COOPERATIVE LEARNING: THE BEHAVIOURAL AND NEUROLOGICAL MARKERS THAT HELP TO EXPLAIN ITS SUCCESS

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Abstract

Cooperative learning is widely recognised as a pedagogical practice that promotes socialisation and learning among students from preschool to post-secondary education and across different key learning areas and subject domains. It involves students working together in small groups to achieve common goals or complete group tasks. Interest in cooperative learning has grown rapidly over the last three decades, as research clearly demonstrates how it can be used to promote a range of achievements in reading and writing, conceptual understanding and problem-solving in science and mathematics, and higher level thinking and reasoning. It has also been shown to promote interpersonal relationships among students with diverse learning and adjustments needs and among those from culturally and ethnically different backgrounds. In fact, it is argued that there is no other pedagogical practice that achieves such outcomes. The purpose of this presentation is to highlight those factors that have been found to contribute to the success of cooperative learning, including recent research in neuroscience that helps to explain how and why students learn when they cooperate.

Interest in cooperative learning began to emerge in the 1970s as reports on the social and academic benefits students obtained from working together to assist each other to learn began to be published (Brown, Fenwick & Klemme, 1971; Gartner, Kholer & Riesman, 1971). These studies showed that children could be taught to facilitate academic accomplishments in others, help underachieving children overcome their motivational deficits, improve attitudes towards others, and enhance communication among group members. Interestingly, students who participated in helping others also benefited, possibly because they had to cognitively restructure the information they were teaching in order to explain it in a way that those being helped could understand (Allen, 1976). In so doing, they often consolidated their own understandings of the information they were teaching and gained greater mastery over it than they had previously. These findings were exciting and helped to stimulate further research on cooperating groups and how they could be used to facilitate learning and socialisation.

As many schools demonstrated traditional instructional approaches to teaching, whereby students were expected to be passive recipients of knowledge, research focused on comparing cooperative learning to competitive and/or individual approaches to learning. In 1981, Johnson, Maruyama, Johnson, Nelson and Skon published the results of a meta-analysis of 122 studies that examined the effects of cooperative, competitive and individualistic learning on achievement. The results showed that cooperation promotes higher achievement and greater productivity than competitive or individualistic approaches to learning. These results were consistent across all subject areas, all age groups, and for a variety of cognitively challenging tasks.

In a follow-up meta-analysis of 111 studies, Johnson and Johnson (2002) examined the effects of cooperative, competitive and individual learning on a number of academic, personal and social dependent variables (e.g. achievement, interpersonal attraction, social support, self-esteem, perspective taking, and controversy) and found that the mean effect sizes (i.e. the strength of the relationship between the independent and dependent variables) for cooperative learning in comparison to competitive and individualistic learning ranged from 0.58 to 0.70. These are effect sizes that Hattie (2009) believes are noticeable and can make 'real-world differences' (p. 17) in educational interventions. In short, the results of this meta-analysis and the Johnson et al. (1981) meta-analysis indicate that cooperative learning in comparison to competitive or individualistic learning has very powerful effects on achievement, socialisation, motivation and personal self-development.

Given that previous investigations of small-group structure have highlighted the academic and social benefits students derive from working cooperatively together, Roseth, Johnson and Johnson (2008) examined the social-contextual view of the mechanisms and processes by which these benefits are promoted. In a meta-analysis of 148 studies that compared the effectiveness of cooperative, competitive and individualistic goal structures in promoting early adolescents' achievement and positive peer relationships, the authors found that higher achievement and more positive peer relationships were associated with cooperative rather than competitive or individualistic goal structures. Furthermore, cooperative goal structures were associated with a positive relationship between achievement and positive peer relationships. Slavin (2013), in a best evidence synthesis of research on primary and secondary mathematics, reading and programs for struggling readers, also reported that well-structured methods such as cooperative learning produce more positive effect sizes than those evaluating either curricula reforms or computer-assisted instruction. There is no doubt that cooperative learning as an instructional strategy has had a profound effect on student learning and socialisation.

What accounts for the success of cooperative learning?

It is well recognised that placing students in groups and expecting them to be able to work together will not necessarily promote cooperation. Groups often struggle with knowing what to do, and discord can occur as members grapple with the demands of the task as well as managing the process involved in learning, including how to deal with the opinions of different members or working with students who make minimal contribution to the group. In order to avoid these pitfalls, groups need to be established so that the five key components of successful cooperative learning are embedded in their structure (Johnson & Johnson, 2009).

The first of these key components involves establishing a state of positive goal independence: group members need to understand that they are required not only to

complete their part of the task but also to ensure that others do likewise. When students understand that they cannot succeed unless others do, and they must coordinate their actions to ensure that this occurs, cohesiveness develops in the group. This is a direct result of the perception of goal interdependence and perceived interdependence among group members. It is this psychological state of positive interdependence that creates the momentum for members to work together. When groups are formed in which positive goal interdependence is not evident, as often happens when groups are formed on an ad hoc basis, group members tend to work either independently by themselves or not at all (Gillies, 2003, 2006).

The second key component involves group members understanding that they are individually accountable for the contributions they make. This sense of accountability emerges when members accept responsibility for completing their part of the task while simultaneously encouraging others to do likewise. In classrooms, teachers will often establish requirements for individual accountability so that each student's contribution to the group can be identified, ensuring that each student is responsible for completing his or her assigned task.

Students cooperate and work better when they have been taught the interpersonal and small-group skills needed to manage group interactions and behaviours. These skills constitute the third key component and include the following behaviours: listening to others, sharing ideas and resources, taking turns, accepting responsibility for one's own behaviour, and engaging in democratic decision making.

The fourth key component that affects cooperative learning is promotive interaction. This occurs when students listen to each other, exchange ideas and offer explanations to assist understanding, provide constructive feedback to improve performance on a task, and facilitate access to resources and materials. These reciprocal exchanges lead to group members feeling more accepted and valued, less anxious and stressed, and more willing to reciprocate and help others in return. The more members interact with each other, the more they will get to know each other as individuals. This knowledge forms the basis for caring and committed relationships (Johnson & Johnson, 2009).

The last key component in cooperative learning is group processing. Group processing is critically important, as it allows members to discuss how well they are achieving their goals and maintaining effective working relationships. It involves members reflecting on what they have done well and what they need to do to achieve the group's goals. Group processing involves (a) summarising group members' ideas and information, (b) encouraging members to participate in group discussions, and (c) checking to see that decisions made by the group are supported by members. When this occurs, students demonstrate greater problem-solving success and higher achievement gains than when they participate in cooperative groups with no group processing or when they work individually by themselves (Johnson, Johnson, Stanne & Garibaldi, 1990). Possible explanations for these results include the following:

- the focus on metacognitive thinking increases awareness among members of the need to think carefully and clearly about the topics being discussed
- group processing assists members to gain insights into how to behave more effectively when interacting with others
- feedback on social skills increases the frequency of their use.

Group structure, composition and task

Given the importance of establishing cooperative groups that include the five key components outlined above, teachers often seek clarification on how groups can be structured to maximise learning, the composition of the groups, and the types of tasks that students find engaging. While the research clearly indicates that groups need to be structured so that the five key components of cooperative learning are embedded in their structure, it is also important to consider both the composition of the group and its size. In a meta-analysis of 66 studies that examined the effects of within-class grouping (i.e. establishing small groups in classes) on student achievement at the elementary, secondary and post-secondary levels, Lou et al. (1996) found that students achieved higher learning outcomes when they worked in small cooperating groups than when they were not grouped or remained in whole-class teaching arrangements. Furthermore, students worked better and achieved more when they worked in groups of three to four members than in groups of five to seven members. Interestingly, the effects of group ability composition were different for students of different relative ability: low-ability students learned more in heterogeneous groups (high, medium and low ability); medium-ability students benefited significantly

in homogeneous ability groups; and group composition made no difference to high-ability students.

Similar results were obtained in a meta-analysis of small-group and individual learning with technology by Lou, Abrami and d'Apollonia (2001), with small-group learning having significantly more positive effects than individual learning on students' individual achievement and group task performance. Student performance was higher in smaller groups (three to five members) than for those working individually, and students gained more individual knowledge in small groups than those working individually with computer technology. Bertucci, Conte, Johnson and Johnson (2010) also found that students' achievement was higher in pairs and in groups of four than when they worked individually. Furthermore, social support and self-esteem were higher when students worked in small groups than individually.

The type of task students undertake in their groups is also important. Cohen (1994) found that the type of task affects the discussion that occurs. Interaction among group members is critically important to the success of small-group activities. Shachar and Sharan (1994) argued that interaction will only happen when teachers create conditions that enable students to work in small groups on tasks that require cooperation among group members. When students recognise the importance of arriving at a synthesis of everyone's contributions and expect that the group product will be presented to the wider class, group cohesion is fostered and students are motivated to complete the task. When teachers structure small group activities so that these conditions are met, students are more interactive, use more words per turn of speech, communicate more equitably so that ideas are shared among group members, and elaborate more to explain the problem at hand.

The results of these meta-analyses indicate that students derive both academic and social benefits when they work cooperatively together rather than when they compete or work individually or alone. Furthermore, students are more likely to achieve more when they work in groups of four or less, preferably mixed-ability groups rather than homogeneous ones, and when they work on tasks that require them to cooperate.

Cooperation and research in neuroscience

There is very little research on the brain processes involved in cooperative learning. In particular, it is not known how the differences in brain processes engaged during cooperative rather than individual or competitive learning lead to more successful learning outcomes. Research in the field of neuroeconomics shows that cooperative behaviour leads to greater activation in regions of the brain associated with reward-based learning (Decety, Jackson, Sommerville, Chaminade & Meltzoff, 2004). It is therefore suggested that individuals experience greater reward during cooperation, which serves to reinforce that behaviour and lead to greater engagement during cooperative tasks.

Another relevant line of neuroscience research concerns neural 'mirroring' processes, or the emulation of others' mental states and experiences in the observer's own brain. It is thought that when we observe others' actions or emotions, the same neural states in their brains are mirrored or emulated in our own brain, as a form of shared experience, and that we come to understand others' intentions and goals through this neural emulation or mirroring process (Rizzolatti & Fogassi, 2014). Research on neural mirroring began with the discovery of monkeys' mirror neurons, which are active when a monkey performs a hand action and when the monkey observes the same actions being performed (Gallese, Fadiga, Fogassi & Rizzolatti, 1996). It appears that simply observing others' actions engages the same brain processes as when we generate and control our own actions, which is suggested to contribute to observational learning (Cattaneo & Rizzolatti, 2009). Indeed, motor learning through observation of actions is commonly used in sports training and used as 'mirror' therapy for movement rehabilitation following stroke (Garrison, Winstein & Aziz-Zadeh, 2010).

While early research on mirror neurons focused exclusively on movement and actions, it is now well accepted that similar mirroring processes operate in other domains and give rise to shared brain states between cooperating partners (Keysers & Gazzola, 2009). Crucially, this neural mirroring process is strongly influenced by social relationships between individuals. The degree to which brain states in one individual are mirrored in another depends on the relationship that individual has with the other, and the degree to which one perceives the other as a member of their own in-group (Hein, Silani, Preuschoff, Batson & Singer, 2010). This fits with well-known research on forming social relationships, showing that we tend to emulate or imitate people we like and we like people who imitate us (Chartrand & Bargh, 1999). Positive in-group relationships between cooperating partners therefore appear to be crucial for neural mirroring mechanisms.

The gap in current research in this area is linking neural mirroring processes to outcomes in cooperative learning. We currently do not know whether the emulation of others' brain states through neural mirroring plays any causal role in the successful outcomes associated with cooperative learning. We do know that mirroring processes play a role in motor skill learning, as widely used in sports training, and we know that positive interpersonal relationships, which are a key element in cooperative learning, also play a crucial role in neural mirroring between cooperating partners. Education neuroscience is a young and growing field and, by increasing understanding of the neural mechanisms that contribute to learning by co-operation, can provide an important new perspective by which to further inform pedagogical practice.

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