Cooperative Learning is a Brain Turn-On

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This We Believe Characteristics

- **An inviting, supportive, and safe environment**
- **High expectations for all members of the learning community**
- **Students engaged in active learning**
- **Multiple learning and teaching approaches that respond to their diversity**
- **Assessment and evaluation programs that promote quality learning**

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Although I attended school for 21 years before entering the University of California, Santa Barbara, Graduate School of Education, Teacher Education Program (TEP) in 1998, I had never worked in learning groups aside from the occasional science experiment or medical school cadaver dissection. Yet even those experiences were not designed as cooperative group work; they were arranged simply for the purpose of sharing materials. Most of my classes in the TEP program incorporated cooperative learning techniques as an integral part of the instruction. In our classrooms, we never sat in rows, but always at round tables with room for four to six students. Rarely did a day go by when we did not work together on a cooperative project such as a poster and presentation, a short videotape, or a skit performance. I responded to this style of teaching and of learning quite positively, both cognitively and socially. Some of my enthusiasm was probably rooted in my being, as I am a global, interpersonal style learner (Checkley, 1997; Kagan & Kagan, 1998). But I found my classmates, with their varied learning styles, also inclined toward collaboration.

As I experienced the benefits of collaboration, I also discovered that an integral part of the process was the departure by our professors from the traditional roles of imparters and assessors of knowledge. Unlike the teachers I had previously studied under, my education professors assumed roles of information resources in more democratic classrooms. I discovered that relinquishing traditional autocratic control and allowing students to collaborate interactively with classmates to achieve common goals resulted in our becoming more invested and engaged in our learning. When I completed my masters of education degree in cooperative learning and became a middle school teacher, I found that I followed the modelling of my teachers and used cooperative learning in my own classroom. I then called upon my clinical and research training and experience in neurology to investigate the learning research being done through neuroimaging and brain mapping. I found evidence of brain and neurochemical activity that supported the positive results I was having with the cooperative approach to middle school teaching.

Psychosocial Benefits

Consider the increased comfort and enjoyment that students have when pleasurable social interaction is incorporated into their learning experience (Reeve, 1996). This is especially true during adolescence when peer group influence plays such an important developmental role in the psychosocial process of separation from parents along the road to individualisation. For example, in early elementary school, students often raise up from their seats when they wave their hands enthusiastically in hopes of being called upon to answer a question. By middle school, some students consider it uncool to volunteer answers or even appear intelligent in class. These same students are more willing to participate and even show enthusiasm about challenging tasks when they are engaged in learning activities with supportive cooperative groups.

Erikson (1968) theorised that the developmental “crises” of adolescence are turning points during periods of increased vulnerability, and these turning points present opportunities for the development of psychosocial strength. He proposed that during these developmental stages the adolescent develops new capacities and psychosocial strengths by working through these developmental crises. Inclusion, a sense of belonging to a group where a student feels valued, builds resiliency. Resilient adolescents have greater success, social competence, empathy, responsiveness, and communication skills. They also demonstrate greater flexibility, self-reflection, and ability to conceptualize abstractly when solving problems.

Successfully planned group work can help to support students during these developmental crisis opportunities by reducing the fear of failure that can cause them to avoid academic challenges. Well-structured cooperative group activities build supportive classroom communities, which, in turn, increase self-esteem and academic performance.

Neuroimaging—Watching the Social Brain Learn

Neuroimaging and neurochemical investigation provide evidence of the brain’s response to stress as well as to pleasure and positive social interaction. Research on the amygdala reveals it to be one location of an affective filter in the brain (Pawlak, Magarinos, Melchor, McEwen, & Strickland, 2003). During periods of high stress or anxiety that some students may experience when asked to do a math problem on the board or make an oral presentation to the class, their emotional state is associated with greatly heightened metabolism (more glucose and oxygen use) flooding this “emotional” portion of the limbic system on Functional Magnetic Resonance Imaging (fMRI) studies.

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When the amygdala is in this hyperexcitable, anxiety-provoked state, there is profound reduction in the neural activity indicative of information flow into and out of the amygdala. In the normal, relaxed state, the brain receives information as sensory input (e.g., for hearing or vision) into specific sensory receptive centres. From these areas, neural pathways project this information to the amygdala. In the amygdala emotional meaning may be linked to the information and connections are made with previously stored, related knowledge (Chugani & Phelps, 1991). The new information, now enhanced with emotional or relational data, then travels along specific neuronal circuits to the higher cognitive centres of the brain, such as the prefrontal cortex, where information is processed, associated, and stored for later retrieval and executive functioning (Kato & McEwen, 2003).

In fMRI scans of adolescents in states of affective, emotional anxiety, when the amygdala is metabolically hyperactive, the pathways that normally conduct information in and out of the amygdala show greatly reduced activity. Thus, new information is blocked from entering the memory banks by this metabolic blockade of the hyperactive amygdala (Toga & Thompson, 2003). When students participate in engaging learning activities in well-designed, supportive cooperative groups, their affective filters are not blocking the flow of information. When you plan your group so that each member’s strengths have authentic importance to the ultimate success of the group’s activity, you have created a situation where individual learning styles, skills, and talents are valued, and students shine in their fortes and learn from each other in the areas where they are not as expert. They call on each other’s guidance to solve pertinent and compelling problems and develop their interpersonal skills by communicating their ideas to partners. The brain scans of subjects learning in this type of supportive and social learning situation show facilitated passage of information from the intake areas into the memory storage regions of the brain. This is consistent with the original cognitive psychology research and theories of Krashen (1982) about the affective filter— that learning associated with positive emotion is retained longer and visa versa.

Reward-Stimulated Cooperative Learning

Studies of brain neurochemistry also support the benefit associating rewarding, positive social experiences with the learning process. This has been called dopamine-based reward-stimulated learning (Waelti, Dickinson, & Schultz, 2001). Information travels along nerve cells' branching and communicating sprouts (axons and dendrites) as electrical impulses. However, where these sprouting arms connect to the next neuron in the circuit, the information has to travel through a gap between the end of one nerve and the beginning of the next one. In these gaps, called synapses, there are no physical structures, unlike the wires that connect appliances to electric outlets, along which the electric impulses can travel. When crossing over synaptic gaps, the information impulse must be temporarily converted from an electric one into a chemical one. Neurotransmitters are brain proteins released by the electrical impulse on one side of the synapse, to then float across the synaptic gap, carrying the information with them to stimulate the next nerve ending in the pathway. Once the neurotransmitter is taken up by the next nerve ending, the electric impulse is reactivated to travel along to the next nerve cell.

Dopamine is the chemical neurotransmitter most closely associated with attention, memory storage, comprehension, and executive function. The theory of reward-stimulated learning and other reinforcement learning theories are based on the assumption that the brain finds some states of stimulation to be more desirable than others. The brain is believed to make associations between specific cues and these desirable states or goals. Dopamine activity can be evaluated through neuroimaging. It has been found that dopamine release is increased in brain centres associated with learning and memory in response to rewards and positive experiences. Research found that the brain released more dopamine into these learning circuits when the individual was playing, laughing, exercising, and receiving acknowledgement (e.g., praise) for achievement (Salamone & Correa, 2002).

These frontal lobe, dopamine sensitive regions are seen on neuroimaging as activated in pleasure and reward, wakefulness, and satiety. It has been shown that drugs of abuse affect nerves along this dopamine pathway. This is a basis for theories that when the brain does not release its own dopamine reward from pleasurable experiences it is vulnerable to the allure of the psychoactive drugs that activate the dopamine pathway (Everitt, Parkinson, Olmstead, Arroyo, Robledo, & Robbins, 1999). Follow up research found that when subjects anticipated pleasurable states, there was increased release of dopamine associated with the expectation of pleasure (Holroyd, Larsen, & Cohen, 2004).

Many of the motivating factors that have been found to release this dopamine are intrinsic to successful cooperative group work such as social collaboration, motivation, and expectation of success, or authentic praise from peers. Because dopamine is also the neurotransmitter associated with attention, memory, learning, and executive function, it follows that when the brain releases dopamine during or in expectation of a pleasurable experience or reward, this dopamine will be available to increase the processing of new information. That is what occurs when students enjoy a positive cooperative learning experience, and even when they anticipate participation in that type of activity.

Cooperative Groups Generate More Participation and Stimulate Multiple Brain Regions

Cooperative group activities, unlike whole class discussions or independent work, provide the most opportunities for students to express their ideas, questions, conclusions, and associations verbally. Gibbs (1995), in her book Tribes reported that in traditionally structured classes each student has about five to ten minutes of individual time to engage in classroom academic discourse. In group work, that amount of time increases dramatically. She found that students experienced a greater level of understanding of concepts and ideas when they talked, explained, and argued about them with their group, instead of just passively listening to a lecture or reading a text.

In addition, metabolic brain activity accelerates during active constructive thinking, such as planning, gathering data, analysing, inferring, and strategising versus passive information acquisition. When the verbal centre becomes engaged while information or a task is being learned, more neural activity travels between the left and right brain. (Chugani & Phelps, 1991). Thus, when students describe their thinking verbally to the group or work on a group chart, diagram, or project, the new information becomes embedded in multiple brain sites, such as the auditory and visual memory storage areas.

Now, with neuroimaging, we know that this multicentred brain communication circuitry enhances comprehension, making new material be more accessible for future use, because it is stored in redundant brain areas (Giedd, et al., 1999).

In mathematical collaboration students learn to test one another's conjectures and identify valid or invalid solutions. Group members are all engaged as they discover techniques to test one member's strategy. If it does not work on repeated tries, they invalidate that strategy and try another. Students who just "don't get it" via a teacher's didactic lecture benefit from the different perspectives of classmates with similar knowledge banks on the subject. In literature and social studies students have a small, safer place to try out ideas they might not express to the entire class. They learn that there is validity to personal interpretation, and they can experiment with critical thinking in a structured small-group setting, with scaffolding provided as needed via teacher prompts about what to discuss and how to run the discussion. This process empowers students to become more active not only in whole-class discussions but in their homework and in speaking their opinion outside of the classroom. This is especially critical during adolescence when "fitting in" is such a strong need that individuality can become stifled (Jernigan & Tallal, 1990).

As neuroimaging evidence has shown, the more a student is engaged in a learning activity, especially one with multiple sensory modalities, the more parts of the brain are actively stimulated (Jagust & Budinger, 1993). When this occurs in a positive emotional setting, without stress and anxiety, the result is greater long-term, relational, and retrievable learning.

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What Constitutes Cooperative Work?

To qualify as cooperative work, rather than individuals working in parallel in a group, students must need each other to complete the task. Students are expected to participate in tasks that are clearly constructed and necessary for the group's success. The teacher remains active as a circulating resource and, when necessary, an arbitrator, but students should be capable of carrying out their tasks without constant, direct intrusion by the teacher. Students, not the teacher, are responsible for accomplishing their tasks in the way they think best, with accountability to each other and to the teacher's standards. Ideally, there is a clear rubric for individual and group assessment, and the students and the teacher take part in the assessment process (Antil, Jenkins, & Watkins, 1998).
When setting up lessons for successful collaboration in cooperative groups, consider the following guidelines that will then be expanded upon with examples of specific cooperative group activities that emphasise each of the five characteristics.
All members have opportunities and capabilities, frontloaded if necessary, such that different students can make their own special contributions. This may require planning ways for students with different learning or intelligence styles to make special contributions to the group task (Webb, Nemer, & Chizhik, 1998).

- Students learn to respect each other as group members. Often this requires teacher demonstration with role-playing.
- The group negotiates roles with guidance from the teacher. Designated roles can vary from group to group.
- There should be more than one answer or more than one way to solve the problem or create the project.
- The activity should be intrinsically interesting, challenging, and rewarding.
- All members have opportunities to make valued contributions to the group product.

Sample Brain-Friendly Cooperative Projects

Cooperative group activities I have used in my middle school classes have had different emphases and goals, but each also conforms to these basic five characteristics of successful group work. Examples of activities that feature each of the aforementioned successful cooperative group guidelines follow.

As neuroimaging evidence has shown, the more a student is engaged in a learning activity with multiple sensory modalities, the more parts of the brain are actively stimulated.

Dinosaur Extinction—Science and Math (extinction theory and scientific notation):
In this activity students are each given an area of expertise that other group members do not have so they are valued for this information. This is a type of frontloading. This increases each student's connection to the group socially and academically, thereby lowering their affective filters. Because there are elements of choice and real-world application, the information students process is patterned with relational memories in the hippocampus and prefrontal lobes for successful storage as long-term memory.

In the dinosaur project, the final process of making informed individual decisions about which extinction theory the student chooses to support brings in frontal lobe executive functions. The group project also incorporates and values multiple skills and talents. This results in more opportunity for students to connect and succeed through their individual learning styles and to engage more of their brains with multisensory stimulation.

Through a strategy called tea party, card party, or jigsaw, students are first put in groups where all five members of the group read articles and text about one of the dinosaur extinction theories, which include:

- **Createaceous-Tertiary Asteroid Theory** (about 65 million years ago) This theory also previews the next topic we will study in geography, continental drift, and the splitting of the supercontinent Pangaea.
- **K-T Extinction** (about 65 million years ago) K is for Kreide, meaning chalk in German, which describes the chalky sediment layer from that time; T is for Tertiary, the next geologic period, when all land animals over about 55 pounds went extinct.
- **The Alvarez Asteroid Impact Theory:** An asteroid four to nine miles in diameter hit Earth about 65 million years ago, penetrated the Earth's crust, scattered dust and debris into the atmosphere, and caused huge fires, tsunamis, severe storms with high winds and highly acidic rain, seismic activity, and perhaps even volcanic activity.
- **Greenhouse Effect:** Large amounts of methane, changing the Earth's atmosphere, caused a greenhouse effect. The methane source is theorized to have come from deep-sea algae deposits and/or from by-products of plant-eating dinosaurs' digestion.
- **Over-foraging:** The herbivorous dinosaurs' over-foraging and the carnivorous dinosaurs' over-culling of the herbivorous dinosaurs could have triggered mass starvation.

After the first groups—which have become expert in one of the five theories of extinction—have read about, discussed, and answered questions I provided, and each group member has completed notes that I reviewed with answers to the questions, the groups are shuffled to form new groups. Each of these secondary groups is the true cooperative group, and each group member is now an expert on one extinction theory.

Group Project:

1. Each group member explains his or her extinction theory while others take notes.
2. After open-ended, student-inspired discussions, each member selects the theory he or she feels best explains dinosaur extinction.
3. Through vote or consensus (a process they have practiced) the group selects the theory they will use for their project.
4. Groups can demonstrate their theory through a skit, report, PowerPoint presentation, overhead projector charts, a video production, models, or several of these options.
5. Each group must include mathematics using scientific notation with exponents for the very large numbers involved in dinosaur research, such as 50 million is 5.0 x 10 to the 7th power.

6. Groups present their findings to the class and complete self- and group analysis reports on rubrics provided.
7. Individual and group grades are based on teacher observations, final products and cooperative behaviour.

Students respect each other

Quiz Show—Helping Students Grow More Brain Connections: Review, practice, and cognitive processing of learned information builds more connecting dendrites and strengthens the membranes surrounding these interneural connections resulting in faster information transport and more efficient memory retrieval.

Using a television quiz show format, students are divided into four teams. Each team works with the same information source, the class literature text from which they took notes for homework. In addition to the group task of creating quiz show questions for their opponents, there is a specific group job for each student. This question-making activity occurs several times a week, using the material from several chapters each time.

The final competition takes place on completion of the book and serves as a third review of the material before the formal individual comprehension assessments. The three reviews consist of the students' first set of notes taken at home independently, the cooperative quiz-making sessions, and, finally, the quiz show itself.

The individual jobs rotate each time the group meets. They include scribe (writes down questions and answers that the group approves) and materials coordinator (makes sure all students bring their books and notes and get the clipboards with previous questions out of the bin). Other jobs are judge (when the group disagrees about whether a proposed question is satisfactory for the quiz show, the judge makes the final ruling, but must back up this opinion with reasons), cooperative overseer (takes notes on cooperative behavior to give the group feedback at the end of the session and reminds students to follow the cooperative rules already set and posted, such as not interrupting and all participate). The analyst keeps track of the group's reasons for rejecting questions. These are also reviewed at the end of the session with the expectation that the metacognition will result in improvement.

Students and not the teacher are responsible for accomplishing their tasks in the way they think best, with accountability to each other and to the teacher's standards.

Through this cooperative activity, neuronal network reinforcement of the reviewed is more engaging. The group processing of text material offers another modality of information input, thereby making the knowledge more accessible for students with varied learning style preferences: auditory, visual, kinaesthetic (movement during the quiz show), and interpersonal. The group negotiates roles with teacher guidance.

Lincoln-Douglas Debate: Group work involving skits, demonstrations, debates, or other dramatisations appeals to the kinetic, verbal, and interpersonal strengths of many students, especially in middle school when energy levels run high and passive sitting in classrooms with directed lectures can be the best way to lose students' attention. Academics are not usually the first priority during adolescence, and dramatisations as part of group work can bring variety and harness energy, and teacher supervised socialising activities in a safe classroom community can increase belonging and confidence. When students observe modelling and then practice the skills needed for successful group work, they are able to build their skills of self-control, managing their emotions, and cooperating and resolving conflicts with others while building executive function, all in a positive emotional state for building emotion links to academic learning. Dramatisations have the added benefit of activating regions of the brain where prior relational memories are stored. The personal meaning inherent in dramatisation results in more opportunities for new information to be connected by the relational memory hook-ups that enhance patterning and retention.

Students work in groups, using their individual skills and interests, to put on a political campaign supporting Lincoln or Douglas through posters, political cartoons, oral debates, skits, and computer or video ads. This project requires students to work together to negotiate rules for campaigning, rules for debating, rules for scoring the debates. Students also need to negotiate with group members for who does which activity such as portraying Lincoln, making campaign posters, directing the campaign video.

If the initial presentation of a new unit incorporates sports, popular music, and audiovisual technology, at least one of these will resonate with most middle school students through their primary or secondary learning strengths or interests.

The teacher determines how many students can work together on some of these activities, but the students must first prepare a plan (prioritising, organising, and judgment skills) to show for which part of the poster or video each individual will be responsible. For the final debates (there can be several sets of debates, depending on size of the class and of the groups) other teachers can be brought in as judges, and the students give them the scoring criteria that were finally agreed upon by compromise and consensus.

Designated, rotating individual roles within the group can include recorder, participation monitor (someone who keeps track of who is participating such that if one member has already given three suggestions and others have not had a chance, the overly active participant is asked to give others time to present their views), creative director (if a physical product such as a poster or computer presentation is part of the project), materials director, accountant, and secretary as needed and with similar duties as described for the quiz show groups. There is more than one answer or way to solve the problem.

"What is Life?"—Group Problem Analysis:

Bringing in all students from the beginning of a unit of study increases relational memory. By presenting the big picture through a comprehensive experience that links with some area of student interest, past experience, or real-world connections, relational memories are triggered and the hippocampus is activated on brain scan as the site where connections are made with the new information that allow it to be coded into recognisable and storable patterns. For example, if the initial presentation of a new unit incorporates sports, popular music, and audiovisual technology, at least one of these will resonate with most middle school students through their primary or secondary learning strengths or interests. This initial exposure to the topic will stimulate their connection to the lessons that follow, because they were engaged early by linking the unit to their interests or personal experiences.

Starting with an innovative presentation such as a recent newspaper report, guest speaker, or by posing a thought provoking question through a demonstration, teachers can all engage students. An example is the engaging and personally relevant introduction to a biology unit, prompting students to define what it means to be alive. I ask students in cooperative groups to define what constitutes a living organism and to record their responses. They then practice prioritising and ordering executive function skills as well as the social skill of reaching a consensus as they decide as a group what characteristics of being "alive" are most significant in defining life. I then give each group a candle that I light and ask them to see if the flame fits the list of functions that define living things. They then refer to their lists, which usually include: consume oxygen or carbon dioxide, reproduce, react, and has a beginning and a termination. The next question for them to debate as a group usually presents a curious problem. If the flame fits with the generated list of characteristics for living things, does that mean the flame is alive? Why or why not? Students are authentically engaged when they start making personal connections and asking questions that relate the initial experience to concrete references or abstract connections. Students will have valid responses that they will be motivated to share because they are personally touched in some way. Once students are connected to the topic through their discussions, they are ready to be engaged in the study of single cell organisms because they are in a low stress, high interest state with unrestricted affective filters and increased release of dopamine.

The activity should be intrinsically interesting, challenging, and rewarding

Early engagement of attention through multisensory experiences and high personal interest is well suited to the multisensory, fast-paced world of adolescents who have grown up in the personal technology age. This middle school American history activity coincides with the study of lifestyles of early settlers in the Colonies and works especially well if done near Thanksgiving.

Classroom visitors, costumes, and food are of high interest to students in any grade, and this activity always resonates with one or more interests the middle school students who have participated in it. For the big picture or global introduction to the unit, we start with a guest speaker from the community. One year we invited the director of the local farmers markets and food stylist. Without any advance notice (to incorporate surprise and novelty) she entered the class in colonial attire with a large basket of produce indigenous to the early New England Colonies. First, she gave the students several unfamiliar vegetables to taste. Distributing this food let the students know it would be an interactive experience and kept them "fed" so that they would not focus on any hunger prompted by looking at the food. Next, she said, "You have been told not to play with your food, but today we will playing with food." Using humour and, again, surprise she won their trust and kept their attention. The promise of playing with food also alerted the interest of the tactile-kinesthetic learners and AD/HD students.

Her presentation continued with demonstrations of how to cut and display foods to make them look more appealing. She explained which foods were the first ones available for either gathering or planting by the colonists, and she finished by demonstrating the construction of a cornucopia. She preceded this demonstration with the assurance that the students would have an opportunity to make their own cornucopias as soon as she finished. This confirmation of a desirable activity before a passive demonstration is an important strategy to keep the focus of high-energy adolescents because they know that the attention they give at the start will help them be successful in a connected activity that will immediately follow. Increased brain activation takes place when subjects are told they will be asked to repeat or immediately use the information or activity they are about to learn (Sousa, 2000).

When the food designer left, all the students were engaged, enthusiastic, and ready to start building their cornucopias. She left them with fruits and vegetables to make cornucopias using rolled tagboard and extra carrots, radishes, and potatoes for food design carving.

Before making the cornucopias, we had a brainstorm session to connect the morning's speaker and group cornucopia activity to the colonial unit that would follow. The experience had generated interest in the colonial period, and students prepared a list of some of the questions they would still like to ask the speaker. Their questions were compiled on a chart, and questions were added based on their suggestions about other facets of colonial life they believed might be interesting to investigate.

After a brief reminder about cooperative group behaviour, fair division of activities, and decision by consensus, students were divided into small groups where they constructed and filled cornucopias. I assigned the students to groups based on their interests, compatibility, and learning strengths. The latter consideration enabled students with limited academic or social skills to participate in groups where their creative or intellectual strengths would be acknowledged as valued contributions to the group project. Depending upon student interest and group consensus, one or two students per group drew a picture of their cornucopia, one student photographed it and posted it on the class Web site, and another student or two researched the origin of the horn of plenty and its relation to Greek mythology.

That initial day's group activity was low stress and planned for fun, positive emotional connections, flashbulb-connecting memories, and to promote curiosity and interest in the unit to come. It was not, in itself, high in academics and may not have added many facts to students' rote memory file with which they could answer questions on a standardised test, but the entire class, from the entrance of the guest speaker to the construction of the cornucopias and the starting of the Web pages, was engaged and actively participating in a history class activity that was fun. It is not often enough that middle school students are provided the opportunity to associate academics with fun. When they are able to make this association, it helps relieve frustration and revitalise their connection with school.

The next time class met, students were still in their cooperative groups, but now each student in the group did Internet research about one of the 20 questions they selected from the list we brainstormed regarding colonial lifestyle, agriculture, foods, Thanksgiving, cornucopias, food styling, other food careers. Their homework from the previous class was to copy from the brainstorm list the five or six topics they thought they might want to research and to use books or the Internet to see which one or two topics were still interesting and had accessible information.

The process of collaborative work is associated with increased neural activity in relational and emotional memory connections and long-term memory storage.

Before the next class, I added five questions (one per person in each group). The questions added were incorporated to avoid missing any of the curriculum standards for the unit. Each student, therefore, had his or her own high interest, personal choice question plus one of the five I added. The formalized list of questions was then projected on the overhead, and students wrote on note cards their first and second choices of which topics they would most like to further investigate.

To refresh students' memories of the information they had already learned and to share new information they discovered doing their homework research, we did a roll call topic for taking attendance. When their names were called for roll, students were to respond with one thing they remembered from the cornucopia presentation the previous day. This strategy increases focus and recall.

Cooperation with group members was necessary to assure all jobs needed to create the Web page would be done and research was not duplicated. The final project of each group was a Web page within the class Web page folder titled Cornucopia. Students were able to work through their learning style strengths and interests. They conferenced with me individually to determine if their topic of research was at their appropriate level of challenge.

Students received feedback from parents and other classes who visited the Web site where there was a place to write compliments, ask questions of the Web page creators, or add related information. By starting the colonial social studies topic with the experiential, artifact-centered, novel, and motivating guest speaker cornucopia experience, the students became curious, intrinsically motivated to ask questions, and they were willing to do the research. In addition, they were motivated to inquire further to satisfy their curiosity about the questions that they, as a class, had created, and the topics they individually selected. Instead of being passive recipients of the unit of study, they were co-creators of an investigation that was developed from their own interests and goals.

Conclusion

As the groups are working, teachers can promote the desired cooperative behaviour by modelling how students can periodically check in with each other to answer these questions during the activity:

1. Is everyone talking?
2. Are you listening to each other?
3. Are you asking questions of fellow group members? What could you ask to find out someone's ideas?
4. Are you giving reasons for ideas and expressing different opinions?

5. What could you ask if you wanted to find out someone's reason for a suggestion?

At the conclusion of each day's group time, group members assigned to record feedback for the group reveal their observation data in their small groups. This is followed by teacher feedback to the whole class, including public praise to students who have done well in the context of group work, particularly those who are not usually high academic achievers or who tend to be classroom management challenges. Successful compromise and inclusiveness, rather than speed at solving the problem or completing the project, is acknowledged.

Classrooms where students are engaged in well-planned cooperative work are more joyful places in which management issues diminish and students develop social and learning skills. Now we know that the process of collaborative work is associated with increased neural activity in relational and emotional memory connections and long-term memory storage. It is reassuring in times of rigid curriculum requirements to have not only the academic and social evidence of the benefit of cooperative activities, but to also have the objective neuroscientific data to support what teachers, and for that matter, the ants and the bees, have known all along.

Editor's Note

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