters the classroom, the instructor, the teaching techniques, the syllabus, the laboratory materials and the examinations all remained consistent. The team study component was the only difference we could discern.

Discussion

In many biology laboratories and classrooms, students are grouped together to do cooperative work. Unfortunately, most college faculty staff have little or no formal training in cooperative learning and as a result they often implement informal and unstructured cooperative learning techniques rather than research-based methods (Bacon *et al*, 1999; Slavin, 1995). In this study we examined the effect of grouping students by preferred cognitive learning style, and also the effect of training them in a team study strategy.

To our knowledge this is the first time the academic achievement effect of grouping by cognitive learning style has been tested in the college science laboratory. Typically, instructors are encouraged to make teams heterogeneous in as many variables as possible, but we hypothesised that college students might work better with others of similar perceptual modalities. The results, however, indicate that grouping by cognitive learning style had no effect on achievement. Koppenhaver and Shrader (2003) grouped undergraduate finance students by *personality* style (assertive versus reflective, and task versus people oriented) and measured the effect on team performance. Similarly to our study, theirs showed that heterogeneous versus homogeneous grouping made no difference in performance. In their study, stability of grouping appeared to be more important to performance than personality style composition. Interestingly, however, they found that heterogeneous teams recovered more quickly when team membership changed. Our teams were stable throughout the semester therefore we did not measure this possible benefit of grouping heterogeneously by cognitive learning style.

The results of our study showed that there was greater achievement, as measured by differences in pre- and post-test scores, when training in a team study strategy immediately followed the assignment of cooperative groups, compared with teams that received no specific training, yet had the same scheduled opportunities for team work.

Numerous studies have shown that achievement is enhanced when individuals learn information together (Johnson and Johnson, 1989; O'Donnel and Dansereau, 1992; Slavin, 1990; 1995). The causal mechanisms of the success of cooperative learning in the college classroom have been identified as: *motivation*, *social cohesion*, *cognitive elaboration and opportunity to practise* (Koppenhaver and Shrader, 2003; Slavin, 1995). In our biology laboratory, motivation and social cohesion were constant between years, but study strategies that included *cognitive elaboration* and *opportunity to practise* were taught only in the first year. Research shows that verbalising improves learning and retention better than just listening, and team study gives students more opportunities to verbalise the biological concepts they were expected to comprehend (see Webb, 1982, and references therein). Furthermore, certain modes of active processing seem to internalise learning more effectively than others (Howard, 1996; Webb, 1982; 1991). White's scripted study strategy was designed to encourage active processing through questioning and elaboration. We believe this technique was especially beneficial for the least academically prepared group members. Our results showed an impressive improvement in scores when students used the scripted team strategy. It is probable that students not trained in the strategy spent less time verbalising and elaborating on the material, and spent more time off-task. Webb (1991) examines four studies by Swing and Peterson (1982) that show how off-task discussion is negatively correlated with achievement.

Scripted Cooperative Dyads is the method shown to be effective at the college level by Dansereau (1988). In contrast to dyads, however, we worked with carefully composed groups of four. Our results clearly showed that a scripted team study strategy could be effectively expanded from pairs to teams of four.

Our research is unique in that by examining group composition and training in a team study strategy, within the context of the STAD method, we were able to develop refinements to this method and determine which components, in the introductory biology laboratory, are most necessary and effective in improving achievement. Because those college biology students specifically trained in a scripted study strategy exhibited greater achievement than students that used a self-selected strategy, it is likely that other introductory level science instructors may also observe improved academic achievement by enhancing team study through the use of organisational and elaborative scripts.

Teaching the scripted team study strategy took less than two hours from the whole course, but increased scores significantly. The techniques do not take any specialised equipment or extensive training to teach; therefore they can be utilised in any educational setting.

Educational Implications

Grouping students heterogeneously or homogeneously (according to cognitive learning style) in teams of four made no difference to their academic achievement, as measured by improvement in test scores.

Training biology students in a scripted team study strategy resulted in improved test scores. Therefore we encourage instructors to develop and use organisational and elaborative scripts during paired or group work.

We further recommend that in all college science laboratories instructors implement a research-based cooperative learning method and spend 1-2 hours during the second laboratory session training students in the method and in accompanying team study strategies. We also recommend modifying the traditional laboratory schedule to facilitate cooperative learning time.

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Appendix 1: Pre and Post Test

1. If a semi-permeable dialysis tube is filled with a 20% salt solution, sealed, and then put in a beaker of pure water, the tube will:
a. gain weight
b. lose weight
EXPLAIN

2. If light shines on an aquatic plant, and it begins photosynthesising underwater it may produce bubbles. Primarily, what type of gas will be in the bubbles?
a. carbon dioxide
b. oxygen
EXPLAIN

3. Why do most plants appear green?
a. because they reflect green wavelengths
b. because they absorb green wavelengths
EXPLAIN

4. An individual neuron can carry messages:
a. in one direction only
b. in both directions
EXPLAIN

5. Which statement about bones is most correct?
a. bones contain living cells
b. bones do not contain any living cells
EXPLAIN

6. The heart is composed of muscle tissue identical to the skeletal muscle tissue that enables your limbs to move
a. true
b. false
EXPLAIN

7. Because urine is filtered from the blood, it usually contains some blood cells.
a. true
b. false
EXPLAIN

Appendix 2. Scoring tool used to grade the pre and post test.

Points awarded	*for...*
2	Correct answer clearly supported by one or more facts.
1	Correct answer partially supported; or incorrect answer with correct explanation.
0	Incorrect answer with incorrect explanation; no response; illegible; restates question; or does not address topic.