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**The Role of Collaboration in the Cognitive Development of Young Children: A Systematic
Review**

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Abstract

Background: Collaboration is a key facilitator of cognitive development in early childhood; This review evaluates which factors mediate the impact of collaborative interactions on cognitive development in children aged 4-7 years.

Methods: A systematic search strategy identified relevant studies ($n = 21$), which assessed the role of ability on the relationship between collaboration and cognitive development. Other factors that interact with ability were also assessed: gender, sociability/friendship, discussion, age, feedback and structure.

Results: Immediate benefits of collaboration on cognitive development are highlighted for same-age peers. Collaborative interactions are beneficial for tasks measuring visual perception, problem-solving and rule-based thinking, but not for word-reading and spatial perspective-taking. Collaboration is particularly beneficial for lower-ability children when there is an ability asymmetry. High-ability children either regressed or did not benefit when paired with lower-ability participants.

Conclusions: Overall, the studies included within this review indicate that brief one-off interactions can have a significant, positive effect on short-term cognitive development in children of infant school age. The longer-term advantages of collaboration are still unclear. Implications for practice and future research are discussed.

Collaboration is a “coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem” (Rochelle & Teasley, 1995, p. 70). Peer-based collaborative activities are used in schools to promote the development of verbal, cognitive and social skills (Gillies, 2006), for example, peer mentoring and group work are commonly utilised (Slavin, 2015). Group composition can include dyads and triads, but a group size of 4-6 children is most common (Kutnick, Blatchford & Baines, 2002). Educational curricula emphasise that pupils should be able to actively engage in collaborative interactions and consider and evaluate alternative viewpoints (Department for Education, 2013). This requires children to develop a complex range of cognitive and social abilities during their first years in formal education.

Cognitive Development and Collaboration

Pioneering research by Doise, Mugny, and Perret-Clermont (1975) highlighted that collaborative interactions with peers benefits children’s cognitive development; subsequent research has sought to understand the underpinning mechanisms. Ideas of cognitive conflict and the importance of discussion dominate understanding of cognitive development (Gillies, 2014), with the two dominant paradigms posited by Piaget (1928, 1932) and Vygotsky (1978).

Piaget posited that central to cognitive development is ‘disequilibrium’, the discrepancy between the information being presented and what is believed to be true (Piaget, 1928). Peer interaction facilitates cognitive disequilibrium via socio-cognitive conflict; an external process where individuals are exposed to opinions different to their own (Piaget, 1959, 1977). Verbal exploration restores equilibrium and results in cognitive re-structuring.

Piaget emphasised the role of equal peer relationships, whereas, Vygotsky argued that cognitive development was more likely when individuals differed in their level of understanding (Duran & Gauvain, 1993). The child’s *Zone of Proximal Development (ZPD)* determines the difference between what they could achieve independently and what they could achieve through collaboration with a more

able partner (Vygotsky, 1978). The process of *inter-subjectivity* occurs when individuals enter a collaborative interaction with different viewpoints, and this enables the development of a shared understanding (Cannella, 1993). Piaget and Vygotsky both emphasise collaboration as a mechanism for cognitive development; highlighting the importance of verbal reasoning and discussion with another individual who has a different viewpoint, with the aim of achieving a shared understanding (Tudge & Winterhoff, 1993).

Topping (2005) presents these concepts within a theoretical model of how cognitive development can occur within a peer learning context, incorporating processes such as cognitive conflict, ZPD and *meta-cognition* (the ability to self-reflect). This model incorporates the reciprocal nature of peer interactions, acknowledging the significant role of communication and affect in facilitating effective peer learning. A recent review of cooperative learning by Gillies (2014) explores current thinking around the importance of language and discussion within the classroom setting.

A relevant alternative conceptualisation of cognitive development is Theory of Mind (ToM; Premack & Woodruff, 1978). ToM, the understanding that others have their own thoughts, feelings and beliefs, which might differ to your own, develops rapidly during early childhood (Baron-Cohen, 2001). Shared attention and information-seeking are key cognitive and social processes required for ToM (Baldwin & Moses, 1996). Wimmer and Perner (1983) concluded that children under 3 years lacked ToM as they were unable to distinguish between what they and others knew. However, by 5 years, the majority of children understood that others might have different, sometimes false beliefs. By 6 years, normally developing children usually have ToM (Perner & Wimmer, 1985), suggesting that children become less egocentric at a younger age than suggested by Piaget's (1952) stage theory (seven years). Collaborative interactions may facilitate the development of ToM, as children are exposed to conflicting views (Dunn, 1994). Alternatively, ToM might be necessary for effective collaboration; allowing the child to appreciate another viewpoint. Several studies have identified correlations between

ToM and cognitive functioning tasks, independent of age and intelligence (Carlson & Moses, 2001; Hala, Hug, & Henderson, 2003). Both cognitive functioning and ToM develop rapidly between 4 and 7 years, and are central to school readiness (Blair, 2002; Capage & Watson, 2001; Riggs, Blair, & Greenberg, 2003).

Knowing which factors influence cognitive development during collaborative exercises for young children has implications for educators and clinicians. However, it is currently unclear whether peer collaboration is beneficial in promoting cognitive, social and emotional development in young children, as studies have reported inconsistent findings. Consequently, the aim of this review is to consider which factors mediate the relationship between peer collaboration and cognitive development in children aged between 4 and 7 years.

Method

Search Strategy and Inclusion Criteria

A systematic search of three major electronic databases (PsycINFO, Web of Science and ERIC) for articles published between January 1975 (following publication of Doise et al., 1975) and December 2015 was conducted (final searches on 12/12/15). Search terms from three key concepts were utilised: social interaction (e.g. collaboration, cooperation), cognitive functioning (e.g. cognitive development, cognitive ability, problem-solving) and participant age (e.g. children, young people, childhood development). The strategy was adapted to suit each database. Forward and backward citation searches were conducted for the final articles.

Studies that fulfilled all of the following criteria were included: (1) included collaborative or cooperative task/s between peers; (2) analysis of data from non-clinical participants aged 4-7 years; (3) included cognitive functioning task/s completed pre- and post-interaction; (4) quantitative design and/or analysis; (5) published in English; and (6) peer reviewed.

Studies were excluded if they met any one of the following criteria: (1) included participants with mental health diagnoses or developmental disorders; (2) participants were outside of the specified age range; (3) not peer-reviewed e.g. conference presentations, dissertation abstracts and books; (4) position papers and reviews; (5) case studies; and (6) non-human participants.

The initial search identified 8529 articles. One hundred and sixty nine articles were identified as relevant from title screening. Abstracts (and full-texts where necessary) were reviewed in line with the inclusion and exclusion criteria. Twenty-seven articles were identified as eligible for inclusion.

The methodological quality of the studies was assessed using the Downs and Black (1998) checklist, which examines reporting, internal and external validity and power. In line with previous reviews (MacLehose et al., 2000; Sohanpal, Hooper, Hames, Priebe, & Taylor, 2012), the checklist was modified to fit the aims of the current review. On item 27, a score of '1' was given if a power calculation was reported. On item 25, a score of '1' was given where age and/or gender was reported for each condition. Overall scores, out of 27, were classified as excellent (23-27), good (18-22), fair (14-19), and poor (less than 13). The first and second authors independently quality rated each paper; agreement between the two raters was excellent ($r = .87, p < 0.001$); disagreement was resolved through discussion. Six papers classified as 'poor' quality were excluded. Twenty-one papers, classed as 'fair' quality, were included in the review (Table 1).

[Table 1 here]

Results

Overview

The 21 studies included in this review had an aggregated number of 2248 participants; sample sizes ranged from 32 to 264. The mean age of participants was 6.3 years ($SD = .59$) for those studies that reported this figure ($n = 12$), and 51.6% of participants were male ($n = 15$).

Most studies investigated more than one variable: the most frequently studied was ability of the child on a cognitive functioning task undertaken as the pre-test ($n = 17$), followed by individual versus collaborative working on the task ($n = 8$) and gender ($n = 6$). Sociability/friendship, discussion during the task, age, feedback and structure were also considered. The articles are organised and discussed in accordance with their primary aim in order to avoid repetition.

All but one study used a mixed-factorial design: Cannella, Viruru, and Amin (1995) used a within-subjects design. All studies involved a pre-test, interaction phase (collaborative task) and post-test (the majority completed all phases in one day). Just over half ($n = 11$) included a control group; typically, participants worked on the same task independently. Interaction tasks were predominantly the same as the pre-post tasks. The median number of interaction sessions was one, with a range of 1-32. The timeframe for completing post-task measures varied from immediately after the interaction to seven weeks later. The majority of studies did not report where the experiment took place; a small number were classroom-based. Therefore, it is possible that many of the studies were undertaken in artificial environments, potentially limiting the generalisability of the findings.

The mean quality rating score was 15 ($SD = .91$). Internal validity (71.4%) was relatively high as were levels of reporting (66.5%). Lowest scores were on the internal validity confounding (35.7%) and external validity subscales (36.7%). No studies reported a calculation of statistical power in reference to sample size.

Individual versus Collaborative Working

Four studies reported a significant advantage of peer collaboration over individual working on post-test measures of planning, reasoning, visual discrimination/perception, problem-solving, and rule-based thinking (Fawcett & Garton, 2005; Gabbert, Johnson, & Johnson, 1986; Gillies & Ashman, 1998; Tudge, 1989). In support of these findings, Tudge and Winterhoff (1993) reported that the improvement of those collaborating with a partner on a mathematical balance beam task was

significantly greater than zero. However, this study did not use a control group so it is unclear whether there would have been a similar improvement for those working independently on the task.

Three studies measured language development. Gillies and Ashman (1998) reported significantly more cognitive language use by those in a collaborative condition and Gómez et al. (2013) reported a large effect size (0.95) of working collaboratively on a measure of oral language. Gómez et al. (2013) also reported a medium effect size in the improvement in social skills for those who had collaborated, compared to deterioration in the 'curriculum-as-usual' control group (Cohen's d of the difference = 0.51). Those who had collaborated during an interactive task used higher reasoning strategies than those who had worked independently (Gabbert et al., 1986).

Three studies reported non-significant differences between collaborative and individual conditions on spatial perspective-taking (Bearison, Magzamen, & Filardo, 1986); word reading (Gillies & Ashman, 1998); and arithmetic (Gabbert et al., 1986). Two of these studies were rated as the highest quality of those included within this review, adding weight to their findings.

Gender

The role of gender in cognitive development was examined using spatial perspective tasks in two studies rated as amongst the highest quality (Bearison et al., 1986; Cannella, 1992). In comparison of same-gender dyads, Bearison et al. (1986) reported that type of conflict differed significantly between the groups: females engaged in more *enactive disagreements* (physically corrected their partner), whereas males engaged in more *verbal disagreements with explanation*. Verbal disagreements with explanation were significantly associated with cognitive development, but only for male dyads, and within an optimum range of 5-8 per interaction. Cannella (1992) extended this, reporting that the gender of the partner was a significant factor; male dyads made significantly more cognitive gains than female dyads. Furthermore, this study concluded that *verbal disagreements without explanation* might actually inhibit learning. Taken together, the findings from these studies suggest that the relationship

between cognitive development and collaboration might be stronger in male dyads. Although these studies were rated as relatively high quality, neither controlled for differences in ability within the dyads.

Ability

The majority of studies in this review varied the ability within the collaboration-dyads and used Piagetian measures of egocentricity and conservation, or non-Piagetian measures of cognitive functioning. Based on pre-test scores, participants were classed as high- or low-ability. Consistently across studies, low-ability participants benefitted most from collaborating with a high-ability peer, compared to low-ability participants who worked on the task independently.

The conservation of liquid task was used in three studies (Psaltis, 2011; Psaltis & Duveen, 2006, 2007). In a study investigating mixed-ability dyads, Psaltis (2011) reported that low-ability participants performed significantly better on an immediate post-task compared to those of low-ability who worked independently. Psaltis and Duveen (2006) confirmed this advantage one month after the interaction phase, indicating stability in the findings. However, Psaltis also included a delayed post-test conducted seven weeks post-interaction and reported that the advantage for low-ability participants was not maintained. The lack of significance between the conditions at this point was attributed to the high rate of progress made by the control group, suggesting that working collaboratively increases cognitive benefits in the short-term for low-ability participants, but this advantage might not be significant in the longer term. Psaltis' study included two control groups: both completed the pre-task but then one control group completed the immediate post-task, whilst the second control group completed the delayed post-task. Even though random assignment took place, there is no report of possible differences between the control groups at pre-test. Therefore, the lack of significant difference at delayed follow-up should be interpreted with caution.

Several studies utilised non-Piagetian measures of cognitive functioning, including sorting ability (Fawcett & Garton, 2005; Garton & Pratt, 2001; Park & Lee, 2015); rule-based thinking (Tudge, 1989; Tudge & Winterhoff, 1993); perspective-taking (Azmitia, 1988; Da Silva & Winnykamen, 1998; Park & Lee, 2015); and cognitive reasoning (Gabbert et al., 1986). Post-test length varied from immediately after the collaborative interaction to four weeks later. All studies demonstrated that low-ability children paired with same-age high-ability children, either within a dyad or a small group setting, improved significantly post-test, compared to same-ability pairings and/or control groups where individuals did not participate in the collaborative interaction.

Cannella (1993) argued that rather than ability asymmetry, it is more important for participants to engage in a *shared cognitive experience*, where their concerns are acknowledged and responded to. In relation to low-ability participants, Psaltis and Duveen (2006, 2007) identified two key types of conversation that were related to cognitive growth: *explicit recognition*, where the low-ability child verbally indicates that they have changed their understanding of the task; and *resistance*, where the low-ability child initially defends their position before accepting the view of the high-ability child. Nearly all of the participants that engaged in explicit recognition conversations improved post-test, and half of the low-ability students who had engaged in this type of conversation made use of novel arguments in their post-test (Psaltis & Duveen, 2006). The authors posited that explicit recognition and resistance conversations facilitate socio-cognitive conflict and consequent cognitive development through active participation in the collaborative exercise. This finding was in contrast to *compliance* conversations, where the low-ability participant passively accepted the high-ability student's views.

Cannella (1993) reported no significant difference in cognitive development between dyads of same- and mixed-ability. However, a greater percentage of the mixed-ability dyads improved compared to the same-ability dyads (58% and 33% respectively). The authors did not report a power calculation,

so the study might have been insufficiently powered to detect a significant effect. Furthermore, although this study was of relatively high quality, there was no control group or longer-term follow up.

Fawcett and Garton (2005) identified a trend towards regression for high-ability participants when collaborating in a mixed-ability dyad, in that their scores were lower on the post-test. The only exception to this was in the condition where ability was mixed and discussion during the interaction phase was encouraged. A lower quality study also highlighted regression on post-test scores for high-ability partners within mixed-ability dyads (Tudge, 1989).

A number of studies explored the interaction between ability and factors such as gender, opportunity for discussion, age, feedback, friendship and sociability.

Gender

Several studies investigated the relationship between gender, ability and cognitive development using spatial perspective-taking or conservation tasks. A consistent finding confirmed an advantage for novice (low ability) males paired with expert (high-ability) females: these males progressed more on an immediate post-test, compared to novices who worked independently (Psaltis & Duveen, 2006, 2007) or within same-gender pair types (Zapiti & Psaltis, 2012). However, there was no advantage over working independently for female novices paired with a male expert.

Psaltis and Duveen (2007) reported that female experts were twice as likely to concede to the view of novices as were male experts. However, novices who interacted with a female expert used significantly more novel arguments during the post-test than those who had interacted with a male expert (Psaltis & Duveen, 2006). Therefore, being paired with a high-ability female is beneficial for the novice regardless of gender, but this interaction might be detrimental to the cognitive development of the female expert.

Psaltis (2011) reported somewhat contradictory findings. Male and mixed-gender dyads of mixed-ability in the interaction condition scored significantly higher on post-test spatial perspective-

taking than those in the control group: there were no significant differences between female dyads who collaborated and those who worked independently. However, on a task classed as more complex, only the female dyads from the interaction condition scored significantly higher than the control group. The authors fail to explain why the mixed-ability female dyad performed differently to the other dyads on these tasks. This study was rated as amongst the highest quality in this review, but this finding was not reported in any other study, so should be interpreted with caution.

Opportunity for discussion

The role of discussion was explored in two studies (Fawcett & Garton, 2005; Pine & Messer, 1998). Pairs or small groups of similar or mixed-ability participants were randomly allocated to either a discussion or control condition (independent working, Fawcett & Garton; no discussion, Pine & Messer). Discussion participants improved significantly more than controls on a card-sorting task (Fawcett & Garton) and a balance beam task measuring rule-based thinking (Pine & Messer). Discussion was mostly helpful to low-ability students and those working in a mixed rather than a same-ability group (Pine & Messer).

Age

Duran and Gauvain (1993) investigated the relationship between ability and age on planning and sequencing. Based on pre-test scores, participants aged 5 or 7 years were classed as 'novice' or 'expert'. All dyads were mixed-ability; the age of the expert (same or older) varied. Novices who collaborated with same-age experts performed significantly better than novices who did not collaborate. However, this finding was not significant when a younger novice collaborated with an older expert. Involvement in the task was coded according to whether the novice or expert engaged in each task activity on their own or together. Increased active involvement in the collaborative task by

the novice was associated with more effective planning in the post-test: conversely, increased expert involvement was related to less effective post-test planning by the novice.

Feedback

Tudge and Winterhoff (1993) provided half of the same and mixed-ability dyads with feedback during the interaction session as to whether they had solved the task correctly. Those who received feedback improved significantly more than those who didn't, regardless of the type of partner and ability composition. These effects were evident immediately and maintained one month later, highlighting the importance of feedback in supporting cognitive development and suggests that feedback might mediate the advantage of ability asymmetry.

Friendship and sociability

Park and Lee (2015) reported an interesting finding in their study, in that being paired with a peer with high social skills led to a significantly greater improvement post-test than being paired with a high-ability peer with low social skills. Da Silva and Winnykamen (1998) have also considered the impact of sociability and ability on a problem-solving task and reported that high-sociable children, regardless of ability, demonstrated greater cooperation and improved significantly more post-test than low-sociable children on a problem-solving task. Children classed as low-ability and highly-sociable progressed significantly more when in mixed-ability dyads.

Fraysse (1994) also explored the role of friendship and ability through a test of conservation. All dyads were mixed-ability but varied on the basis of friendship: self-selecting '*mutual friends*'; '*unilateral associates*' where only one had chosen the other; and '*negative associates*' where neither had selected the other. Post-collaboration, mutual friends showed the greatest improvement, worked together for longer and had the highest number of positive exchanges. Unilateral peers where the low-ability student had selected a high-ability student had the next greatest amount of improvement.

A relatively small number of studies of varying quality have explored the impact of friendship and sociability on cognitive development. Therefore caution needs to be taken when drawing conclusions. It would be useful for the role of sociability to be further investigated within a stronger methodological framework.

Structure

Gillies and Ashman (1998) randomised small mixed-ability groups to a structured or unstructured condition. The structured condition received two training sessions, which explicitly taught small group procedures and interpersonal behaviours to promote group collaboration. Following this, both conditions participated in small group activities over a period of six weeks. Post-interaction analysis confirmed that the structured groups used more cognitive and higher level language strategies. However, there was no significant difference between the groups on a test of word-reading, a generalised measure of the cognitive skills directly involved in the group activities. Limited conclusions can be drawn as only one study measured the impact of structure; however, this study was rated as one of the highest quality, providing some legitimacy to the suggestion that structure encouraged cognitive development directly related to the group activities, but this benefit did not generalise to other components of cognitive development.

Discussion

This review aimed to explore which factors affect the relationship between collaboration and cognitive development in children aged 4 to 7 years. In all studies, participants engaged in collaborative tasks, which supports the ToM literature, as children become less egocentric at an earlier age than Piaget's (1952) stage theory predicts. Positive effects of collaborative-working, compared to individual-working, were reported on a range of cognitive measures, including visual discrimination, visual perception and problem-solving. Higher quality studies reported benefits of collaborative-working on

card-sorting, language ability and rule-based thinking tasks. However, several higher quality studies reported no significant differences between conditions on measures of word-reading and spatial perspective-taking. Therefore, collaboration does not appear to be beneficial across all components of cognitive functioning and could be a function of task difficulty; collaboration might be more beneficial on complex cognitive tasks (Gabbert et al., 1986). Based on the studies reviewed, ability and gender have the greatest impact on collaboration and cognitive development.

Consistent with Vygotsky's theory, collaboration led to short-term cognitive benefits for low-ability children who were paired with a high-ability peer. Several high-quality studies reported improvements on sorting ability, conservation and spatial perspective-taking. The socio-cognitive conflict and disequilibrium caused by being paired with someone with a different view on the task seems to have facilitated cognitive development. This process requires active participation through discussion and reasoning. Discussion seems to be most helpful for low-ability children, highlighting the importance of different opinions being verbalised, to allow socio-cognitive conflict to become apparent and resolved.

Several studies identified the factors that interact with ability: gender, age, discussion and feedback. These studies identified conditions that provide an advantage to low-ability participants. For low-ability males, the greatest amount of discussion and cognitive development was seen when they were paired with a high-ability female. However, for low-ability females, being paired with a high-ability male had no additional benefit to working independently. These findings can be understood in the context of power imbalances within the collaborative dyad. With regards to gender roles in society, it could be argued that as males hold more power, the pairing of high-ability females with low-ability males is more equal due to the female holding more power in terms of knowledge. When the female is classed as low-ability, the male has an advantage both in terms of power and ability, reducing the benefits of collaboration for the female (Psaltis & Duveen, 2006). This explanation is supported by the

findings regarding age; when there was too great a power imbalance (expert older child), the novice did not progress cognitively. Therefore, Vygotsky's assertion that ability asymmetry is important for cognitive development to occur is supported, as well as Piaget's assertion that it is unhelpful for there to be too great a power imbalance within the dyad. The majority of these studies were rated towards the lower end of the quality rating scale due to limitations in the reporting of the data (Psaltis & Duveen, 2006, 2007; Zapiti & Psaltis, 2012). Furthermore, all of these studies involved the same author and utilised Greek-Cypriot populations, so it is unclear whether this effect would be replicated in other countries and cultures.

There is a wealth of evidence that highlights the potential benefits of peer mentoring in terms of academic attainment and confidence building (Beasley, 1997; Bowman-Perrott et al., 2013). However, this review highlighted several studies which reported that high-ability participants did not benefit as much or at all from collaborating with a low-ability peer. One explanation is that low-ability children may require external input to provide the socio-cognitive conflict needed for cognitive re-structuring. For high-ability children, the process might be more internal (meta-cognition), reducing the need for collaboration (Pine & Messer, 1998). Furthermore, in a small number of studies, high-ability participants regressed on their post-test (Fawcett & Garton, 2005; Tudge, 1989). Tudge (1989) discusses the role of confidence in influencing others in a problem-solving exercise, when the correct answer isn't explicit. Therefore, it would be interesting to see whether this regression is maintained after a process of internal reflection on the problem.

Several methodological limitations were identified across the literature, with no study achieving higher than 'fair' quality. Although the checklist was designed for health interventions, the studies reviewed consistently failed to meet certain relevant methodological criteria; recruitment details were often omitted (e.g. recruitment method and rate), so selection bias may be a factor. Many of the studies used the same measure for the pre-test, interaction phase and post-test, which is useful for measuring

change over time on one area of cognitive functioning, but poses a potential issue around practice effects. Only a few studies investigated whether the benefits of collaboration generalised to other areas of cognitive development. Furthermore, no studies explored the impact on cognitive development of engaging in non-cognitive collaborative exercises in the interaction phase. In real-life classrooms, groups of 4-6 children predominate, yet most of the studies utilised dyads. Therefore, it is unclear whether the variables discussed here generalise to larger peer collaborations.

Only four of the reviewed studies included delayed post-tests, so firm conclusions about maintenance and incubation effects of collaboration cannot be drawn. As many of the studies used one-off interventions, it is unlikely that long-lasting effects would be seen. As no studies included a follow-up several months after the initial collaboration, we are unable to comment on whether there is a long-term legacy effect.

Limitations in the methodology of this review may affect the interpretation of the literature. This review focused on studies of children aged 4-7 years; therefore, effects for older children are not considered. An additional review of the literature on different age groups may be warranted. Only articles available in English language were included, which might have led to bias in study selection. Despite the shortcomings of the review, there are implications for future research in this area. The methods for testing cognitive functioning have developed since many of the reviewed studies were undertaken; it would be interesting to move away from Piagetian measures and explore the short and long-term impact of collaboration on measures of executive functioning, such as attention, inhibition and cognitive flexibility. The impact of having an ability differential within a collaborative interaction has been explored, but has largely neglected the potential benefits and drawbacks for high-ability students. Future research could investigate this further. The roles of gender, feedback, structure, discussion and age merit further research in this age group due to the limited number of studies investigating these variables.

The results from this review have implications for the fields of education, health and care. The role of language and discussion in facilitating helpful cooperative interactions seems key to cognitive, social and emotional development. The different language processes involved in collaborative exercises are explored in-depth in Gillies (2014), and this review has aimed to build on this understanding further, through discussion of which language processes facilitate cognitive development in young children.

This review highlights the role of friendships and sociability in collaboration and cognitive development. If both partners within a dyad are not very sociable, it is likely that the collaborative interaction will be unsuccessful, as each participant focuses on their individual needs rather than those of the dyad. In order to facilitate positive collaborative interactions for this sub-group, it is likely to be advantageous to pair them with someone that they identify as a friend. Thinking Actively in a Social Context (TASC; Wallace, Bernadelli, Molyneux, & Farrell, 2012) is an educational framework to stimulate thinking and problem-solving. Based on Vygotsky's principle of ZPD, small groups of mixed-ability children work creatively and collaboratively on a task. This review indicates aspects of group composition to consider when implementing the TASC approach.

Within any classroom there will be a range of additional needs, including developmental disorders, and learning disabilities. In particular, children with Autism Spectrum Disorder (ASD) or attachment difficulties are likely to find it more challenging to build peer relationships and might have ToM difficulties (Stokke, 2011). Therefore, it is likely that they will experience difficulties collaborating with peers. Children with social skills deficits are likely to find it much more challenging to understand subtle social cues, and to identify and work within their partner's ZPD.

It is not always going to be practical to group students based on all of the variables considered within this review at any one time. Nor is it going to be feasible to meet the individual needs of all of the children in the class in every collaborative interaction. Rather the provision of a range of

experiences is recommended, including opportunities for individual and collaborative working, with a variety of abilities, and opportunities for discussion and feedback. In this way, all children's needs and strengths can be considered within their learning environment.

Conclusions

“What the child can do in cooperation today, he can do alone tomorrow” (Vygotsky, 1962, p.104). Overall, the studies included within this review indicate that brief one-off interactions can have a significant, positive effect on short-term cognitive development in children of infant school age, particularly for low-ability children, above and beyond what would be expected from working on the same task independently.

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Table 1

Characteristics of studies included in review

Authors	n	Age (years)	Interactive session	Control group	Independent variable(s)	Dependent variable(s)	Main findings	Quality rating
Azmitia (1988)	132	5	Building task	No	Ability	Spatial perspective Visual perception	Mixed ability dyads performed better than same ability dyads or individuals.	15
Bearison, Magzamen, and Filardo (1986)	106	5-7	Model replication	Yes	Individual/ Collaborative Gender	Spatial perspective	No significant difference between individual and collaborative conditions. Gender differences in types of disagreements: females more likely to physically correct their partner, males more likely to verbally disagree. The latter within an optimal range was significantly associated with cognitive development.	17
Cannella (1992)	66	5-7	Spatial awareness task	No	Gender	Spatial perspective	Male same-gender pairings made significantly greater cognitive gains than female same-gender dyads.	16
Cannella (1993)	66	5-6	Spatial awareness task	No	Ability	Spatial perspective	No significant difference between same ability and different ability dyads. However, a higher proportion of different ability dyads improved.	16
Cannella, Viruru, and Amin (1995)	56	5-6	Spatial and literacy tasks	No	Ability	Spatial perspective Literacy	Gender of individual or partner did not affect extent of cognitive development.	14
Da Silva and Winnykamen (1998)	80	6-7	Spatial awareness task	No	Sociability Ability	Spatial perspective Cooperative behaviours	Sociable children improved significantly more on the cognitive task. Low ability sociable children progressed significantly more in mixed ability dyads. This was not significant for non-sociable children.	14
Duran and	70	5, 7	Sequencing	No	Ability	Sequencing	Novices paired with same-age experts improved	15

Authors	n	Age (years)	Interactive session	Control group	Independent variable(s)	Dependent variable(s)	Main findings	Quality rating
Gauvain (1993)			task		Age		significantly more than those who worked individually. This was not found when the expert was older. Increased novice involvement was significantly related to effective planning. Increased expert involvement was significantly related to less effective planning.	
Fawcett and Garton (2005)	100	6-7	Card sorting	Yes	Individual/ Collaborative Ability Discussion	Card sorting	Those who collaborated scored significantly higher than those who worked individually. Only low ability children working with a high ability peer improved significantly. There was a trend towards regression for higher ability participants. Discussion condition improved significantly compared to no discussion.	16
Fraysse (1994)	76	6-7	Conservation task	No	Friendship Ability	Conservation	Friendship peers progressed significantly more than non-friends and worked together for longer. On a generalisation task, the dyad where the low ability student had selected the high ability student scored the highest.	14
Gabbert, Johnson, and Johnson (1986)	52	6-7	Problem-solving	Yes	Individual/ Collaborative Ability	Problem-solving Visual discrimination Visual perception Memory Arithmetic	Those who collaborated scored significantly higher compared to those who worked individually on measures of problem-solving, visual discrimination/ perception and memory. There were no significant differences in arithmetic.	15
Garton and Pratt (2001)	222	4, 7	Card sorting	Yes	Individual/ Collaborative Ability	Card sorting	Lower ability children in mixed ability dyads improved significantly more than same ability dyads and those who worked individually.	15

Authors	n	Age (years)	Interactive session	Control group	Independent variable(s)	Dependent variable(s)	Main findings	Quality rating
Gillies and Ashman (1998)	152	6-7	Problem-solving	Yes	Individual/ Collaborative Structure	Cognitive language and reasoning Word reading	Those who collaborated scored significantly higher than to those who worked individually in their use of cognitive language and higher levels of cognitive reasoning. There were no differences on a word reading test.	17
Gómez <i>et al.</i> (2013)	232	5-6	Matching, sorting and role playing	Yes	Individual/ Collaborative	Oral language Social skills	The collaborative condition improved more than the control group in oral language skills. The collaborative condition demonstrated improved social skills, whereas the control group worsened.	15
Park and Lee (2015)	108	5	Sorting	Yes	Individual/ Collaborative Ability Social skills	Classification Perspective-taking	Those who collaborated improved significantly more than those who worked individually. Working with a more socially skilled peer had a greater impact on improving performance on the perspective-taking task than the cognitive ability of the partner.	17
Pine and Messer (1998)	103	5-7	Balance beam task	Yes	Ability Discussion	Rule-based thinking	The discussion condition improved significantly more than the no discussion condition. Discussion was of greatest benefit to low ability participants in mixed ability groups.	15
Psaltis and Duveen (2006)	226	6-7	Conservation task	Yes	Gender Ability	Conservation	Non-conservers who collaborated made significantly more progress than non-conservers who worked individually. Resistance and explicit recognition conversations were most important for cognitive development. It was advantageous for male novices to be paired with a female expert, but disadvantageous for female novices to be paired with a male expert.	14
Psaltis and Duveen (2007)	226	6-7	Conservation task	Yes	Gender Ability	Conservation	Female conservers were twice as likely to concede to non-conservers as male conservers. Female novices in mixed gender dyads were most likely to engage in resistance conversations.	15

Authors	n	Age (years)	Interactive session	Control group	Independent variable(s)	Dependent variable(s)	Main findings	Quality rating
Psaltis (2011)	264	6-7	Conservation task	Yes	Gender Ability	Conservation	Low ability participants in mixed ability dyads progressed significantly more compared to low ability participants working individually. Dyads where a male novice was paired with a female expert showed the most progress.	16
Tudge (1989)	84	5-7	Balance beam task	Yes	Individual/ Collaborative Ability	Rule-based thinking	Participants who worked collaboratively improved significantly compared to those working individually. High ability participants regressed after collaborating in mixed ability dyads.	15
Tudge and Winterhoff (1993)	81	5-6	Balance beam task	No	Individual/ Collaborative Ability Feedback	Rule-based thinking	Collaborating with a more advanced peer was more advantageous than working alone or working with an equally competent partner. When feedback was provided, this difference was no longer significant.	16
Zapiti and Psaltis (2012)	159	6-7	Spatial awareness task	No	Gender Ability	Spatial perspective	It was advantageous for a male novice to be paired with a female expert, but disadvantageous for female novices to be paired with a male expert.	15

Key messages:

- Immediate benefits of collaboration on cognitive development are highlighted for same-age peers. Collaborative interactions are beneficial for tasks measuring visual perception, problem-solving and rule-based thinking, but not for word-reading and spatial perspective-taking.
- Collaboration is particularly beneficial for low-ability children when there is an ability asymmetry. High-ability children either regressed or did not benefit.
- A range of collaborative experiences should be provided in education, including opportunities for individual and collaborative working, with a range of peers with mixed abilities, with opportunities for discussion and feedback.
- Future research should utilise modern measures of executive function, attention and memory.
- The potential benefits and drawbacks for high-ability students should be further explored.