Cooperative Learning & Science

High School Activities

Michael Michels

Angela Manzi

Janina Mele

Australian Edition by Alison Stone, Hawker Brownlow Education

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EDUCATION

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Foreword

By Dr. Spencer Kagan

For a number of years, those of us who were pioneering the cooperative learning movement observed and puzzled over an anomaly. The extensive research on cooperative learning revealed that academic achievement gains were as large and as consistent among secondary students as among primary school students, yet implementation of cooperative learning was far greater at the primary level. A large scale meta-analysis involving hundreds of research studies revealed no difference in the effectiveness of cooperative learning for secondary school vs. primary school students — for all students, large, consistent gains in academic and social variables were found.[1] It just was not logical: Logic would dictate that if the evidence in support of cooperative learning was equally strong for primary and secondary, implementation should also be equally strong. But for quite a number of years, cooperative learning flourished at the primary school level and languished at the secondary school level.

It was only belatedly that we realised the problem resided in the resources and trainings we were offering. Those of us who were developing the field of cooperative learning were developing generic cooperative learning methods, but in our workshops and books we never specifically outlined how to apply those methods to understanding the periodic table, the layers of the earth, the difference between speed and velocity, macromolecules, or the nature of a DNA helix. This book, *Cooperative Learning and Science: High School Activities*, goes a long way to remedy that deficit.

Cooperative Learning and Science: High School Activities follows a recent tradition begun in 1998 with the publication of Tom Morton's *Cooperative Learning & Social Studies*.[2] When that book was published, we were flabbergasted. Almost immediately, the book became one of Kagan Publishing's best sellers. Secondary school teachers were saying, *"Finally a book just for me"*. We followed Morton's publication with two books for secondary school maths: Dina Kushnir wrote *Cooperative Learning & Mathematics: High School Activities*[3] and Becky Bride wrote *Cooperative Learning & High School Geometry*[4]. In each case, the response exceeded our expectations. Secondary school teachers were clamoring for cooperative learning resources.

Today, our secondary workshops are now just as popular as our primary workshops. Secondary teachers are responding to the workshops with unbridled enthusiasm, *"Finally a workshop just for me!"* Demand for cooperative learning trainings and resources among secondary school and university professors now rivals the demand among primary school teachers.

Why Has Cooperative Learning Come to Secondary School?

What happened to account for this shift? What brought cooperative learning to secondary school? I can offer six explanations: 1) Students are carrying the cooperative learning message; 2) Students are different today; 3) Employability skills are shifting; 4) Block scheduling; 5) Resources are becoming available; 6) Structures.

Students Carry a Message. A number of years ago, I began doing large trainings. A pattern emerged. First, we would be called to train the primary school teachers. A few years later, we would get a call to train the middle years teachers. Then, a few years later, we would get another phone call. This time it was a request to train the secondary school teachers. What was happening? A few years after we trained the primary school teachers in the cooperative learning methods, the middle years teachers observed a profound difference in students coming from feeder schools where cooperative learning was taking place. The students were more polite, had a more positive attitude toward school, and were more oriented toward achievement. They were, simply put, better students. And then, a few years later, the secondary school teachers saw the difference and so they wanted training. The students were moving up and bringing the message with them!

Students Are Different. Today's secondary school students little resemble the students of my generation. I have talked with many older teachers and they confirm: Today's students are *different*. They report that they cannot get the same positive reaction from students today when they use the same teaching strategies. To engage students today, they have to use far more active and interactive instructional strategies.

When I attended secondary school, we looked up to our teachers. We wanted to please them, and learn from them. What a teacher said was important. There was respect for the teacher, school, and learning. Our teachers and classes were *interesting*. In fact, class was the most interesting thing in our world. Today all of that has changed. Fast-moving violent films, television, music videos, video games and the Internet bombard today's secondary school students. The teacher and class are no longer the most interesting sources of stimulation. Whereas a lecture was an engaging source of stimulation for my generation, the same lecture is boring for today's youth — media has upped the ante!

How does that help explain the increased demand for cooperative learning at the secondary school level? Brain science reveals the brain is more engaged during social interaction than any other time.[5] When we institute cooperative learning, students immediately become engaged. Peer interaction can compete with the acquired need for fast-moving stimulation; a lecture cannot. Students come to school not to listen to a teacher, but to interact with their peers. Cooperative learning allows students to do what they most want to do. Research reveals that students not only learn more when we use cooperative learning, but they also like school, class and content more. Cooperative learning is the instructional methodology of choice for today's students.

Employability Skills. Consciously and unconsciously, our educational system is preparation for participation in the workforce. Traditional methods in which students were told what to do and expected to do it paralleled the traditional workplace in which a boss told the employee what to do and the employee was expected to do it. Today's workplace is different. High technology has led to specialisation which has led simultaneously to independence and interdependence. Employees with their very specialised skills are given tasks, but are expected to use creativity and initiative in fulfilling them. The boss cannot possibly know all the specialised skills of today's employees; the employees have to make decisions on their own. At the same time, they have to work with one another. No one person can design and make a state-of-the-art computer. Today's workplace is dominated by teamwork. Teams work on components, coordinating their efforts with other teams. Over 70% of today's employees work in teams as part of their regular job, and the number is increasing.[6] Today's teachers and administrators realise that the traditional approach to structuring a class (teacher as boss) will not prepare students to make decisions, work creatively, and acquire teamwork skills. Cooperative learning is becoming popular at the secondary school level partly because it prepares students for the kind of world they will enter.

Resources. The increased demand for secondary resources and trainings in cooperative learning is supported also by more responsive publications and workshops. *Cooperative Learning & Science* is another milestone along that path. With their *Cooperative Learning & Science*, Michael, Angela, and Janina are doing for secondary school science teachers exactly what Dina Kusnir did for secondary school maths teachers. They show how selected cooperative learning structures can be used across the curriculum to generate powerful, engaging lessons with any content. In the last few years, we have begun providing subject-specific workshops for secondary teachers. Rather than interacting with a primary teacher to discuss how to use a structure, secondary teachers process cooperative learning methods by interacting with fellow secondary teachers in their own content specialty.

Structures. Secondary teachers are learning the power of structures. Structures are an easy and effective approach to cooperative learning. Let's take a closer look at the many advantages of Kagan Structures.

Kagan Structures

Older models of cooperative learning were lesson-based. That is, the model demanded that teachers design and implement complex cooperative learning lessons. The message with the lesson-based approach: Stop teaching the way you have been teaching, we will show you a better way. It is difficult, if not impossible, to spend each night planning brand new lessons while maintaining content integrity.

In contrast to the lesson-based approach, the structure-based approach to cooperative learning provides a very different message: Keep teaching what you have always taught; keep your existing lessons. Structures will allow you to make those lessons more engaging, efficient and successful. Structures demand little or no special planning time and do not demand a radical transformation of existing lessons. Structures are simple instructional strategies that make a world of difference. For those of you new to the concept of structures, let me provide an example.

For purposes of comparison, let's contrast RallyRobin with the traditional way we have students respond to questions in our classroom. RallyRobin is one of the simplest of all the Kagan Structures — it can be used with no preparation and no change in content, at almost any point in a lesson. In a RallyRobin, students in pairs take turns speaking, usually naming things from a list, recalling or generating ideas. In a science class, RallyRobin may be used to have students take turns generating possible alternative explanations for a phenomenon.

For our comparison, let's look into the classrooms of two different teachers who want their students to review the inert elements:

- **Traditional class:** The teacher says, *"Without looking at the periodic table, who in the class can name an inert element?"* Students then raise their hands to be called on.
- **Kagan Structures:** The teacher uses the structure RallyRobin. He says, *"Turn to your partner and do a RallyRobin naming inert elements without looking at the periodic table."* Each student then takes a turn with his/her partner, each naming an element and then waiting for his/her partner to name the next one.

These two teachers have structured the interaction in their classroom differently — they are using different structures.

What are the benefits of using the cooperative structure RallyRobin rather than the traditional structure? The list is long. To name a few:

- Every student in the class generates several answers, as opposed to a selected few students generating one answer each
- All students are engaged so none tune out or get off task
- Half the class is answering at any one moment as opposed to only one student in the class
- The teacher can authentically assess students' knowledge by listening in to a randomly selected group, instead of just hearing from the high achievers
- Students like the variety; they say the structures are fun
- Students with answers become a resource rather than being put down as "know it alls" or "brown nosers"

- Students feel mutually supportive, not in competition with one another for teacher approval
- Test scores go up
- Students acquire teamwork skills and attitudes

This last point, that students learn to work in teams, is particularly important for science instruction. The day of the mythical “lone scientist” has come and gone. As science has become more sophisticated and complex, scientific inquiry is conducted increasingly by interdependent teams. The sole authorship of science papers was first replaced by co- and multiple authorships. Today, numerous interdependent teams, often in different labs, coordinate efforts and conduct science. As science continues to build on the complex methodologies and findings that are being established, interdependence among scientists will become even more the norm and teamwork skills will be prerequisite for full participation in the scientific community.

The structures you find in *Cooperative Learning & Science* are carefully selected to improve science instruction. They represent a range of types of structures.

Pairs Check is used following an introduction of a new skill; it is guided practice to master the skill. The skill can be anything from solving a type of equation to adjusting the flame on a Bunsen burner. The advantage of Pairs Check is that students get immediate supportive feedback and coaching; they do not have to wait until after you mark papers. An added advantage for teachers, of course, is that Pairs Check eliminates a great deal of unnecessary marking of worksheets.

Find Someone Who is active practice in consulting. Instead of treating a text as the ultimate or sole source, students find consultants in the class to help them find answers. An added benefit of Find Someone Who is that it allows students to get up from their desks and move around the room; a welcome break, especially if you are teaching a long session.

Mix-N-Match also energises the class through movement. It is geared to the type of content that typically comprises the matching part of an exam. *Cooperative Learning & Science* provides ready-made blackline masters for Mix-N-Match. (Hint: Copy the cards onto coloured card and laminate them before cutting them to make an enduring set that can be used year after year.)

Corners allows students to express their preferences and to know and appreciate their classmates. In a secondary science class, the most powerful form of Corners is to have each member of the team go to a different corner of the room, gaining expertise from classmates that he/she can share after returning to teammates. Corners leads to content mastery, but in the process provides a great boost to self-esteem and peer acceptance because each teammate makes a unique, valuable contribution.

Give One, Get One also allows students to become experts, then share their expertise with others. An answer I “Get” from a classmate becomes an answer I “Give” to another classmate, and to my teammates at the end of the activity. In the process, I learn more. As we teach, we learn.

Word Webs are a wonderful exercise in the type of relational thinking core to so much of science. Important fields of science aim at understanding non-linear, mutually interactive webs of relationships. Traditional outlines cannot easily depict those relationships. How do I show in an outline a link between IIA1 and IIIC2? In a Word Web, the relationship is expressed with a simple arrow.

Agree-Disagree Line-Ups is a structure to use when discussing science related ethics. Science education today cannot escape value issues. We can make a human from an egg of an unborn fetus. But should we? We can tell if someone is prejudiced (whether he/she knows it or not) by doing a brain scan of the amygdala as he/she is shown pictures of faces of people of different races. But should we? Should brain scans that reveal amount of impulsivity be considered in determining early parole for prisoners who have committed violent crimes? Today's students will shape the future of our society as they vote on value issues like these. It is not our job as science educators to teach values, but it is our job to have students reflect on and think more deeply about the value issues inherent in our content. The perfect structure for this is Agree-Disagree Line-Ups. As students come to listen to, understand, and respect points of view different from their own, they become more thoughtful and articulate.

Avoiding Two Sins

There are two ways to go wrong as we have students work together to do science: Group Work and Group Marks. It not hard to find teachers who report, *"I tried cooperative learning and it did not work!"* What they don't realise is that they violated basic principles of cooperative learning, probably by doing group work or by using group marks. The authors of *Cooperative Learning & Science* gracefully side-step these traps.

Group Work is unstructured interaction. A teacher gives students a problem or a task and tells them to work together. The results are predictable and terrible. The high achiever, not wanting for the group to do poorly, takes over. Resentments build on both sides: The high achiever thinks, *"I had to do it all";* the low achiever feels, *"I was not included".* Unstructured work in groups is wishful thinking. We hope the students will all participate and learn, but we have not taken responsibility for creating those outcomes. Structures are carefully designed to avoid the pitfalls of group work; they structure interaction to include the PIES principles: Positive Interdependence, Indivdiual Accountability, Equal Participation and Simultaneous Interaction.[7] Each teammate participates about equally and is accountable for his/her contribution. The structures in *Cooperative Learning & Science* are carefully designed to include the PIES principles and avoid the trap of group work.

Group Marks also violate basic principles of cooperative learning and produce lamentable outcomes. The teacher gives a project to a group and then gives the project a mark. Each person on the team gets that mark for the project. Predictably, group marks produce free riders. Johnny does no work at all on the project, but gets a good mark because his teammates completed a first-rate project. Or, Johnny does a great job on the project, but gets a lower mark because Susie did a poor job on her part. Group marks are unfair and create a backlash against cooperative learning.[8] Cooperative learning is designed to promote learning; if we want to assess the effects of our instruction, there is no alternative to assessing the effects on individual learners. *Cooperative Learning & Science* provides structures for learning; it avoids the trap of group marks.

An Appreciation

Michael Michels, Angela Manzi, and Janina Mele have made an important contribution to the process of releasing the power of cooperative learning in secondary school classrooms. With *Cooperative Learning & Science*, any secondary school science teacher will find ready-made, proven activities. Be careful, though. The book should come with a warning label: *Caution Advised. Use of the Enclosed Activities Is Likely to Lead to an Addiction!* All it will take is trying a few of these activities in your own classroom and observing the reaction and performance of students, and you will get hooked. The wonderful thing, though, is that once you have mastered a structure, you will find it easy to generate your own activities for any content you teach. *Cooperative Learning & Science* is a springboard to a new way of teaching. Try it. You may well get hooked.

Good luck,

Spencer Kagan
June 14, 2003

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2 Pairs Check

In pairs, students take turns solving problems. After every two problems they check answers and celebrate with another pair.

1. In teams of four, shoulder partners are formed. Partner A in each pair does the first problem, talking out loud. Partner B watches and coaches. Partner B praises.

2. Reverse roles: Partner B does the second problem. Partner A watches, coaches and praises.

3. Pairs check with their face partners after every two problems. Teammates coach and correct if needed.

4. The team celebrates after reaching agreement on the two problems.

5. Shoulder partners do more problems, continuing to check with their face partners after every two problems.

Student Instructions:
Pair up within your team. Partner A will answer the first problem while Partner B coaches. Partner B helps if necessary and praises Partner A when both agree. Partner B solves the next problem while Partner A coaches. Once both problems are finished, check with the other pair from your team. If you have different answers, determine which is correct. When you all agree, circle the check mark to the right and give a team handshake. Complete the problems in the same fashion.

Pairs Check
Activities & Blacklines

Biology

Chemistry

Earth Science

Physical Science

General Science

Pairs Check
Biology Activity Ideas

1. Transcription/Translation

Objective: Students will work in pairs to solve and check one another's work for problems relating to protein synthesis.

ATCGCAT Transcribe to mRNA ____________________	AUG CCG UCA UAA Translate to the amino acid sequence ____________________

2. Reactions of Photosynthesis

Objective: Students will work in pairs to solve and check one another's work for problems relating to the reactions of photosynthesis.

The compound produced as a result of the light reactions is ____________________	The number of ATP molecules produced in the light reactions are ____________________

3. Terms of Cell Structure

Objective: Students will work in pairs to solve and check one another's work for problems relating to cell structures and organelles.

The protein factories are known as

____

The lysosome is responsible for:

____

4. Population Genetics

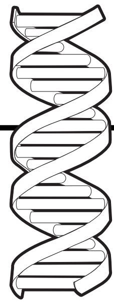
Objective: Students will work in pairs to solve and check one another's work for problems relating to Hardy-Weinberg & Genetics Probability.

The Hardy-Weinberg Equation is

____

If 50% of the population is heterozygous for a trait, what is the frequency of the recessive allele?

____



Genetics

Instructions: On a separate sheet of paper, complete the Punnett Squares described.

Name: ______________________ Name: ______________________
Date: ______________________ Date: ______________________

1 Complete a Punnett Square for the following cross: GG x Gg	**2** Complete a Punnett Square for the following cross: GG x gg
3 What would the phenotypic ratio be in a cross between a homozygous green pea plant and a heterozygous pea plant?	**4** What would the genotypic ratio be in a cross between a homozygous short pea plant and a heterozygous tall pea plant?
5 Complete a Punnett Square with genotypic and phenotypic ratios for the following cross: a purebred smooth pea with a hybrid pea.	**6** Complete a Punnett Square with genotypic and phenotypic ratios for the following cross: a purebred wrinkled pea with a hybrid pea.
7 Complete a Punnett square with phenotypic ratios for the following cross: two parents that are both hybrids for height and pea colour.	**8** Complete a Punnett Square with phenotypic ratios for the following cross: one parent that is hybrid for height and pea colour, and one parent that is purebred recessive for both traits.
Sponge: Create and complete a genetic cross of your own.	Sponge: Create and complete a genetic cross of your own.

Innate or Learned?

Instructions: Write whether the behaviour is "innate" or "learned" and write your reason for your answer.

Name: ______________________ Name: ______________________

Date: ______________________ Date: ______________________

1. Coughing Type of Behaviour: Reason:	**2. Riding a Bicycle** Type of Behaviour: Reason:
3. Tying Shoes Type of Behaviour: Reason:	**4. Sneezing** Type of Behaviour: Reason:
5. Sweating Type of Behaviour: Reason:	**6. Shivering** Type of Behaviour: Reason:
7. Having a Fever Type of Behaviour: Reason:	**8. Eating with a Fork** Type of Behaviour: Reason:
9. Biting Fingernails Type of Behaviour: Reason:	**10. Feeling Pain** Type of Behaviour: Reason:

Sponge: If your pair or team finishes early, then come up with at least five more examples of innate behaviour and at least five more examples of learned behaviour.

Mix-N-Match
Earth Science Activity Ideas

1. Ocean Floor Features

Objective: Students will identify the region of the world with its characteristic ocean floor feature.

Trench	**West Coast of South America**

2. Identification of Weather Terms

Objective: Students will identify the weather system and match it with its name or type of weather associated with it.

	**Low Pressure System**

3. Identification of Planets

Objective: Students will match a fact about a planet with the name or picture of the planet.

Visible surface has a large red storm.	

4. Identification of Stars and Constellations

Objective: Students will match pictures or facts with different celestial bodies and constellations in the universe.

Orion, The Great Hunter