Developing and Assessing Students' Collaboration in the IB Programme

December 2013

Education Research Center

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Credits

Education Research Center at Texas A&M University

The Education Research Center (ERC) at Texas A&M University (TAMU) studies major issues in education reform and school governance in order to improve policy and decision-making in P-16 education.

For additional information about ERC at TAMU research and evaluation, please contact:
Education Research Center
at Texas A&M University
112 Harrington Tower
4232 TAMU
College Station, Texas 77843-4232
erc.cehd.tamu.edu

Contributing Authors

Education Research Center
at Texas A&M University:

Kim B. Wright
Brooke Kandel-Cisco
Tracey S. Hodges
Sandra Metoyer
Anna Witt Boriack
Susana E. Franco-Fuenmayor
Jacqueline R. Stillisano
Hersh C. Waxman

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EXECUTIVE SUMMARY

The Education Research Center conducted a best evidence synthesis of literature on student collaboration in K-12 settings. The purpose of the synthesis was twofold: (a) to identify research-based practices of teaching with, learning through, and assessing student collaboration, and (b) to use research-based themes in an analysis of IB curriculum documents in order to assess the extent to which IB's collaborative teaching and learning practices align with research.

The study included both a meta-analysis and research synthesis of 153 studies addressing various aspects of student collaboration across K-12 educational settings in reading/writing, humanities, mathematics, and sciences. Additional study foci included culturally and linguistically diverse settings and the use of technology for collaboration. The content analysis examined 47 IB curriculum documents from general IB curriculum documents, as well as the PYP, MYP, DP, and IBCC programmes.

The best evidence research synthesis revealed the following components of successful collaborative practices in K-12 settings:

- Specific and focused teacher role in collaborative process
- Purposeful means of grouping students based on student, task, and culturally-related factors
- Targeted incorporation of technology
- Roles for individual students
- Tasks that are open-ended and/or multi-faceted
- Specific structuring of the collaborative process
- Consideration of the social complexities of the collaborative process
- Sufficient time for cognitive processes involved in collaboration

The primary recommendations include the following:

- Adopt a clear definition of collaboration for IB stakeholders, especially curriculum writers and practitioners
- Revise IB curriculum documents; where necessary, to include research-based aspects of successful collaboration most salient to particular student levels and subjects
- Provide professional development and teacher follow-up within each programme area on the definition and practices of successful collaboration
- Conduct further research on whether higher education collaboration assessment practices could be successfully utilized with K-12 students

In conclusion, the best evidence of research on student collaboration identified collaboration as a social process of knowledge building that requires students to work as an interdependent team towards a clear objective resulting in a well-defined final product, consensus, or decision. Collaborative tasks and groups are structured so that teams of students must rely on one another to share resources (e.g., materials, knowledge, experience, insight, and skills), utilize meta-cognitive processes, and communicate with each other in order to complete a task and/or arrive at a consensus best achieved with equitable participation of all members.

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CHAPTER 1: Introduction

Background

The International Baccalaureate Organization (IBO), founded in 1968 in Geneva, Switzerland, was created with three main goals: (a) to deliver an education that promoted critical thinking skills, (b) to foster international and intercultural understanding among its students, and (c) to offer a diploma providing academic credentials for entrance to post-secondary education anywhere in the world (Hill, 2012). The mission of the four IBO programmes, Primary Years Programme (PYP), Middle Years Programme (MYP), Diploma Programme, and IB Career-related Certificate Programme (IBCC), is to "encourage students across the world to become active, compassionate and lifelong learners who understand that other people, with their differences, can also be right" (IBO, 2013).

Woven throughout the framework of the IBO programmes is an emphasis on developing learners who exhibit intercultural understanding and are able to collaborate with others in a world with an ever-expanding focus on global exchange (IBO, 2013e). For the past several decades, numerous federal reports and commissions have called for schools to more fully develop the collaborative skills of K-12 students. The report by the U.S. Department of Labor Secretary's Commission on Achieving Necessary Skills (SCANS), for example, suggested that interpersonal skills and the ability to work and negotiate with others from diverse backgrounds are two of the six interpersonal competencies considered critical to success for 21st century students entering the work force (SCANS, 1991).

Defining Collaboration in K-12 Education

Instruction that develops the ability to work and negotiate with others mentioned in the SCANS Report (1991) is most frequently termed "collaborative learning" in K-12 educational contexts. In our preliminary search of the literature, however, we noted that both practitioners and researchers refer to collaborative learning, as well as associated methods of instruction, such as grouping, task design, and assessment using a broad set of frequently interchangeable terms. These terms include, but are not limited to, collaborative learning, cooperative learning, peer learning, peer tutoring, group work, and team learning. Collaborative learning and cooperative learning, the main terms under which most other group instructional formats are subsumed, are the most frequently interchanged. Table 1.1 provides an overview of the major features of each method.

Table 1.1 Key Features of Collaborative and Cooperative Learning

Key Feature	Collaborative Learning	Cooperative Learning
Definition	An active, constructive process where students work in groups on authentic tasks that require high-order thinking and problem-solving skills (Smith & McGregor, 1992)	"…the instructional use of small groups through which students work together to maximize their own and other's learning" (Johnson, Johnson, & Holubec, 1994, p. 4)
Role of Knowledge (Construction vs. Transmission)	Knowledge is jointly constructed by students in collaborative groups.	Knowledge is transmitted from students to other students and all learn from each other.
Group work and structure	Students work jointly for the entire duration of a collaborative task with or without specific group roles, such as recorder and materials manager	Students may work together and independently for different aspects of a task in specific formats, such as jigsaw or numbered heads together
Role of teacher	Help students develop motivation towards interaction in collaborative process	Help students develop cooperative behaviors to build positive interdependence
Task structure	Open-ended and challenging tasks that require decisions and consensus; one students could not complete independently	Any task can be structured to be completed cooperatively (Johnson, Johnson, & Holubec, 1994)
Role of student	Used to assign specific over-arching responsibility to the group, such as record keeper or materials manager	Individual student roles not dictated

The two methodologies have some theoretical differences, most notably in how each views the role of knowledge. Collaborative learning, with its roots in Paigetian social constructivism, is based largely on the idea that knowledge is a joint construction of individuals working together (Smith & MacGregor, 1992). Cooperative learning, on the other hand, focuses more on the knowledge individual students bring to, and take from, tasks that require them to work together. In spite of this major difference and a few minor differences with regard to group work and task structure, the terms are often used interchangeably, sometimes within the same source. For example, while defining cooperation in a 2011 study on cooperative approaches in science, Zacharia, Xenofontos, and Manoli (2011) cited five prior studies in their definition (Brown & Cole, 2000; Erlandson, Nelson, & Savenaye, 2010; Kapur & Kinzer, 2007; Moreno, 2009; Nelson-LeGall, 1992), two of which focused on cooperation and three of which focused on collaboration. The Zacharia et al. study did not make a distinction between the two methods as is the case in several other research studies focusing on collaborative or cooperative learning. In a 2009 meta-analysis of the impact of collaborative learning in K-12 schools, Williams & Stanne cited Johnson and Johnson's (1991) seminal work on cooperative learning to elucidate the large number of studies conducted on group learning formats in the last 90 years.

The lack of distinction between collaborative and cooperative learning in research perhaps stems from the fact that, aside from a more philosophical question of whether knowledge is constructed or transmitted when students work together, both collaborative and cooperative learning have similar strengths, features, and applications in K-12 classrooms. In advising on how to develop group approaches in the classroom, it would be both tedious and impractical to tease the approaches apart. Therefore, in order to capture the most inclusive picture of successful student collaboration in K-12 instructional settings, we chose to include research focusing on both collaborative and cooperative learning. Though collaborative learning and cooperative learning differ in their conception of elements of instructional methods, such as task structure, both have been shown to improve student achievement and motivation to learn (Johnson, Johnson, & Stanne, 2000; Williams, 2009). Therefore, in the search of literature, we looked at any instructional method that requires students to work together for all or part of an instructional activity or period, as well as associated teacher and student behaviors.

Through analyses of 153 studies and 47 curriculum documents throughout K-12 learning environments in both IB and non-IB contexts, we developed the following definition of collaborative learning, which we believe includes the most salient aspects of all group instructional methods studied: Collaboration is a social process of knowledge building that requires students to work as an interdependent team towards a clear objective resulting in a well-defined final product, consensus, or decision. Collaborative tasks and groups are structured so that teams of students must rely on one another to share resources (e.g., materials, knowledge, experience, insight, and skills), utilize meta-cognitive processes, and communicate with each other in order to complete a task and/or arrive at a consensus best achieved with equitable participation of all members.

Purpose of Study

In order to identify theoretical approaches and practical aspects of student collaboration, researchers conducted a best-evidence synthesis (Slavin, 1986) of research literature on student collaboration in K-12 settings across core content areas, including reading/writing, humanities, mathematics, and sciences. Additional searches were conducted for technology and cultural and linguistic diversity. The best evidence synthesis approach was chosen for the present study because it allows for the inclusion, analysis, and discussion of a wide array of research approaches, including quantitative, qualitative, and mixed methods studies.

Rather than just a broad overview of the literature, such as in traditional literature reviews or effect size reporting in a meta-analysis, the best-evidence approach allows for both effect size reporting and inclusion of qualitative, quantitative, and mixed methods studies that show promising practices in collaboration. The best-evidence synthesis approach employs systematic inclusion criteria using terms most relevant to the topic, calculates effect size measures as in a meta-analysis to determine the effect of interventions, and explains studies in detail so that readers can make decisions about which treatments, ideas, and/or interventions are best for a particular situation.

The present study seeks to describe interactions between teaching, learning, and assessment practices involved with the collaborative process across K-12 settings, with additional attention given to practices involving technology and various cultural or linguistic contexts, including international studies and those involving students learning in a non-native language. The purpose of the synthesis is twofold: (a) to provide a best-evidence synthesis of research on student collaboration through the lens of teaching, learning, and assessment across K-12 in the subjects of reading/writing, humanities/social sciences, mathematics, and sciences; and (b) use findings from research to conduct an analysis of IB curriculum documents in order to determine to what extent IB's current collaborative practices align with research. Additionally, the study provides recommendations to IB curriculum developers and practitioners on collaborative practices that might enhance the teaching, learning, and assessment of student collaboration across all IB programmes.

The following research questions guided the study:

1. How is collaboration defined and described within the K-12 educational contexts?
2. How is collaboration defined and described in IB programmes?
3. What examples of promising practice exist that accommodate different strategies of integration of curriculum components for collaboration as school-based initiatives and classroom practices in IB and non-IB contexts?
4. What are developmentally appropriate methodologies, models, and tools used for assessing

the quality of collaboration and different types of collaboration skills and dispositions?

5. What examples of promising practice exist that accommodate different methods of assessment of integration and delivery for collaboration as school-based initiatives and classroom practice?
6. What is the impact of promising initiatives and practice on the development of collaborative skills and dispositions at different stages of education?

Summary

Several research reviews and meta-analyses have shown that there are positive medium-to-high effects of group collaboration on several important student outcomes, such as academic achievement, motivation and effort, and engagement in learning (Hattie, 2009; Johnson et al., 2000; Webel, 2013; Williams, 2009). These positive effects also appear to be robust across most subject areas, student age groups, and types of outcomes (Hattie, 2009). Of the eight categories revealed in a meta analysis of teaching practices promoting achievement in science, Schroeder, Scott, Tolson, Huang, and Lee (2007) found student collaboration to have the second strongest effect (ES=0.95) of all of the teaching practices studied. The present study expands upon the prior research by including effect size information for specific collaborative practices across K-12 settings, across content areas, and across outcomes. We also build on the prior research by looking at not only achievement outcomes, but also at affective and behavioral outcomes. Missing from the current research literature are studies with depth and breadth in both content and coverage.

CHAPTER 2: Methodology

Literature Searches

Search Strategy and Criteria for Inclusion

Our researchers examined collaboration from multiple lenses, including pedagogical strategies, student learning approaches, and assessment. The initial list of essential search terms was generated from both the research questions and a broad preliminary literature search (Slavin, 1987, 2009). The final list of search terms, (see Appendix A) agreed upon by the ERC and the IB Organization, were utilized in a key word search of several journal databases, which included Academic Search Complete, Education Full Text, ERIC, Social Sciences Full Text, Psychlit, JSTOR, and Google Scholar. In addition, the Tables of Contents of peer-reviewed journals relevant to topics of K-12 education (e.g., *American Education Research Journal*, *Journal of Research on Technology in Education*, *Journal of Research in Mathematics Education*, *Research in Middle Level Education Quarterly*, *Reading Research Quarterly*) were reviewed. A search of relevant citations in the reference lists of retained articles was also conducted.

The initial literature search located 27,252 articles, 387 of which were retained for coding. The following are general reasons why articles were excluded in the initial database searches:

- Duplicated previously retained articles
- Focused on topics unrelated to K-12 students (i.e., higher education or university students)
- Focused on collaboration in fields unrelated to education
- Focused on collaboration among teachers rather than students
- Focused on teacher-student collaboration rather than student-student collaboration

- Were not related to focus subject areas (sciences, humanities, mathematics, reading/writing, cultural diversity, linguistic diversity, and technology)
- Used collaboration as an aspect of study, but not a measured variable

Coding Studies

The studies identified in the initial search were carefully scrutinized by four coders using the following criteria for inclusion in coding: (a) published in the last 5–10 years (2003-2013), (b) focused on K-12 students, (c) included findings relevant to increasing the quality of student collaboration, (d) reported empirical data, (e) related to a core subject area (reading/writing, humanities, mathematics, and sciences), or related to technology or cultural and linguistic diversity. Studies that did not meet initial coding criteria were excluded from the study. Due to the low number of studies retained regarding assessing collaboration under the initial coding criteria (8 studies located in the search and 4 retained based on coding criteria), we relaxed original criteria related to K-12 students, a core subject area, and articles published in the last 5-10 years in order to obtain and synthesize a sufficient number of studies for a meaningful discussion of assessing collaboration.

In total, we coded 195 articles, using standardized forms for later discussion in the literature synthesis. (See Appendix B for the initial coding scheme.) Table 2.1 provides an overview of content areas addressed by studies retained after the first round of coding. To determine inter-rater reliability, a 10% random sample of articles was recoded by a second coder, yielding an inter-rater reliability of 79%. After coders discussed differences in coding, 100% inter-rater reliability was reached.

Table 2.1 Articles Retained from Initial Coding

Content Focus	Number of Retained Studies Addressing Content Focus
Reading/writing	36
Humanities	12
Mathematics	53
Sciences	44
Technology	46
Cultural/linguistic diversity	26
Multiple subjects	18
Non-content specific	7
Assessment	11

Note: Several studies investigated more than one content area; therefore, the number of studies reported in the table does not reflect the total number of studies coded.

Synthesizing Study Findings

For the best evidence synthesis, the 195 coded studies were further subdivided into two groups for a second round of more in-depth coding. Sixty-six studies for which effect sizes could be calculated were included in the meta-analysis in order to identify promising practices in collaboration. The remaining 129 studies were included in a research synthesis to capture the most complete picture of student collaboration and implications for practices within each subject area. The research team divided the studies into two syntheses in order to achieve the recommendation by Slavin (1986) that, "studies that meet standards of germaneness and methodological adequacy but do not yield effect size data should be discussed on the same basis as those that do yield effect size data" (p. 10).

Meta-Analysis

Inclusion Criteria. A total of 66 articles were included in the secondary coding scheme for the meta-analysis. To be included in the final meta-analytic synthesis, articles needed to include a (1) intervention, (2) clear control group, (3a) means and standard deviations for the control and treatment groups, or (3b) a calculated effect size with treatment group and control group sample sizes. Of the 66 articles included in the secondary coding, 42 included the necessary statistical information to calculate and interpret effect sizes. Articles excluded from secondary meta-analysis coding were included in the research synthesis. A detailed coding sheet is included in Appendix C.

Effect Size Calculations. For each identified theme, an effect size was computed (Cohen's *d*, 1988), and then weighted by the reciprocal in the sampling variance (Hedges & Olkin, 1985). For every study and every category, weighted *g* effect sizes and sampling error variances were calculated. In articles that did not provide means or standard deviations, *F* ratios and *t* ratios were converted to effect sizes. Effect sizes were computed with each one weighted by the reciprocal of its variance, which gives more weight to effect sizes that are more reliability estimated. This allows for more reliability and consistency across the final calculations and interpretations.

Every theme also included the calculation of a homogeneity statistic *Q,* which determines whether separate effect sizes within each category shared a common effect size (Hedges & Olkin, 1985). The statistic *Q* has a distribution similar to the distribution of chi-square, with *k* -1 degrees of freedom in which *k* equals the number of effect sizes. With homogeneity statistic, we were able to determine if outliers in specific data sets were affecting the effect sizes. If so, outliers could be removed to standardize the results and make them more applicable to the final outcomes.

An additional category of "no intervention" was included in the final analysis as three studies included effect sizes for collaboration, but did not conduct an experiment with an intervention. Instead, each of these quasi-experimental studies focused on using the pre-test measures as a baseline for future success of students. The effects were seen as promising and, therefore, included in the final analysis.

Interrater Agreement. Four trained researchers coded the studies independently with a 10% sample selected for reliability. Researchers reached 100% agreement for inclusion of articles in the final meta-analytic analysis. During the coding process, agreement greater than 90% was maintained between the four researchers. Any discrepancies were discussed until 100% agreement was reached.

Research Synthesis of Remaining Articles

Inclusion Criteria. Based on the initial search parameters and a research approach (quantitative, qualitative, mixed methods, etc.), 129 studies from the initial round of searching were included in the research synthesis. The research team evaluated those 129 studies for quality of research methods. The evaluation of study quality was an essential step, because in a research synthesis, the investigator does not have access to the original data and therefore has to rely on the results presented by study investigators. The criteria for study quality were based on the guiding principles for scientific research in education set forth by the National Research Council's Scientific Research in Education (Shavelson & Towne, 2001). Specifically, studies were included in the final synthesis if the research was empirical and was connected to a relevant theoretical framework or conceptual model, used an appropriate research design to investigate the study's research questions, included clear and detailed descriptions of the research, and presented logical conclusions based on the data found. The studies did not necessarily have to include an experimental design, and studies conducted in naturalistic settings that could be replicated through similar qualitative methods were also included. After evaluating each study for quality, 122 of the 129 original research studies remained in the synthesis.

To become intimately familiar with the remaining studies, the research team began by reading and reviewing each study multiple times. Salient information was coded for each study, such as participants, research questions, study design, and key words related to the findings. During this phase researchers eliminated studies that appeared to be relevant to student collaboration during the initial search phase, but upon further reading, included findings not relevant to the research questions. After coding each study and evaluating for relevance to the research questions, 107 of the original 122 studies remained in the pool of synthesis studies.

In order to contribute subject-area detail to meta-analysis findings, the remaining 107 studies were organized by discipline, with the exception of studies focusing on classroom environment, social context, cultural and linguistic diversity, and assessment. A total of 27 articles were included for reading/writing, 12 articles for Humanities and Social Studies, 25 articles for Mathematics, 23 articles for Science, 4 studies for classroom environment, 5 articles for social context, 10 articles for cultural and linguistic diversity, and 11 articles for assessment. Findings for studies that addressed a specific discipline and cultural/linguistic diversity or a specific discipline and technology were included within the findings for the discipline. Findings for the ten studies that focused on collaboration and cultural/linguistic diversity and the three studies that focused on collaboration and technology with no discipline-specific findings were listed in a separate section. Within each section, studies were placed into one of three categories: a) studies focused on the student, b) studies focused on the teacher, approaches, and activities, and c) studies focused on technology and teachers, approach, and activities.

These categories reflect the themes that emerged across study findings and represent the trend in which the research literature addresses student collaboration. The factors that are needed for student collaboration, such as the student, teacher, technology skills, and social environment, are addressed within and across each of the four categories. Because the majority of the studies specifically related to assessing collaboration were non-content specific, we summarized those findings in a separate section. In addition, due to the small number of articles addressing classroom environment and social context, the research team listed them independently of content area.

IB Curriculum Document Content Analysis

Identifying IB Curriculum Documents for Content Analysis

The extent to which the International Baccalaureate's current approaches to teaching and learning intersect with the aspects, skills, and dispositions of collaboration identified in the research literature were analyzed through a content analysis of IB curriculum frameworks, subject guides, and other documents deemed relevant by either the research team or IB. Researchers were given access to the Online Curriculum Centre to download relevant curriculum documents from the Primary Years Programme (PYP), Middle Years Programme (MYP), Diploma Programme (DP), and International Baccalaureate Career-related Certification Programme (IBCC). The content analysis was conducted utilizing *a priori* themes extracted from findings of the best-evidence synthesis of research. The research team and IB stakeholders agreed upon both the *a priori* themes and list of documents for analysis. A complete list of documents of can be found in Appendix F.

Establishment of *A Priori* Themes

Findings of the best evidence synthesis were reviewed in order to determine *a priori* themes for the curriculum content analysis. *A priori* themes are categories established prior to analysis based on theory (Weber, 1990). Prior to analysis, operational definitions of each theme and examples of evidence were documented to ensure that, "they can be applied by a single researcher over time and multiple researchers will be thinking about the same phenomena as they code (Miles & Huberman, 1994, p. 63)." The themes cover three main categories: (a) overall aspects of collaboration, which includes considerations such as theoretical models and definitions; (b) teacher factors related to collaboration, including things such as teacher roles in classroom activities and scaffolding of student work; and (c) student factors related to collaboration, such as roles and expectations for students. (See Appendix D for a complete list of content analysis themes and operational definitions.)

Coding Documents

In order to determine the extent to which IB's curriculum documents align with the *a priori* themes, a coding instrument was adapted from a previous document analysis (Stillisano et al, 2013) to record whether documents contained descriptive (i.e., direct); or inferential, i.e., indirect; evidence of collaboration (See Appendix F for instrument). IB curriculum frameworks, subject guides, and other relevant documents were unitized for coding syntactically at the sentence level. Researchers initially scanned documents for coding of an *a priori* theme, i.e., direct evidence in words or phrases of the IB curriculum documents related to themes from research. As patterns in the documents became more clear, additional coding of curriculum documents was used to focus on inferential coding (i.e., coding larger segments of data or themes in data that exhibit *a priori* themes not directly stated in the text segments) (Miles et al, 1994).

To establish inter-coder reliability and determine agreement on interpretation of codes, a team of three researchers check-coded a random sample of documents. Inter-rater reliability ranged from 84.4% to 85.4%. After the research team revised examples and definitions of the *a priori* codes to clarify meaning, the sample of documents was recoded with 100% inter-rater agreement.

CHAPTER 3: Best Evidence Synthesis of Research

Meta-Analysis Findings

A meta-analysis was conducted on all of the studies that measured the effect of an intervention on student collaboration using numbers. Meta-analysis techniques include exhaustively reviewing literature to determine studies that analyze student collaboration. These articles were then coded for information about theory, type of intervention, and impact. All of the numbers measuring the effect were then consolidated into averages from studies that focused on the same type of intervention. The goal of a meta-analysis is to quantify how much of an effect an intervention has on multiple samples over time.

Much of the data from each of the studies included in this analysis was measured both qualitatively and quantitatively, but for the purpose of the meta-analysis, only quantitative data were examined. Meta-analytic techniques seek to quantify the effect of an intervention or method across samples, so the qualitative data in the studies were not applicable to this methodology. The purpose of this study is to provide a quantitative synthesis of published literature examining collaboration in content area classrooms.

The meta-analysis revealed six general categories related to promising practices in student collaboration: role of the student, computer assistance, task type, role of the teacher, collaboration process, and grouping method. Each of these categories represents the type of intervention aimed at improving the quality and quantity of student collaborations for maximizing student success. Each of the 42 included studies focused on a different component of collaboration and used an intervention (or no intervention for 3 studies) that looked specifically at one of the 6 themes identified in the meta-analytic procedure. Tables showing overall effect sizes for each theme are presented in Appendix A. Effect sizes for the major themes ranged from .3706 for the Role of Students to .9353 for Grouping Method. These effect sizes indicate how relevant each of the six themes is to understanding student collaboration. In general, teachers who want to improve the student collaborations in their classrooms should focus more on the themes that showed high effect sizes.

Role of the Student

Studies involving student roles are largely based on social network theory and social learning theories (Bandura, 1997). These interventions and corresponding theories rely on the fact that students are social beings and learn in environments that allow them to engage with each other. Examples of these interventions include structuring the collaboration by assigning students specific roles, which help them determine their unique part in the group. For example, the teacher might give each student a specific role, such as the time keeper or manager, to ensure that the student learns how to work with a group while completing a specific set of tasks toward the larger goal.

The role of students within a collaborative group is essential to the functionality of the group. Students sometimes need guidance in how to be a productive member of the group and how to contribute equally to the group's intended outcomes. Results from the four studies that focused specifically on the roles of students within groups were summarized; and comparisons were made in how groups function without specific assignment of roles. From the positive effect sizes of all four studies, we can infer that assigning roles improves the quality of group interactions and the achievement of students working in those groups. The overall effect size (.371), however, is the lowest of all the analyzed effect sizes by theme. This indicates that of the six themes of this meta-analysis, role of the student is the least influential factor.

Computer Assistance

As student collaborations grow in popularity in classrooms, so do the uses for technology. Although the present study limits discussion to studies involving use of computers, any type of technology can be implemented into student collaborations. During the literature search for this analysis, very few studies that focused on technology were retrieved. Of the studies retrieved, computers were the only technology focused on. Computer assistance refers to students working collaboratively with other students via a computer or to a student working collaboratively, with the computer acting in place of another student. For example, students might work in collaborative pairs with other students from different classrooms or even schools. The computer becomes a vehicle for the collaboration. Further research is needed to better understand how different technologies can be used in student collaborations.

Unfortunately, only one study in this analysis directly analyzed computer assistance and its use in developing student collaboration. The study not only focused on how dyads of students worked with the computer to collaborate but also analyzed behaviors contributing to student success. Further analysis revealed the differences among high and low groups. Overall, all groups showed growth in using computers for collaboration purposes, with the average of all groups resulting in a positive, high effect size of .71. This effect size indicates that using computers can help facilitate collaboration among students. This could be the result of students being very comfortable using computers and technology as well as presenting more opportunities for students to engage with other students.

Task Type

A third important aspect in student collaboration is task type. Task type includes the way the teacher structures the task for students. Studies related to task type examined structured tasks in which students had scripts and/or scaffolding of processes to work through. Unstructured tasks involved students working through the collaboration process on their own, with minimal input from the teacher. This type of intervention also focused on the activity students were asked to do, such as a project-based learning, discovery-based activity or a worksheet-based activity. The goal of task-based intervention studies is to determine the types of tasks that are best for enhancing student collaboration and the type of structure that those tasks should include. For example, several studies compared how collaboration differs when students work with detailed guidelines for the task versus when students are given a broad task and asked to construct the goals. Tasks that had preset goals generally worked better for group collaboration, so that students could focus on working together rather than trying to manage a large problem.

Task structures were either unstructured/structured or systematic with set goals explained/left-goal-setting up to the students. According to the results of the five studies included in this analysis, the overall effect size for this theme was .6129, which shows a moderate, positive effect for task type. Overall, studies in which students had to complete set goals and structured tasks were more successful in achieving the desired outcomes. They also showed greater growth on individual cognitive assessments. All average effect sizes for the individual studies were positive and ranged from low (.22) to high (.91). When students did not have specific goals to accomplish, they often became more concerned with defining the problem than with working as a group. Unless students were already familiar with collaborative assignments, they were often unsuccessful in working together and accomplishing the task.

Role of the Teacher

Studies focused on the role of the teacher emphasized what the teachers do in relation to student collaboration. This can include the degree of scaffolding, support, or structure the teacher provides. The role of the teacher as a mentor, facilitator, or complete bystander to the student collaboration group is also examined. For example, most of the studies looked at how students collaborated with each other when the teacher was an active participant in the group discussions: asked questions, redirected behaviors, or provided solutions to minor disputes. When teachers played an active role as a facilitator who gave much of the decision-making power to the group, students collaborated more efficiently. If the teacher was more strict or completely inattentive, the students were not as successful at collaboration.

Just as the role of students can be influential in group collaborations, so is the role of the teacher. Only one of the four studies showed a small negative effect, while the other three showed positive effects. The studies focused on the extent to which teacher was involved in the collaboration process (i.e., teacher serving as a facilitator, group mentor, or have a more active role in the group). This also included whether or not the teacher helped with the process or the product the students were asked to complete. For each of the studies that showed a positive effect, the teacher actively engaged with students about the process of working collaboratively.

The overall average effect size for role of the teacher was .6127, indicating a moderate, positive effect when teachers focused on the process of collaboration. These outcomes are consistent with the previous results demonstrating that the teacher has an active role in how worthwhile and effective the collaboration process might be for the students.

Collaboration Process

A fifth intervention type that emerged from the meta-analysis focuses on the collaboration process. Studies include examinations of the structure and the purpose of the collaboration process. Different types of collaborations, structures of groups, and activity types are holistically measured for their influence on student motivation and achievement. Additionally, different types of collaboration such as collaborative learning, individual learning, and cooperative learning are examined. For example, many of these studies sought to better define “collaboration” and compared collaborative learning and cooperative learning. The main difference in these studies was the focus on goal-setting. If students had the freedom to set small goals to get to a larger goal, they had more efficient collaborations. If all the goals were set for the students or the task did not require setting the goals, the students then worked independently, in close proximity to each other, which defines the term ‘cooperative learning.’

Each of these studies examined the effects of the learning process of collaboration and was heavily influenced by cooperative learning theory (Johnson and Johnson 1981, 1989). From Table 3.2, one can see that the average effect size for the 16 studies was .6405, which indicates a moderate effect. The collaboration process theme included the highest number of individual studies, and the moderate effect shows that this is a relatively positive influence on student collaboration. The structure of the collaboration process itself, compared to other processes, such as individual learning, induces a more favorable impact on interaction among students.

Moreover, only three studies included in the collaboration process theme demonstrated negative effects, indicating that the collaboration intervention did not result in gains in student achievement. Overall, these results were atypical and deviated from the majority of studies. Special populations, confounding variables, or threats to validity could be contributing to these conclusions. In other words, the particular students in the sample could have unique characteristics that could have an effect on the results or there could be an error in how the intervention was presented.

Grouping Method

The final category of collaboration identified by the meta-analysis is the grouping method. This intervention explores how students are grouped (i.e., ability, achievement level, gender). The goal is to analyze whether different ways of grouping students might have an effect on their achievement, motivation, or cooperativeness in working within a group. For example, many studies employed the use of jigsaw method, which had students randomly placed in groups. Several other teachers grouped students based on their abilities and a few others allowed students to choose their own groups. Each grouping strategy showed promise, but in different settings. The purpose of the collaboration was found to drive how the students should be grouped.

The student collaboration theme resulting in the highest effect size, .8935, was that of grouping method. The ten studies included in this analysis related to grouping methods looked at differences in grouping students based on choice, gender, and their abilities. According to the studies, grouping plays a role in student collaboration. No studies from this group resulted in a negative effect size, indicating that all differences in grouping methods showed gains in effectiveness of student collaborations. Studies with the largest effect sizes used random grouping methods with structured tasks and instructional teaching techniques (such as the jigsaw method) to enhance student learning. The combination of these factors showed a marked growth in students' abilities to work collaboratively and improved individual student achievement.

No Intervention

For the no intervention group, researchers analyzed three studies that did not include an intervention but instead compared post-test measures to pre-test measures. These studies looked holistically at the degree to which collaborative learning influenced students' achievement. Students were tested individually on a pre-test measure using a task that they did independently. Next, students were placed in cooperative learning groups to complete further assignments. They were tested afterwards. The results summarized the differences in students' performance when working independently or in collaborative groups.

Students performed significantly better when working in collaborative groups compared to working independently. Although these results are limited in that the researchers did not use a specific control group but instead used baseline procedures with individual students, results still demonstrate a comparison among the other 39 controlled studies. The no intervention theme had the second highest effect size, .816, indicating that collaboration positively improves students' achievement. This category of studies can be compared to the studies that utilized a control group design and built a strong case for the reasons of why student collaboration works and is successful in student achievement.

Conclusions

In total, six themes were identified as demonstrating effects on student collaboration: collaboration process, computer assistance, grouping method, role of students, role of teacher, and task type. Studies that included no intervention, but used pre- and post-measures were analyzed as a control factor against the studies that included interventions. Results showed positive effects for each theme.

From these results we can conclude that the greatest predictor of cognitive student success in student collaboration is the grouping method that teachers utilize. The least influential predictor of student success is the role of individual students in the collaboration process. With the exception of the low effect size from the Role of Students theme, all themes displayed moderate to high effect sizes, indicating that these are reliable factors that might have an influence on student achievement in collaboration. Overall, since many of the themes showed statistically significant, or relevant, effect sizes, it can be concluded that a combination of the themes would result in the most successful approach to building student collaboration. For example, if a teacher structures the task, acts as a facilitator, uses an appropriate grouping method, and helps the students set their goals, the students will be more successful in working collaboratively.

Research Synthesis Findings

Research synthesis findings are organized by content area and further subdivided within each section into one of three categories based on the study's main independent variable. The three categories are (a) studies focused on the student; (b) studies focused on the teacher, approaches, and activities; and (c) studies focused on technology and teachers, approach, and activities.

The categories are reflective of the themes that emerged across content area study findings and represent the ways in which the research literature addresses student collaboration. The student skills, teacher skills, and technology skills needed for student collaboration in each content area are addressed within and across each of the three categories. Where possible, the non-content specific focus areas of classroom environment, social context, technology, cultural and linguistic diversity, and assessment are sub-divided into student, teacher, and technology categories for analysis. However, due to the small numbers of studies in each of these categories, study findings were summarized holistically within the category rather than by themes of student, teacher, and technology factors.

Reading/Writing

The studies that focused on student collaboration and reading or writing utilized a variety of research methods: three studies used mixed methods, nine studies applied quantitative methods, and 19 studies incorporated qualitative methods. The studies examined many areas within the construct of collaboration including the use of collaboration in classrooms by teachers; collaboration and literacy skills and achievement; combination of group work and individual writing; mixed-age collaboration groups for writing; specific methods and techniques for collaborative reading and writing, including online contexts; collaborative strategic reading; learning platform technologies' influence of collaboration; and online learning communities.

Reading/Writing Student-focused Studies. Some studies examined how collaboration is practiced in a general sense in the reading/writing classroom. MacQuarrie, Howe, and Boyle (2012) conducted a naturalistic study to determine characteristics of a group work at the secondary level, and the teachers' and students' behavior towards this type of collaboration. Systematic observations were analyzed, and it was found that group work was an integral part of the classroom for both teachers and students. Furthermore, students used more productive dialogue when they were in small groups than when they were in a bigger group or individual settings. This finding was recorded in spite of the fact that the small groups received little direct support from the teachers who approached the small groups as an equivalent of the whole-class set up, just on a smaller scale (Macquarrie, Howe, & Boyle, 2012). These results imply that secondary students can be successful in small groups, even without direct teacher support.

Other studies have specifically focused on collaboration and reading. Davis and Neitzel (2012) examined the sense-making behaviors of middle school dyads when reading print and digital texts. Students took a prior knowledge test, were randomly placed in dyads, and asked to read two articles (one in print and one on the computer). Afterwards, the students were requested to take a comprehension test on each article. Analysis of video and screen recording data indicated that students used many of the same sense-making strategies when reading both texts. For the digital text, students spent more time using strategies to make sense of text and planning how to read the text. No differences in comprehension or collaboration were found between the text types. These findings suggest that text type and collaboration play a small role in student comprehension and there might be other factors to consider.

Finkbeiner, Knierim, Smasal and Ludwig (2012) used a sample of ninth-grade English as a foreign language students' to explore which cooperative learning strategies students used when working on a reading task, and to examine to what degree these strategies were adequate and successful. The students were then put into two types of dyad: those completing tasks without teacher support and those completing tasks with the availability of the teacher. Analysis of video interactions revealed that, despite the level of teacher support, students dyads frequently used cognitive and socio-affective strategies, but not metacognitive strategies. Teachers' actions were teacher-centered and instruction-based instead of scaffolding the students. These results indicate that teachers need to be trained on how to support students by providing scaffolding. Students also need to be trained on how to use metacognitive strategies when collaborating together on reading tasks.

An action research study (Flint, 2010) examined a "partner/buddy" reading approach in a first grade classroom. The study specifically examined how literary transaction and social interaction worked together to support emergent and early readers. At the same time the study examined whether the partner/buddy reading approach used social interaction as a technique to promote literacy.

When the field notes, videos of students buddy reading, and audio of informal interviews were analyzed, three themes emerged: (a) reading strategies and prior knowledge were used by the students to scaffold each other, (b) meaning was constructed by the partners/buddies by making connections with and to the text, and (c) social interaction and motivation occurred through play while the students were reading. Students, especially early readers, may benefit from the scaffolding and meaning making that occurs during partner/buddy reading.

Using a sample of 52 sixth-grade students, Hall's qualitative study (2012) examined the participation of struggling readers in small groups, composed of students who shared similar perceptions of themselves as readers. Hall (2012) concluded that the experiences varied for struggling readers who had different perceptions of themselves. Students were introduced to a 6-step comprehension routine and were then placed in groups based on how they rated themselves as readers (high, average, or low). Reading comprehension abilities did not play a role in how the groups were constructed, so each group had a mixture of students who read above, on, or below grade level. The results demonstrated that students who read below grade level had little participation in the first four to six group discussions, regardless of how they had rated themselves as readers. As the study progressed, struggling readers increased their participation in group discussions and became leaders in their groups. One possible explanation is that the struggling readers were able to see how their peers engaged with the text and used comprehension strategies as their peers did. This study occurred over eight weeks, so that struggling readers had plenty of time to observe their peers and become comfortable with their group members (Hall, 2012). These results imply that struggling readers may benefit from collaboration with peers, but enough time must be given for them to observe and become comfortable interacting with their peers.

Almaguer (2005) explored the effect of dyad reading on the reading achievement of Hispanic English language learners (ELLs) in the third grade. The students were placed in dyads of one student who was reading well and another who was struggling. Students who participated in the dyad reading scored significantly higher in the areas of reading fluency and comprehension (based on comprehension questions) than the students who did not take part in this activity. The effect sizes for both areas were also educationally significant. There was no significant difference between dyad and non-dyad students for comprehension (based on the cloze procedure). Further analysis revealed that both students who participated in the dyad benefited from it (Almaguer, 2005). English Language Learners who are struggling readers might benefit from reading dyads.

Studies have also focused on how student collaboration can be used with writing activities. Ferguson-Patrick's (2007) action research study examined the role of peer interaction and collaboration in developing the writing skills of six-year old students in Australia. Over the course of six months, students learned collaborative approaches that were designed to increase both the quality and quantity of their writing. The findings showed that peer interactions contributed to both the quality and quantity of students' writing. Students often shared strengths and expertise and provided encouragement and assistance in the form of peer tutoring when collaborating together (Ferguson-Patrick, 2007). Therefore, using collaboration may help students develop their writing skills and be more productive in their writing.

Collaborative writing may also help students to co-construct knowledge. Rojas-Drummond, Albarran, and Littleton (2008) explored the interactions that occurred when primary students collaborated with each other to write a group story. They also examined how oracy and literacy mediated these interactions. Students wrote a group story and then enriched the narrative with pictures, animation, voice, and music, turning the story into a multimedia production. Video analysis revealed that students co-constructed knowledge and developed collaborative creativity (Rojas-Drummond et al., 2008).

The discourse that occurs during collaborative creative writing activities has also been studied (Vaas, Littleon, Miell & Jones, 2008). Naturalistic observations of students who were participating in ongoing collaborative writing projects that had been planned by their teacher occurred over the course of a school year. Video and audio analysis revealed that overlaps and interruptions by students are important in the collaborative creative writing process. Overlaps and interruptions allowed ideas to build on each other, which resulted in richer and more complex ideas. The authors suggest that in creative collaborative environments, the most productive talk might be free flowing and unpredictable, rather than linear (Vaas et al., 2008).

Rodnes (2012) examined how group work can be used in combination with individual writing. Upper secondary students were given the task of analyzing a cartoon strip. The students were also provided with a handout listing the analytical concepts (literary devices) that could be used in cartoon strips. Students then chose a cartoon strip for analysis, formed groups to discuss their thoughts, and then used the rest of class for individual writing. Students completed their individual writing at home and turned in the assignment for a grade. Field notes and videos were analyzed and revealed that students tested out analytical concepts and interpretations of the cartoon strip when they were in their small groups. The points that were made during the small group discussion influenced students' individual writing (Rodnes, 2012). This study shows the possible benefits of using group work and individual writing together.

Reading/Writing Teacher-focused Studies. Studies have also examined specific collaborative approaches that could be used for reading/writing instruction. Roberts and Eady (2012) explored the influence of a mixed-age collaborative approach on the learning that took place during creative narrative writing. For the study, students were asked to complete a story that the class had read. The students were able to choose a partner to discuss their story ideas with and then wrote the first few sentences of their story in class. Next, the students had to share their abstracts with the peer, who had no prior knowledge of the story, for him/her to comment and make suggestions to the context. This process of sharing the story with someone new continued throughout the writing process. At the end of class, there was a group conference where each student read their incomplete story and received comments and advice. Analysis of audio, interviews, students' writing, and observations revealed that very little collaboration took place initially because students selected partners based on social factors, such as level of friendship, rather than writing ability. However, when students had to select a new student with whom to share their story, they often selected an older, more competent writer. Students took the feedback they received from these collaborations and the group conference and incorporated it into their writing (Roberts & Eady, 2012). These findings indicate that allowing students choose their own partners for collaborative writing does not always result in collaboration actually taking place. It might be more beneficial for students if they are directed to share their writing with someone new. Whole class group discussions could also be used to provide feedback for students.

Another study (Jones, Reutzel, & Fargo, 2010) compared two methods of writing instruction: interactive writing and writing workshop. The study explored whether the method of writing instruction made a difference in kindergarten students' growth in early reading skills. Interactive writing is a group writing experience, while the writing workshop encourages students write at their own pace and then conference and share their work with the class. No statistically significant differences were noted between the two groups on any of the outcome measures (Jones et al., 2010). The results suggest that both interactive writing and writing workshop have collaborative elements and are effective for helping kindergarten students grow in their early reading skills.

Other studies have explored specific collaborative learning approaches that can be used with reading activities. Law (2011) examined how cooperative learning with teacher guidance affected fifth graders' reading comprehension. Two different collaborative learning approaches were studied: the Jigsaw and the drama method. A control group with traditional teacher-led lessons was also included in the study. For both the Jigsaw and drama methods, teachers scaffolded instruction as students collaborated in their small groups. The results showed that students in the Jigsaw method group had significantly higher scores on reading comprehension tests than students in both the drama and control groups. When students were re-tested three months after the conclusion of the study, students in the Jigsaw method still scored significantly higher than students in the control group but were not significantly different from students in the drama group (Law, 2011). These findings indicate that the Jigsaw method can enhance students' reading comprehension, but teachers need to scaffold students to ascertain that students use the method appropriately.

A pilot study conducted by Topping and Bryce (2004) examined the influence of peer reading and peer thinking on students' thinking skills and attitudes toward reading. Peer reading pairs a higher-level reader with a lower level reader. Together they read a text with the higher-level reader assisting the lower level reader as needed. Peer thinking partners also differ in reading abilities but work on teaching each other higher-level thinking skills along with reading comprehension; both partners ask questions about what they have read. For the study, seven year olds were the tutees while 11 year olds were the tutors for both conditions. The study was conducted in two phases. During Phase 1, both groups did paired reading for six weeks. In Phase 2, one group continued with paired reading while the other group did peer-thinking for 10 weeks. The results indicated that the peer thinking tutees scored significantly higher on thinking skills compared to the peer reading tutees. Peer thinking tutees also showed some improved attitudes towards reading. The peer thinking tutors did not show any difference in thinking skills or attitudes toward reading. One possible reason for this lack of growth is that the peer thinking tutors already had high thinking skills and attitudes towards reading. The peer thinking tutees and teachers provided very positive feedback, but the feedback from peer thinking tutors was less encouraging. The study was limited in time and the tutors had little training, but peer thinking could be used to increase students' thinking skills and attitudes toward reading (Topping & Bryce, 2004).

Collaborative strategic reading (CSR) is another approach that has been studied (Vaughn et al., 2011). An experimental study was conducted with seventh and eighth grade students to examine the effects of CSR on reading comprehension and fluency. CSR teaches students four comprehension strategies to use before, during, and after reading. The teachers taught students the CSR strategies over a four to six week period. Once students were proficient using the strategies, they were assigned to small groups to implement the strategies while they made meaning of a text. Students in the CSR group scored significantly higher than the control group on the reading comprehension portion of the Gates-

McGinitie Reading Comprehension Test, but did not show higher levels of reading fluency (Vaughn et al., 2011). These findings suggest that CSR may become an approach that could increase students' reading comprehension.

Early and Marshall (2008) investigated the use of the mandala technique to help adolescent ELLs interpret and appreciate English literature. The mandala technique uses non-linguistic symbols to represent complex constructs. For this study the theme, style, and characters of a story were represented using the mandala technique. Students formed groups of three and completed a mandala on a short story of their choice. Analysis of field notes, interviews, students' written reflections, student self-evaluations, and student essays showed that the mandala technique helped the students grow in their interpretation of and appreciation for English literature. The mandala technique also had a verbal/visual multimodal aspect that helped students develop their academic literacy (Early & Marshall, 2008). Although this study focused on ELLs, the mandala technique could also be used to help other students with their appreciation for and interpretation of literature.

Reading/Writing- Technology-focused Studies. Jewitt, Clark, and Hadjithoma-Garstka (2011) examined the use of Learning Platform (technologies in English primary and secondary schools. Learning Platform technologies included online learning environments, communication technologies, and technologies used to share resources and information. Interviews of administrators, teachers, students, and parents, along with classroom observations at 12 schools provided the data for the study. Learning Platform technologies increased opportunities for collaborative learning at the case study schools. Students were able to collaborate with students in their own classes, but also with the students at other schools.. This resulted in more peer interactions and gave students an opportunity to build their collaboration and communication skills. Moreover, online communication made discussions less personal, which allowed students to discuss more difficult topics and critique each other's work (Jewitt et al., 2011). In general Learning Platform technologies might increase student collaboration, and specific Learner Platform technologies might aid students collaborate and increase their reading and writing skills.

Killi, Laurinen, Marttunen, and Leu (2012) examined how student pairs engaged in online reading practices and co-constructed meaning and knowledge when exploring a controversial issue online. The study also explored students' performance on an essay-writing assignment together with students' perceptions of collaborative online work and essay writing. Students self-selected a partner and were asked to write a joint essay on a controversial topic. The pairs discussed the topic and researched it online before writing the joint essay. The analysis of video files which recorded students' online activity and discussions revealed five collaborative reading types: (a) co-constructors of knowledge, (b) collaborators, (c) blenders (mix of collaborative and individual processes), (d) individual readers, and e) silent readers. When the joint essays were analyzed, the co-constructors received outstanding marks, the collaborators received excellent marks, the blenders and individual readers received between excellent and good marks, and the silent readers received good marks. Students perceived the collaborative work as being beneficial for them (Killi, Laruinen, Marttunen, & Leu, 2012). These findings indicate that collaborative online reading and joint essay writing may help students co-construct knowledge; however, this may take time and students might need some guidance collaboration techniques.

Another study (Chung & Walsh, 2006) followed kindergartners and first graders for two semesters as they used a computer for joint story writing. The purpose of the study was to look at how the students' joint story writing process developed over time and how students used the computer for joint story writing. It was found that students moved from individual control of the mouse and keyboard to more collaborative control as the study progressed. The stories that students wrote went from individual stories written in parallel to collaborative stories written together. Student roles also changed over the course of the study. At the beginning of the study, students with higher literacy skills were leaders while other students were observers. By the end of the study the students were sharing the roles of leader and observer. The computer also played an important role in students' collaboration. The partners were able to use the computer to explain their ideas and track their progress. This helped students to focus their efforts and stay on task (Chung & Walsh, 2006). These results suggest that students may need extended time in order to fully develop their collaboration skills. In addition, a computer might become an integral part of a joint, student writing process. .

Woo, Chu, Ho, and Li (2011) examined how wikis could be used to scaffold primary students during collaborative writing projects. During the six-week study, students worked in mixed gender and mixed ability groups on a wiki article about an animal of their choice. The students could add photos or graphics to their work. The teacher provided rules for the usage of wiki and asked the students to co-write and exchange feedback and comments through the wiki. Students could work on their wikis during class and outside of it. The teacher provided scaffolding to the students by providing timely feedback during the process. Analysis of a student questionnaire revealed that students enjoyed using the wiki and perceived that it helped them collaborate and improve their writing. Students also reported that peer comments helped them scaffold their writing. The tracking function in the wiki helped the teacher scaffold students' learning by providing information about the edits students were making (Woo, Chu, Ho, & Li, 2011). It became apparent that wikis can be used to scaffold students' writing and encourage collaborative writing.

Grant (2009) also explored the use of a wikis to support a collaborative research and writing project. This study was conducted with secondary students who collaborated with each other in groups of six to nine students on a topic within an assigned subject. Over three weeks students had to research and write on their wiki about the topic of their choice. Six students participated in a focus group interview, the teacher was interviewed before and after the project, and the wikis were analyzed throughout the project. The collected data showed that the groups initiated the project by deciding on topics to cover either individually or in partners. This resulted in each group's wikis covering several different topics. Very few students tried to edit materials on other students' pages. When they conducted any editing, the page was reverted to the initial draft. During the focus interview, students indicated that they did not think it was useful or desirable to edit each other's work (Grant, 2009). In contrast to the findings of the previous study (Woo et al., 2011) it appears that in this study, wikis were not a valuable tool for collaborative writing.

Another study (Marttunen & Laurinen, 2007) explored how debating with a partner influenced secondary students' argument diagrams. In this study, students constructed individual argument diagrams, read three articles on the topic of the argument diagram, and then revised their original diagrams. The next period students used collaborative argumentation-based learning (CABLE) Internet tools to debate the topic of their diagram and construct a joint argument diagram with a partner. Finally, students were allowed to revise and complete their individual argument diagrams. Analysis of individual diagrams before and after the debate along with the joint diagrams and chat transcripts of the debates revealed that students made several modifications to their individual diagrams after the debate. The modifications included adding new arguments for or against their topics. These findings suggest that debate and construction of joint argument diagrams with a partner helped students construct knowledge, which deepened and broadened their argumentation diagrams (Marttunen & Laurinen, 2007). This study is another example of how collaboration can aid students to co-construct knowledge.

Co-constructing knowledge can also occur when students read online collaboratively. Castek, Coiro, Guzniczak, and Bradshaw (2013) examined the characteristics of collaboration when students were asked to work together on researching information on the Internet. Students were provided with a prompt and asked to construct an oral response with a partner researching the topic. Analysis of screen reading actions and participants' dialogue and interactions revealed characteristics of productive and less productive team work. The characteristics of more productive groups were (a) planning before searching, (b) referencing back to the prompt, (c) determining whether the resources found were related to the prompt, and (d) having both students equally contribute to the dialogue, which resulted in well constructed joint summary statements. Less productive groups were characterized by (a) focusing on details not related to the prompt, (b) starting off by using incorrect prior knowledge and verifying that knowledge using information online, (c) not determining the reliability and accuracy of the information found online, and (d) getting off-task easily (Castek, Coiro, & Bradshaw, 2013). The authors suggested that all students could benefit from scaffolding through reading the sources online collaboratively. According to the authors, this technique will aid students to become more productive.

Reading skills can also be influenced by collaboration though specific collaborative techniques that use technology. One technique that has been used to develop reading skills, peer interaction, and self-concept in elementary students is Electronic Peer-Assisted Learning for Kids (EPK; Tsuei, 2011). Students in the study participated in peer tutoring for Chinese language arts. One group used a synchronous online learning environment (EPK) while the other group participated in face-to-face peer tutoring. The pairs of students consisted of one higher ability and one lower ability student. Each 30-minute tutoring session for both groups started with the higher ability student being the tutor and the lower ability student being the tutee. Halfway through the session (15 minutes) the roles reversed. The findings showed that students in the EPK group had significantly higher reading comprehension and self-concept scores than students in the face-to-face group (Tsuei, 2011). These results suggest the peer tutoring in an online learning environment may help increase elementary students' reading comprehension and self-concept.

Internet Reciprocal Teaching (IRT) is another specific collaborative technique that can be used to increase students' reading performance. Henry, Castek, O'Byrne, and Zawilinski (2012) examined the impact of IRT on students' roles in the classroom. IRT combines reciprocal teaching with Internet-based text to help students learn how to read, write, and communicate online. This study focused on three struggling readers who used IRT to learn strategies important to online reading. Students worked in collaborative groups and were often recognized as experts who could assist others in completing tasks or using certain strategies. Field notes, video and audio, documents from the IRT tasks, screen captures, and interviews were analyzed and reveled three themes. The three themes were: (a) online literacy skills were developed and academic achievement increased, (b) motivation and engagement to learn in collaborative groups increased, and (c) struggling readers experienced role reversals during the study and became experts, which enhanced their self-confidence and self-efficacy (Henry et al., 2012). These findings indicate that IRT might help struggling readers (or other students who have low classroom participation) become experts and active members of the classroom.

Online learning communities can also be used to discuss what students have read and increase their critical thinking skills (Simpson, 2010). In this study, Year 5 students in Australia participated in a collaborative online community called a book rap. Schools signed up to be part of a rap via a moderated website. The book, rap points, and a teacher support notes were published on the website before the rap begins. During the rap, worksheets and rap points were collected to scaffold face-to-face discussions with peers. Students then decided on individual or group messages to be sent to the website moderator. The moderator posted the messages on a general discussion board for others in the rap group to read. It was found that the book rap encouraged student responses to the book through both face-to-face and online collaboration. The students did show gains in critical thinking, but there was little student engagement with technology (Simpson, 2010). Students may benefit from both face-to-face and online collaboration, but should also be engaged with the technology.

Reading/Writing Summary. In the reading/writing literature, researchers discussed approaches to collaboration in reading and writing instruction in the classroom. The research in this section also examined the teachers' role in initiating collaboration in the classroom. Some of the specific collaborative activities that were examined included (a) a combination of group work and individual writing, (b) mixed age collaboration, (c) interactive writing versus writing workshop, (d) the Jigsaw method versus the drama method, (e) peer reading and thinking, (f) collaborative strategic reading, and (g) the mandala technique. Collaborative activities that utilized technology included (a) learning platform technologies, (b) specific approaches to on-line collaborative reading, (c) collaborative writing, and (d) online learning communities. Measured outcomes included reading comprehension, attitudes towards writing, quality and quantity of writing, and student behavior during collaborative activities. Overall, students' reading and writing skills improved from collaborative activities in the reading/writing classroom.

Humanities/Social Sciences

Studies focusing on humanities or the social sciences incorporated a variety of research methods with four studies using mixed methods, five studies using quantitative methods, and three studies using qualitative methods. The studies for humanities/social sciences examined many areas including the impact of individual characteristics on group work, impact of collaborative activities and technology on student outcomes, the effect of explicit group skills training on teachers' implementation of collaborative activities and teachers' perspectives of students, and the successful and less successful attempts to use online learning environments for collaboration. Studies that analyzed student level data will be summarized first.

Humanities- Student-focused Studies. There are multiple factors to consider when asking students to collaborate with each other. For example, the individual characteristics of students might have an impact on student learning outcomes. One study examined individual student characteristics and how these characteristics interact with the outcomes of cooperative learning activities. Huber (2003) found that uncertainty-oriented students (those motivated by self-regulation type activities) benefited from process-based instructional approaches, such as cooperative grouping. In contrast, certainty-oriented learners (those motivated by structured situations) preferred more teacher guidance and did not take advantage of student-centered instructional settings (Huber, 2003). Therefore, individual student characteristics need to be considered when undertaking collaborative activities.

Another factor that might play a role in student outcomes is the type of activity. Schuitema, Veugelers, Rijlaarsdam, and Ten Dam (2009) conducted a study with eighth-graders who participated in lessons with an explicit focus on dialogic citizenship education in small groups. The students were divided into small group dialogues were able to better justify their opinions than students who participated in the same lessons using whole class dialogue. Additionally, the more group work that students participated in within the dialogic citizenship lessons, the stronger their ability was to justify their opinions. These results imply that group work might be a more effective method by which to implement dialogue rather than a whole-class setting approach (Schuitema et al., 2009). Another study described student changes when process drama was included in a Social Studies lesson in a fifth-grade classroom (Rosler, 2008). When drama-focused lessons were introduced, student engagement, collaboration, and student leadership increased in quantity and quality (Rosler, 2008). Finally, Layne, Jules, Kutnick, and Layne (2008) found that training students on group skills and integrating more collaborative learning reduced the achievement gap between the highest and lowest achieving students.

Student outcomes might also be affected by collaborative activities that include technology. One study examined sixth-grade students who applied technology to create concept maps (Lin, Wong, & Shao, 2012). Students either worked in pairs with each other having a tablet (1:1) or in a group with one tablet for the whole group (1:m) to create concept maps. The results indicated that the 1:1 group had higher quality student-to-student interactions, but their concept maps were of lower quality. The 1:m group had lower quality student-to-student interactions, but their concept maps were of a higher quality. There were no significant differences between the two groups for learning outcomes (Lin et al. 2012). This indicates that the quality of student-to-student interactions may not influence the quality of student products.

Van Aalst and Chan (2007) conducted a study with twelfth-grade students who worked together on creating collaborative portfolios in using an online platform, Knowledge Forum. The construction of collaborative portfolios allowed students to document collective knowledge gains as they worked together on selecting the highest quality work from the group, not just individual accomplishments and contributions. Students in the collaborative portfolio group had statistically significantly higher concept and content scores than students in the control group. Additionally, students who participated in the Knowledge Forum more often had also higher concept scores (Van Aalst & Chan, 2007). This indicates that the use of online platforms, such as Knowledge Forum, to create collaborative portfolios may increase student achievement.

Other studies have also examined the use of technology in collaboration and the effect of it on student outcomes. Lu and Law (2012) conducted a descriptive study with secondary students in Hong Kong that documented the collaborative development of wikis. In general, students failed to use the wikis collaboratively and tended to develop wikis in parallel fashion without any interaction. Students' project performance was influenced by the amount of feedback they provided to their peers. The students who provided more feedback to their peers did better on their projects overall. Other factors, such as receiving feedback from peers and grading peers, did not have an impact on project performance (Lu & Law, 2012).

A recent descriptive study explored the nature of collaboration during online inquiry (Castek, Coiro, Guzniczak, & Bradshaw, 2013). Students' collaborative efforts while participating in online inquiry were categorized by the researchers as either productive or less productive collaboration by the researchers. The characteristics of productive collaboration were documented as (a) strategic planning, (b) interaction focused on prompts, (c) dialogue, and (d) equal contributions from participants. Less productive collaboration was characterized by (a) focus on irrelevant details, (b) inquiry based on incorrect background knowledge, (c) use of resources that lack legitimacy, and (d) distraction during online searches (Castek et al., 2013). These findings imply that teachers might need to train their students on productive collaboration practices.

Humanities- Teacher-focused Studies. Layne, Jules, Kutnick, and Layne (2008) integrated explicit group skills training in secondary classrooms in Trinidad and Barbados over an eight-month period. As the training progressed, teachers moved from a more traditional teacher-centered approach to a more collaborative learning approach. Teachers' perceptions on what a good student was also changed to include autonomy, working well in groups, getting along with others, and exchanging ideas (Layne et al., 2008). These results imply that explicit training on integrating group skills in the classroom may be helpful for teachers.

Humanities- Technology-focused Studies. Technology is becoming a tool used to enhance and support student collaboration. Many studies focus on the use of online learning environments for collaboration. Zieger and Farber (2011) studied seventh-grade students utilizing a multi-user virtual environment (MUVE) to complete a project-based learning unit on the U.S. Constitution. Student survey results indicated that 69% of students perceived cooperative work online to be just as valuable as face-to-face cooperative work. About 80% of students agreed or strongly agreed on the fact that cooperative learning resulted in generation of better ideas. Additionally, students reported that they became more engaged with each other when collaborating in the MUVE environment. The students who were self-described as “shy” in face-to-face settings showed higher participation rates in the online setting. Students were requested to sign a code of conduct and forewarned that the teacher would receive updates on their work,. This technique helped students to stay on task (Zieger & Farber, 2011). These results indicate that online learning environments can help students collaborate and students enjoy the use of these environments.

Other studies focused on less successful implementation of CSCL environments. Baker, Bernard, and Dumez-Feroc (2012) documented the implementation of a computer-supported collaborative learning environment (CSCL) in a secondary history-geography class in France over six months. In this study, the CSCL approach did not help the teacher or students reach their pedagogical goals. Such goals included developing an academic level of discourse, engaging in argumentative debates, and encouraging students participate in shared meaning making. One possible reason for the lack of success with the CSCL approach may have been the presence of socially powerful students who convinced their peers not to use academic discourse during the CSCL debates. It is suggested for the teachers to consider socio-cultural factors within a classroom before implementing any collaborative tasks. It is also vital to remember that online environments are not socially neutral environments and socio-cultural factors still need to be considered before using them (Baker et al., 2012).

Another study (van Drie, van Boxtel, Erkens, & Kanselaar, 2005) focused on student use of argumentation to develop historical reasoning. Researchers compared the use of two different CSCL argumentative tools used to represent an historical argument; a graphical representation (argumentative diagram) and a linear representation (argumentative list). There were no statistically significant differences between the two tools pertinent to development of historical reasoning. Additionally, the use of the CSCL environment did not increase participants' historical reasoning. Most of the interaction between the participants focused on procedures (van Drie et al., 2005) rather than on developing relevant arguments. These aforementioned results further imply that the use of online learning environments is not always successful.

A final group of studies examined how specific types of technology can be used in collaboration. Higgins, Mercier, Burd and Joyce-Gibbons (2012) analyzed the use of multi-touch tables by Year six students during a history task. For the task, students used clues to figure out who was responsible for a mining accident. One group of students completed the task using a multi-touch table, which displayed the clues on slips of digital "paper." Students could move the slips around the screen and resize them as needed. The second group was provided with the clues on small pieces of paper and was asked to gather around a regular table to complete the task. The multi-touch table groups took less time to complete the task, but the difference was not significant. The groups differed in how they viewed the clues. All of the multi-touch table groups gathered together to view the clues and read them, while only one paper group used this strategy. The other paper groups either had individuals viewing the clues and reading them aloud or individuals viewing the clues and the reading them silently (Higgins et al., 2012). These results suggest that multi-touch tables might encourage more collaboration among students as compared to the paper-based tasks.

Humanities/Social Sciences Summary. The social studies literature discussed many specific activities and technology through which collaboration in the classroom could be implemented. It also examined factors that might have influence on implementation of collaboration in the classroom. These factors included individual characteristics of students and provision of training for teachers and students on group work skills. Collaboration skills in social studies were incorporated using a traditional small groups approach. However, many other studies described the utilization of technology as the method for initiating student collaboration in classrooms. This type of collaboration included tools such as wikis, online portfolios, online inquiry, and computer-supported collaborative learning environments. Measured outcomes included student achievement, collaboration skills, and student interactions. Overall, it appears that collaboration can have positive effects when implemented in the social studies classroom.

Mathematics

The 25 studies that focused on student collaboration in mathematics utilized a variety of research methods including four studies that incorporated mixed methods, six studies that used quantitative methods, and 13 studies that employed qualitative methods. The studies examined many facets of student collaboration including: student perceptions of collaborative work in mathematics; the quality of student work produced in collaborative mathematics tasks; how the group work or collaboration functions in mathematics class, including how individual students function in and contribute to collaborative efforts; the role and stance of the teacher in collaborative work; and specific tools or technologies that support collaborative work in mathematics. Studies that examined student level outcomes will be summarized first.

Mathematics- Student-focused Studies. Using a large sample (n= 10,076) of 13-year old Japanese students, House (2003) examined the relationship between instructional activities, classroom practices, and student motivation in Japan. The study used data from the Third International Mathematics and Science Study (TIMSS). The findings revealed a statistically significant positive correlation between the amount of time that students reported working in pairs or small group in mathematics class and the extent to which students expressed enjoyment for learning mathematics and the frequency with which students reported trying to solve problems related to new topics. Summers (2006) also examined the motivation of students in the context of collaborative mathematics work. The comparative study with a sample of 200 sixth-grade students used beginning and end of school year survey data to describe the effect of mathematics peer learning groups on the development of shared social and academic goals. The findings revealed that students who valued group work tended to have higher task orientation than did students for whom group work was not valued. While group work might set the stage for academic goal orientation for certain students, the study did not establish causal links between the two.

Jansen's case study with 24 sixth-graders (2006) examined student perceptions of collaborative work. Using interview data and video analysis of footage from two mathematics classrooms, Jansen found that students generally held positive perceptions of collaborative group work. Students reported efficiency, social interaction, shared understanding, and access to multiple strategies as benefits of group work. Students noted that social conflicts were the drawback of group work. The video analysis also revealed that in one of the classrooms, the teacher functioned as an expert and keeper of the answers, while the other classroom teacher acted as a facilitator and placed primary responsibility for learning on the students. Jansen noted that the way in which the small groups functioned in each classroom reflected the stance of the teacher as expert or facilitator.

Working with 65 private kindergarten students in Turkey, Tarim's experimental study (2009) focused on the effects of the cooperative learning method on preschoolers' ability to solve verbal mathematics problems (addition, subtraction, and apportion). Results revealed that students in the experimental group one (cooperative learning) benefited significantly more than those in the control group (mean difference, 2.91; p=0.011), as did children in the experimental group two (cooperative learning; mean difference, 4.36, p=0.000). Additionally, Tarim found that following the intervention, students in the experimental groups were more likely to share and ask peers whether they needed help, and were more likely to involve all group members. Students and teachers perceived group work more positively following the intervention than at the outset. This study confirms the positive effects of cooperative group work in a preschool setting.

While the studies described above primarily examined student perceptions of collaborative work and student-level outcomes of collaborative work, the next group of studies delved into the processes of group work in mathematics classrooms. These studies sought to describe what students do in groups, how collaborative groups function, and how each individual student contributes and receives knowledge and feedback in a collaborative group setting.

Dekker, Eishout-Mohr, and Wood (2006) utilized extensive discourse analysis of two third graders' problem solving episodes in order to better understand how students regulate their own collaborative activity. The researchers found that students were able to regulate their own collaborative learning in order to balance the demands of the mathematical task, classroom norms, and time constraints. The findings suggested that open-ended tasks allowed for a variety of students to function at different levels of understanding and still contribute to collaborative work, while classroom norms more generally supported collaborative process and work. Cakir, Zemel, and Stahl (2009) also sought to describe how students manage and organize their activity and time in order to collaborate. This study used a collaborative online environment for the study setting. The authors found that students had to use a variety of tools and modalities in the online environment in order to bring thinking to the attention of other group members. Explicit verbal and written cues were important for successful collaboration within the online mathematical solving problem activity.

Mueller (2009) examined the factors that have an influence on how students integrate the ideas of others into their own mathematical justifications and arguments. Using a case study approach with 24 sixth-graders, Mueller found several factors that were present when students incorporated peers' ideas into their own thinking: (a) a collaborative environment where time is utilized to collaborate with groups and explore and revisit ideas; (b) open ended tasks with time allocated to revisit thinking; (c) representations that allowed students to incorporate other students' ideas into their own ; and (d) access to tools such as manipulatives that enabled students to externally represent thinking. Similar to the Jansen (2006), Mueller found that the manner in which the students interacted in groups reflected the teachers' stance as an expert or facilitator.

Webb and Mastergeorge (2003) also analyzed how students incorporate into their studies feedback and ideas from peers generated during collaborative work. More specifically, Webb and Mastergeorge pursued the following research questions: (a) Among students who receive help during small group work and apply it to problem solving, why do some succeed in learning how to solve the problems, whereas others do not? Why are only some students successful in receiving explanations? (b) Among students who receive explanations, why are only some students successful in applying the help they receive? First, results revealed that students who asked peers more specific questions, obtained higher post-test scores than students who asked fewer specific questions. Second, receiving help from peers significantly correlated with post-test scores. In other words, students who received high-level help performed better on the posttest than students who did not receive that type of support. Third, the level of immediate follow-up behavior after receiving peer feedback significantly related to posttest scores. The higher the level of a student's immediate follow-up behavior after receiving help, the greater his/her chances of performing correctly on the post test are. Finally, the results suggested that solving problems correctly without assistance after receiving help significantly correlated with posttest scores. Students who solved at least one problem correctly without assistance after receiving help obtained higher post-test scores than students who did not. In summary, this study suggests that students benefit from asking for help from the peers by taking action and applying that help in a more individual, autonomous setting.

Kotsopoulos (2010) investigated students' interaction in collaborative group work, and as with the work of Mueller (2009) and Jansen (2006), found connections between a teacher's collaborative stance and the interactions of student groups in the teacher's class. Using a case study approach with 34 eighth-grade students, Kotsopoulos analyzed student discourse and video footage of class time, conducted focus groups, and examined student journals. Looking at data across groups in the class, the findings detailed the roles that students assume in collaborative group work. Two primary roles emerged: (a) the foreman, who does little work, but directs activities, and (b) the laborers, some of whom participate in the work activities and others who are excluded from the group work. Kotsopoulos also noted that the students were aware of the teacher's philosophy about group work and could articulate the teacher's philosophy during group debriefs, but did not enact that philosophy during actual collaborative group work independent of the teacher. Finally, the author found that after watching videos of the group work time, students began to change behaviors towards more inclusive collaboration. This finding suggests the importance of student self-awareness during collaborative activity and that the collaboration is a skill that must be taught or encouraged.

Armstrong's descriptive study (2008) detailed the factors that encourage group flow in collaborative group work. Armstrong (2008) describes flow as, "a state of experience in which an individual is intensely focused on and absorbed by an activity, so much so that the experience is inherently self-motivating (Csikszentimihalyi, 1990). This state may occur when the individual's level of skill is matched by the level of challenge involved in doing the activity so that he/she is motivated to continue" (p. 102). With a sample of two classes of 8th grade students, Armstrong video recorded class sessions and analyzed student discourse as well as the physical movements that students made during class. Armstrong found that the group that had a decentralized structure achieved flow, but did not complete the mathematical problem. In contrast, the other group's interactions were dominated by one student's correct answer. The group did not achieve flow; however, it did complete the mathematical problem. This study highlights the importance of balancing process and product among groups when collaborating with each other. Rogat and Linnenbrink-Garcia's case study (2011) utilized a sample of 24 sixth-grade students and examined the role of group processes in the variation in the quality of group work. The authors analyzed video footage from mathematics lessons and found considerable variation across groups in terms of processes. Much of the groups' time and energy were consumed by social regulation focused on how to follow directions and divide up work, rather than interacting with the content and developing understanding. In general, groups with lower quality outcomes tended to have one directive group member. In contrast, groups with higher quality outcomes, tended to have high levels of engagement from group members and positive socio-emotional interactions.

Barron (2003) also investigated the processes that students use in collaborative group work in mathematics class and how the quality of those processes influenced problem solving outcomes. Using a case study approach, Barron found that less effective groups ignored or rejected proposals from group members, whereas more effective groups discussed or accepted them. Conversations in less effective groups were relatively incoherent, which was evident from their proposals for solutions that were not being built on preceding discussions. In more successful groups, it was rare for a proposal not to be directly linked to the prior conversation. In relation to student-level problem solving outcomes, students who had been in successful groups scored better on the same and a related problem during solo problem-solving sessions than did students who were in less effective groups. The findings from this study suggest the importance of not only including collaborative work in mathematics problem solving, but also ensuring that students in collaborative groups know how to n interact with each other in quality ways.

Francisco (2013) explored a similar question in his descriptive qualitative study of six 15- and 16-year olds. Francisco sought to understand how collaborative activity influenced students' mathematical understanding and knowledge. The author found that collaborative activity provided more opportunities for students to examine their ideas and build more sophisticated reasoning. Additionally, as found in Mueller (2009), open-ended tasks and certain content, such as statistics, allowed for more collaboration and increased levels of student mathematical growth. Similar to other studies in this section, Francisco found that the teacher had to facilitate and model the collaborative discourse between students and had to consider the culture of "doing math" in the classroom.

Kumpulainen and Kaartinen (2003) also sought to examine the interactions among students during collaborative work. The authors observed and analyzed behaviors and interactions of three dyads of 12-year old students during geometric problem solving tasks. The authors found that successful collaboration required coordination of communication, language, and activity toward a shared understanding. In other words, the data suggested that collaboration is primarily a social construction and that students' communication is likely to have a mediated role in shaping collaborative dyad activity in mathematics class.

Webel's study (2013) also suggested that collaborative mathematics work does not occur in a vacuum, but rather is mediated by social interactions. Using video footage from collaborative mathematics lessons, Webel asked 22 ninth-, tenth, and twelfth-grade students to watch themselves interact with each other during the class. Webel also interviewed the students and debriefed their self-surveillance during the video footage. The findings revealed that students' collaborative work is characterized by competing goals in the areas of mathematical/social, group/individual, and personal/normative areas. Webel suggests that these competing goals can work against productive collaboration in mathematics, and further asserts that teachers must take into account students' feelings about and goals for collaborative group work when assigning and describing collaborative mathematics tasks to students.

White, Wallace, and Lai (2012) conducted a study with three student dyads in a ninth-grade Algebra I class. The authors collected data, such as video footage, server logs, and pre- and post-tests during a three-week unit on linear graphing. White and colleagues investigated how the dyads' approaches to collaboration changed over time, as well as how students interacted with one another with the help of mathematic objects during the unit. The data suggested that the dyads' development of analytic approaches to constructing slopes corresponded with greater frequency of collaborative work. As the pairs became more efficient in interpreting and solving slopes, their collaborative interactions progressed from relatively independent actions to increased joint activity in which one student directed the others, and finally to joint activity in which each student contributed equally and meaningfully. This finding suggests that students working in collaborative settings need time to learn the content and procedures for working with peers.

White and Pea (2011) also examined how students work together in collaborative mathematics tasks. In two middle school classes, the researchers conducted a design experiment and video case study of students' collaborative work in heterogeneous groups during a summer pre-algebra program. The data demonstrated that over the course of the unit, students became more efficient and effective in working together and using representational tools. As they worked on increasingly difficult tasks, both groups moved from somewhat uncoordinated and inconsistent approaches toward the establishment of more stable and successful ways of coordinating participants and aligning representations of text with functions. Similar to the findings from the White, et al. (2012) study, findings from this study suggest that students must be provided with the space and time to better understand the interaction with one another on collaborative mathematics tasks.

A final study that addressed student-level constructs in collaborative mathematics work, examined the interaction between two 16-year old students while they were working on computerized mathematical investigation tasks related to probability theory. Pjils, Dekker, Van Hout-Wolters (2007) set out to understand how interaction between the two students helped and hindered their mathematical learning process. Using data from discourse analysis of student audio, written artifacts, and computer simulation server files, the authors found that while both students showed growth in mathematics, the student that engaged in self-questioning and wondered aloud about his ideas and answers showed greater growth. In contrast, the other student tended to accept the peer's ideas without discussion or reflection.

Mathematics Teacher-focused Studies. The next group of studies focuses on teachers and specific activities initiated during collaborative learning contexts. While the studies noted above included some findings about teachers' involvement, the articles below will delve deeper into the subject.

Hoek and Gravemeijer's (2011) design study included a teaching intervention and analysis of observations, videotape, and field notes from 45 Dutch students, aged 16 - 18 years old. The intervention was based on Simon's Hypothetical Learning Trajectory (1995) of observation, interpretation, argument, discussions, planning, and conjecture. Hoek and Gravemeijer examined how the development of teacher instructional skills influenced students' interactions during cooperative learning. The researchers found that when teachers assumed the role of a coach (as opposed to a sole instructor and purveyor of knowledge), students demonstrated more collaborative behaviors. Furthermore, as the teachers transformed their instructional role into a facilitation approach, students in cooperative groups moved from completing parallel, but independent work and engaging in disputational talk to exploratory talk and collaboration. An earlier study by Hoek and Seegers (2005) also examined the connection between teachers' behaviors and language and the resulting effects on student behaviors and problem solving in collaborative mathematics settings. The authors established that the teacher's transformation in instructional approach, from direct instruction to coaching and facilitating, was accompanied by a similar transition in student behaviors and talk. In one of the classes, class exploratory talk, characterized by critical reflection and equal participation, increased from 16% to 66%; simultaneously, cumulative talk, characterized by an emphasis on agreement, and acceptance without reflection, decreased from 72% to 33%. Data from the second class suggested similar findings where exploratory talk increased from 21% to 74% and cumulative talk decreased from 68% to 12% over the course of the school year.

Webb, Nemer, and Ing (2006) similarly studied a professional development and parallel instructional intervention and examined the influence of teachers' action on students' subsequent behaviors. More specifically, the researchers sought to understand if and how the professional development improved student-helping behaviors in small groups, and if the teachers' discourse influenced students' helping behaviors. The professional development and intervention for students centered on skills needed to work collaboratively and included (a) inclusion activities (also called class-building), (b) activities that developed basic communication skills, (c) activities that elicited students' helping skills in work groups, and (d) activities that cultivated students' ability to give explanations. The data from two teachers and six different 7th grade urban classrooms (n = 223) in California, suggested that students adopting the role of help-givers, due to their understanding of a problem, mostly gave low-level help to peers, such as providing unlabeled answers to a problem. Student help-seekers, or those asking for help due to confusion on a problem, on the contrary, mostly asked general questions of their peers and accepted answers without attempting to discern the validity of the answer or those that confirmed their own thinking. The researchers observed that, even with the focused professional development, the teacher maintained the role of a knowledge giver, while students acted as passive knowledge receivers.

Using a qualitative case study with interviews and observations, Siegel (2005) examined how one teacher interpreted and implemented a research-based (Johnson & Johnson) approach to cooperative learning into his classroom. Siegel found that the teacher's understanding of cooperative learning was consistent with the research-based model. Nonetheless, the teacher adapted the model for his own classroom in three major ways: the teacher used his own techniques to implement cooperative learning; the teacher integrated cooperative learning into his existing, basic lesson plan; and the teacher implemented cooperative learning approach differently in his high-performing and regular classes. The findings of this study suggest that in-service training should encourage teachers to articulate their assumptions about teaching and their daily teaching practices, consequentially empowering teachers to incorporate cooperative learning into their daily practices, as opposed to positioning cooperative learning as something new and separate from regular practice.

Staples (2008) also investigated teacher practice during student collaboration activities. Staples conducted observations, video analysis, and interviews with 10th, 11th, and12th grade students (n=31) and their teacher in an effort to understand how teachers support and sustain students' participation in collaborative interactions as the students work in heterogeneous groups on open and conceptually focused problems. Four categories emerged from the data that characterized the teacher's role in supporting and sustaining student participation in collaborative mathematics work: (a) accountability system, including group quizzes and tests, and verbalization of positive group practices; (b) positive sentiment, such as selection of appropriate tasks for student success, student choice of when to demonstrate knowledge, multiple chances for mastery, acceptance of a variety of solutions and products, and praise; (c) tools and resources, including structured materials, explicit framework for interdependence and defined group roles; and (d) teacher-group interaction that allowed students to guide questioning.

Mathematics-Technology-focused Studies. The following group of studies includes technology-based interventions or teacher-driven technology activities that provide the context for collaborative student work.

Hurme and Jarvela (2005) examined the types of metacognitive processes that emerged during the use of Knowledge Forum, an educational software designed to help and support knowledge building communities, by Finnish 13-year olds (n=16) in mathematics. Data from content analysis of computer notes in Knowledge Forum during a mathematical problem solving activity, suggested that the Knowledge Forum platform did not support the use of high-level academic mathematics language or metacognition by students. The networked discussions between students were characterized by social language rather than attempts to argue mathematical processes. The authors attributed this misalignment to several reasons including the difficulty for users of Knowledge Forum to insert formulas, due to the symbolic nature of the mathematics concepts and the need for more explicit language scaffolding in CSCL environments.

Bouta, Retalis and Paraskeva (2012) evaluated an online 3D environment (Co-Sy World) for teaching mathematics collaboratively in a primary setting. The authors explored the extent to which students' behavioral, affective, and cognitive engagement is supported by the 3D environment and, in turn, enhanced student collaboration. Data included online chat logs, high inference classroom observations, and pre- and post-test. Data were compared between the treatment s and a control groups. The findings suggested that the 3D environment was more effective in engaging student interest and enhancing student-to-student interaction compared to interactions in the traditional classroom setting.

Mathematics Summary. In the Mathematics literature, researchers discussed the ways in which collaboration is used in K-12 mathematics classrooms. The research in this section also examined the teachers' role in facilitating collaboration and the ways in which students respond to teachers' roles and assumption about collaboration. The studies also describe the settings and tools that are present when students collaborate in ways that are characterized as high quality and frequent. The specific approaches studied include 3D interactive experiences, the Knowledge Forum platform, and dyad mathematical problem solving. Measured outcomes included mathematics achievement, attitudes towards mathematics group work, quality and quantity of interactions and contributions during group work, and student academic language use. With few exceptions, the studies suggested that students benefit from collaborative activities in the Mathematics classroom.

Science

Science-focused studies included a variety of research methods with four studies using mixed methods, eight studies using quantitative methods, and nine studies employing qualitative methods. They examined topics including the role of prior knowledge; student roles in groups; the types of group talk and discussion that occur during collaboration; specific collaborative approaches (thinking aloud pair problem solving, the Jigsaw method, natural field inquiry, and group investigation); teacher training for implementing cooperative learning in the classroom; how teachers implement cooperative learning;

the use of the Jigsaw method with technology; computer-supported collaborative learning tools (Knowledge Forum and wikis); software programs for collaboration (GroupScribbles); and technology for collaboration (interactive white boards). Studies that examined student level data will be summarized first.

Science Student-focused Studies. Gijlers and de Jong (2005) investigated the influence of prior knowledge on the development of knowledge and the associated learning processes within a collaborative discovery-learning context in a science classroom. Thirty 15- and 16 year olds worked in dyads with a computer-based physics simulation. The authors discovered that the composition of dyads in terms of prior knowledge was related to the learning processes. Heterogeneous pairs (higher achieving and lower achieving students) discussed different hypothesis more and carried out the experiments. The student with more prior knowledge served as a guide for the partner, where the less achieving student would learn from the explanations provided by the student. The high achieving student in this case was able to explain the material to the partner, thus, allowing both students understand the material better. Therefore, heterogeneous pair work appears to be beneficial to both the high and low achieving students. Too large of a gap between the low and high achievers, however, led to frustrating situations with the high achieving students conducting all the work and not providing explanations. The conversations of the more homogeneous low-and average-achieving dyads focused primarily on searching for information about the assigned task. The homogeneous dyads were more likely to experience difficulties creating a meaningful conversation and constructing new knowledge as compared to heterogeneous student groups (Gijlers & de Jong, 2005). The results from this study indicate that heterogeneous student pairing is presumably better for students' construction of new knowledge. Nonetheless, it is vital to remember that when the pairing takes place, high achieving students should not be paired with extremely low achievers.

Another study concluded that the roles that students take during a collaborative activity may affect their final products. Crinon and Marin (2010) examined the explanatory science texts that were written by fourth and fifth grade students. After finishing writing the texts, one group was assigned to read another group's text and make comments and suggestions. The group that received feedback responded to it in a written form. The students from both groups then revisited and revised the texts. The results indicated that students in the group that read the text and made suggestions made greater progress in their writing than students who received the feedback (Crinon & Marin, 2010). The authors suggested that this could take place because the reviewers had to reflect on the task instead of just receiving instruction on the task from their partners. These findings indicate that collaborative peer review process might be helpful if all students are involved in the reviewing process. A collaborative activity, group talk, might be used as a solution to engage all students in the class.

Aside from group roles in collaboration, the degree to which collaborative activities encouraged students to engage in discussion was also found to influence student learning. A case study of four students from a public, alternative school program for 6th-, 7th-, and 8th-graders in an urban U.S. area examined types of group talk that contributed to the development of scientific concepts. Simultaneously, the case study analyzed cognitive factors that influenced collaborative learning (Zinicola, 2008). The students participated in 12 science sessions and were asked to construct scientific explanations for 12 investigations that took place during these sessions. The results revealed that group talk advanced the learning for students for all the sessions. When both concrete and abstract elements were present in the activities, all students had higher learning scores. One possible explanation is that these activities offered challenges for the students and inspired them to talk. The materials collected also provided evidence for these theories under development. Activities with little visual evidence and obvious causal explanations resulted in little discussion. Additional results showed that students who talked more had lower gains (Zinicola, 2008). These conclusions should be taken with caution since the study involved only four students. It is still not clear how the findings would translate into the small group collaboration among students in a full classroom.. These results imply that group talk can help students learn and construct scientific knowledge. To have the greatest benefit, activities that are used for group talk should include both concrete and abstract elements.

The types of discussion that occur during collaborative work can also influence student outcomes. Another study (Howe & Tolmie, 2003) investigated the effects of the consensus, guidance, and discussion on student outcomes that occur during collaborative work. Students were assigned to one of four conditions: Type 1 students, who were required to discuss and reach a consensus with teacher guidance; Type 2 who students who were required to discuss an idea with guidance, but not reach a consensus; Type 3 students who were required to discuss and reach a consensus without teacher guidance; and lastly Type 4 students who were given guidance but were not required to discuss ideas or reach a consensus. All student groups were given a conceptual and procedural pre-test, were asked to complete a group task (with different combinations of coming to a group consensus, expert guidance, and group discussion), and then were provided with a conceptual and procedural post-test. Students in Type 1 group (discuss in small groups, reach a consensus, and receive guidance) scored equivalent to students in Type 3 group (only discussion and consensus) in regards to conceptual growth, but better in regard to procedural growth. Students in Type 1 group also scored equivalent to students in Type 4 group (guidance but no discussion or consensus) for procedural growth but better in regards to conceptual growth. Students in Type 2 group (discussion and guidance, but no consensus) showed the lowest growth of any of the other groups (Howe & Tolmie, 2003). Therefore, implementing discussion, consensus, and expert guidance in collaborative learning settings seems to provide a solution to the problem of integrating conceptual and procedural teaching. Other forms of collaborative talk have also been examined.

Winters and Alexander (2011) investigated what proportion of students' collaborative talk was indicative of forethought (planning), self-reflection (monitoring), performance (employing strategies), and motivational behaviors and how these behaviors related to learning outcomes. A sample of 54 high school students from three private and public secondary schools were randomly paired with a partner of the same gender and given 30 minutes to learn about the circulatory system, using a hypermedia learning environment. All students made significant learning gains from the pre- to the post-test. The proportion of all student utterances that were coded as performance, self-reflection, and motivation were significantly associated with gain and post-test scores. Students who had greater gains engaged in collaborative regulatory process (memorizing, reading notes, seeking consensus, summarizing, taking notes, evaluating content, and expressing feeling of knowing) to a greater degree than students with lower gains (Winters & Alexander, 2011). Although these results were positive, the authors cautioned the reader that unstructured peer collaboration using a hypermedia learning environment needs to be well thought through, as students have varying degrees of success using it. Therefore, some students might need a more structured collaborative environment or scaffolding in order to become successful learners/collaborators.

In a study with 150 secondary science students, Tao (2003) found scaffolding that during peer collaboration improved students' understanding of the nature of science (NOS) through peer collaboration (Tao, 2003). Students worked in dyads to take a pre-test, read four science stories, answered questions, discussed the stories, and took a post-test. While there were only marginal improvements in students' views of NOS from the pre- to the post-test, the peer collaboration setting of the instruction provided students with experiences of conflict and co-construction that helped them develop shared understandings of NOS. Many students, however, interpreted the science stories in ways other than that intended by the instruction and changed from one set of inadequate views of NOS to another rather than to adequate views (Tao, 2003). Science stories used in peer collaboration might provide students with the opportunity to discuss and construct arguments; however, this case suggest that the teacher should actively scaffold students' understanding to ascertain that adequate and correct views are being constructed.

Science Teacher-focused Studies. Other studies examined specific collaborative approaches and their influence on student outcomes. Jeon, Huffman, and Noh (2005) used a post-test only approach to compare the outcomes of a thinking aloud pair problem solving (TAPPS) approach with individual problem solving and control group problem solving approaches. Students in the TAPPS and individual problem solving groups were on how to use the two approaches. The students then used their assigned problem solving approaches during a seven-week unit in chemistry. Students in both the TAPPS and individual groups scored significantly higher overall than those in the control group on the problem-solving post-test. Students in the TAPPS group performed better than students in the individual or control group on the conceptual knowledge portion of the problem-solving test as well (Jeon et al., 2005). These results indicate that the TAPPS approach might be an effective method for a cooperative group problem solving.

The Jigsaw method is a traditional cooperative learning approach that is employed in many classrooms. Eilks (2005) used a participatory action research study to examine the use of the Jigsaw method in a chemistry classroom. The study specifically investigated students' opinions on learning in a Jigsaw classroom; whether students thought learning in a Jigsaw classroom had the potential to make chemistry learning more attractive, and whether it could help the students improve their communicative and social skills or their personal development. Students applied the Jigsaw method to learn about atomic structure over five, 45-minute class periods. Teacher's feedback on the method was obtained by researchers during the meetings scheduled. Students provided feedback through two types of surveys: open-ended and Likert-scale questionnaire. Teachers reported that, in comparison to traditional methods, students scored higher on tests when the Jigsaw method was used. The teachers also noticed that when using the Jigsaw method students' activity levels were high and intense. These two factors played a role in all of the participating teachers planning to use the Jigsaw method in the future. Students reported positive opinions about the Jigsaw method and liked science lessons more when the Jigsaw method was applied (Eilks, 2005). This study indicates that traditional cooperative learning approaches, such as the Jigsaw method, can be used in the classroom to increase student achievement and motivation.

Another specific collaborative strategy that has been studied is collaboration during natural field inquiry (Rozenszayn & Assaraf, 2011). A collective, instrumental case study was used to document 12th grade Israeli students' experiences with collaborative learning in a field-based ecology class. Students traveled to the Arava valley to conduct field research three times (for a total of 8 days) over the course of nine months. The researchers collected audio of students' discussions, student interviews, student observations, field notes, and student assignments. Students concentrated on discussing methods of measurement and observation when being in the open field, rather than the known methods from class (which are completely different from those used in the field). Another major part of their discussions was for knowledge construction, whereby students integrated prior knowledge into a new idea to determine whether they agreed, disagreed, or wished to modify their thinking regarding the idea. These discussions took place between students with the same or similar learning abilities. The role of the teacher was crucial during knowledge construction as she had to deal with and dispel misconceptions, as well as connect the low-ability with high-ability students (Rozenszayn & Assaraf, 2011). This study shows that natural field inquiry can present some unique opportunities for collaboration and knowledge construction, but the teacher still needs to have a presence.

The group investigation (GI) method is another form of collaborative inquiry that is used in science classrooms. Oh and Shin (2005) investigated students' perceptions of the positive and negative aspects of the GI method. Students wrote about their experiences with GI twice during an academic year. These written responses were collected and analyzed. Students reported several positive learning outcomes resulting from the GI implementation. The GI method prompted learning from peer interactions and provided students with ownership and motivation for learning. Some students considered the GI method inappropriate for them, especially those who had little interest in science and science learning or those that had rarely been exposed to inquiry-based approaches (Oh & Shin, 2005). These findings imply that specific strategies and scaffolding might need to be implemented by the teacher in order to enhance student participation in GI activities.

Teachers may need to undergo training in order to learn how to successfully implement cooperative learning in their classrooms. Thurston et al. (2008) examined how training urban and rural teachers in group-work skills effected student outcomes in science. Teachers from both urban and rural schools were recruited to take part in professional development on group work training activities for their students. The teachers were also provided with science materials that they could use to introduce group work practices in their classrooms. Students were given the Performance Indicators in Primary Schools (PIPS) as a pre-test, were taught group work skills by their teachers, were asked to use group skills during science lessons, and then were requested to take the PIPS as a post-test. The training and use of group skills occurred over the course of a school year. The results indicated that students in the urban and rural schools had statistically significant gains in science achievement as measured by the PIPS. Pre- and post-intervention observations also revealed that urban students made significantly more propositions; all students offered significantly more explanations to propositions after the intervention took place (Thurston et al., 2008). This study indicates that training teachers, who in turn train their students on effective group work skills, may increase student outcomes and influence the types of behavior that occur during collaborative group work.

Teachers use many different approaches to encourage collaborative activities in their classrooms. Pilouras and Evangelou (2012) used field notes, videos of lessons, student protocols, and teachers' reflective diaries to determine the approaches that teachers used in promoting collaborative inquiry conditions in the classroom. The results showed that teachers used the following socio-cultural principles and approaches: (a) inquiry as the organizing principle of curricular activities, (b) establishment of a collaborative community, (c) use of discursive strategies to scaffold students' learning, and (d) design of activities that bridge colloquial and scientific language (Pilouras & Evangelou, 2012). If teachers can implement these four principles and approaches appropriately, they may help students cross cultural boundaries and make school science more meaningful and relevant to them. The implementation of cooperative learning strategies can differ from teacher to teacher, even if they attend the same training.

One study (Siegel, 2005) explored the variations that occurred when teachers implemented a cooperative learning model in their classroom after learning about it from a peer leader who had attended 15 hours of professional development on cooperative learning. The study found that teachers developed concepts of cooperative learning based on their training from the peer leader and their classroom experiences. Teachers' teaching styles and their teaching context (lesson objectives, perceptions about student ability, task difficulty, curricular constraints, and opportunities for collegial support) influenced their decision making during lesson planning. Teachers needed to plan for cooperative learning and have the experience and knowledge to carry out those plans in order to implement cooperative learning in their classrooms. Before implementing cooperative learning in the classroom, teachers needed to consider several factors including their role in the classroom and how it might change, their current teaching and cooperative learning and how they might be integrated together, and their work with other teachers to develop new cooperative learning lessons (Siegel, 2005). Teachers might also use technology to help them implement collaborative activities in the classroom.

Science- Technology-focused Studies. Technology can be used to enhance traditional cooperative learning approaches. Zacharia, Xenofontos, and Manoli (2011) examined how the Jigsaw Cooperative Approach (JCA) and the Traditional Cooperative Approach (TCA) influenced students' learning, specifically their understanding of concepts related to ecology, architecture, energy, and insulation of CO_2-friendly houses. The students worked in pairs to complete a WebQuest on the design of a CO_2-friendly house. The students took a pre-test, completed the WebQuest according to their cooperative approach (JCA or TCA), and then took a post-test. Both groups had statistically higher post-test scores, but there was no significant difference between the two groups. One possible reason for this outcome is that the screen capture data revealed that the JCA group engaged in a working mode similar to the TCA group once they returned from their experts groups to their home groups. Instead of teaching others, the JCA group visited all the websites together, discussed and took notes once they returned to their home groups (Zacharia et al., 2011). This study indicates that traditional cooperative learning methods, including TCA and JCA, can be combined with online learning environments, such as WebQuest, to increase student learning. Teachers, however, need to ascertain that their students have skills to fully implement the traditional cooperative learning methods before combining them with technology.

Gallardo-Virgen & DeVillar (2011) also investigated how the Jigsaw method can be used in combination with technology using a comparison group, post-test only design. This study examined how the application of a collaborative approach that included student dyads, shared technology, and the

Jigsaw method influenced the academic achievement of 24 fourth-grade private school students in Mexico. Students in the experimental group worked in dyads and shared a computer screen, but each had their own keyboard and mouse. Each person in the dyad became an expert in a sub-theme and shared his/her new knowledge with a partner via the Jigsaw method. In the comparison group, each student worked individually on their own computer to study the information. Students in the experimental group scored significantly higher on the final assessment compared to the students in a comparison group, suggesting that students who shared computers did better than those working individually (Gallardo-Virgen & DeVillar, 2011). These results are important for schools that have high computer to student ratios as students could each have their own keyboard and mouse (which are relatively inexpensive), but share a monitor in order to collaborate together. Other studies have examined the use of specific online learning environments for collaboration.

Tan, Yeo, and Lim (2005) used a case study to examine the implementation of a computer-supported collaborative learning tool (CSCL), Knowledge Forum, in a 7th grade science research course. Students formed groups of three to four and performed three activities. They used Knowledge Forum to discuss the first and third activities. An analysis of the Knowledge Forum discussions found that students extended their discussions on scientific phenomena by using scaffolds related to identifying variables and stating hypotheses. Students reported that the online scaffolds within Knowledge Forum enhanced their scientific thinking and encouraged them to interact with and express their ideas to peers. Knowledge forum also allowed students to socially contrast knowledge (Tan et al., 2005). Another study (Oshima et al., 2004) also examined the use of Knowledge Forum as a collaborative tool in the science classroom. In this study, Knowledge Forum was used as for collaborative reflection on two science lessons in two 6th-grade classrooms. One lesson focused on hypothesis testing, where each student group completed its own investigation related to the same phenomenon; and the other was an open-ended collaborative construction activity, where each student group completed a portion of a one investigation of a phenomenon. The analysis of student discussions on Knowledge Forum revealed that students in both groups were more likely to share and discuss their ideas when they were aware of the fact that their ideas and thoughts are visible and sharable. Additionally, students in the collaborative construction activity were more likely to communicate both within and between groups, and were more idea-centered. They frequently shared their ideas with each other in the open-ended collaborative construction activity (Oshima et al., 2004). This indicates that more open-ended inquiry activities could lead students to being more involved in social construction of knowledge when they use an online learning environment, such as Knowledge Forum, to share their ideas. These two studies (Oshima et al., 2004; Tan et al., 2005) imply that online learning environments can be successfully used for collaboration and the social construction of knowledge.

Wikis are another method of collaborative learning where students collaborate with each other to construct knowledge. Pifarre and Staarman (2010) investigated how 9-10 year olds used wikis to collaborate with each other on a science project. The science project on Mars spanned 13 one-hour lessons. Pairs of students were prepared to collaborate together using the Thinking Together approach. The pairs then conducted research about Mars. Three pairs of students were grouped together to write a collaborative text in the Wiki environment about Mars. Each pair of students had a 10-15 minute period to work in the wiki. Contributions to the different spaces of the Wiki environment were collected and analyzed. Analysis of the Wiki environment revealed that the final Wiki product was a joint, collaborative effort and not just individual pairs' work. Furthermore, students collaborated and discussed their contributions during all their collaborative work in the Wiki environment (Pifarre & Staarman, 2010). This is another example of how online learning environments can be used to facilitate student collaboration.

The type of problems that students face in an online learning environment may influence how they collaborate. Kapur and Kinzer (2007) randomly assigned triads of students to either a well-structured or ill-structured problem-type treatment. The groups were than given two hours to solve a problem in a synchronous collaborative environment. The group members could only communicate via text-only chat and did not know each other's identities. Analysis of the groups' discussions and solutions revealed that the ill-structured problem groups engaged in more discussion about the problem. Nonetheless, it is vital to mention that, one or two members of the team tended to dominate the discussions. The domination of one or two group members was locked in early on in the discussion and had a negative effect on the discussion quality and group performance (Kapur & Kinzer, 2007). In order to make a CSCL beneficial to all students, teachers need to ensure that all students take an equal part in the discussions.

Other studies have focused on specific pieces of software for collaboration and communication. Looi, Chen, and Ng (2010) examined the extent to which GroupScribbles (GS) software could improve learning, participation, collaboration, epistemology, and attitudes toward science learning in two Primary 4 classes. GS is a software program that allows students to make notes on "scribble sheets" on the lower portion of a computer screen. The students can then share their "scribbles" on a public board at the top of the computer screen. Two classes (high and mixed ability) used GS for 10 weeks. Each week the classes had one GS science lesson for and one non-GS science lesson for an hour. The post-test scores revealed that students in the high ability class had significantly higher post-test scores than classes that did not use GS. The survey results showed that the GS activities also brought positive changes to students' epistemology and attitudes towards science learning. Analysis of classroom sessions' video, field notes, screen notes, and teacher and student interviews revealed that the whole class was engaged during the GS activities. Also, students took active roles in analyzing information, interacting with peers and teachers, solving problems, and designing solutions. The results imply that the use of GS has many benefits including (a) supporting instant formative feedback from students and teachers, (b) playing a positive role in both individual and group learning, (c) facilitating collaborative learning, and (d) increasing student engagement in collaborative learning activities (Looi et al, 2010). GS is just one example of a software program that might be used to increase collaboration in a science classroom.

Different types of technology can also be used to encourage collaboration. Kershner, Mercer, Warwick and Staarman (2010) studied how Years 4 and 5 students use interactive whiteboards (IWB) to collaborate with each other in science class. The analysis of video and interviews revealed that the IWB allowed students to: a) show their thinking on screen, b) reference background knowledge that was saved on additional screens, and c) receive support without the teacher needing to be physically present. The study also found that the IWB was better suited for different types of science tasks, such as (a) open-ended tasks, (b) series of tasks set up by the teacher that students can move through the tasks at their own pace, and (c) work that requires multiple tasks (i.e. discussion, visual representation, and note-taking) to complete (Kershner et al., 2010). It appears that IWB can be successfully implemented for collaboration on science activities, but the tasks must be suitable for the IWB.

Science Summary. The science literature discussed collaborative activities and the combination of collaboration and technology. It also examined other topics, such as: the role of prior knowledge in collaboration, students' roles in collaborative groups, the types of group talk and discussions that take place during collaboration, teacher training for implementing collaborative learning, and teachers' implementation of collaborative learning techniques in the class once they are trained. The science literature focused on specific collaboration activities and skills that could be incorporated without technology. These activities and skills included: thinking aloud pair problem solving, the Jigsaw method, natural field inquiry, and group investigation. Collaboration with technology was also studied and included wikis, software for collaboration, combination of traditional collaborative learning methods (the Jigsaw method) with technology, and other computer-supported collaborative learning environments. Measured outcomes included student achievement, collaboration skills, and students' perceptions of collaboration activities. Collaboration can be successfully implemented in a science classroom with the students reporting positive experiences.

Classroom Environment (non-content specific)

Some studies focused on how the classroom environment affected collaboration. Classroom environment can be defined in numerous ways. For the purpose of this synthesis, a classroom environment study examined how a classroom could be structured in order to encourage collaboration. Four studies focused on classroom environment and are summarized below.

Elbers and de Haan (2005) studied the social norms of collaborative work within a school and classroom. Using a sample of 22 seventh-grade Dutch students, the authors analyzed audio and video recordings of mathematics vocabulary-focused lessons. The authors investigated that the minority Dutch language learning students' opportunities for interaction were increased and supported by native Dutch-speaking students' assistance. Elbers and de Haan assert that this support was possible because the school and classroom had an assumed culture of peer collaboration. The authors purport, however, that although the native Dutch-speaking students supported the language learners, this relationship was potentially creating a dependency between the native speakers and language learners.

Gort (2008) examined the nature of peer interactions in a two-way partial immersion (Spanish/English) learning context during writing workshop. Gort collected data from field notes and corresponding audiotapes, semi-structured interviews with six-year old students, student artifacts, and classroom observations. The findings revealed that spontaneous peer collaborations emerged naturally and frequently within the writing workshop setting. These peer teaching/learning interactions provided opportunities for students to negotiate meaning with one another through hybrid literacy practices such as blending of Spanish and English, home and school registers, and formal and informal knowledge. This meaning making facilitated the development of bilingualism, biliteracy, and cross-cultural understanding for students. Gort suggested that for ELLs an environment, in which students are encouraged to mix their linguistically, socially, culturally hybridized experiences and ways of being, is essential in empowering students to collaborate with one another.

Martin-Beltran (2010) also examined a dual immersion setting to better understand meaning making for ELLs. The ethnographic study included fifth-grade students in a dual-immersion setting and collected data through field notes, observations, analysis of memos, student work, digital audio, and video recordings in order to understand the nature of student interactions. Martin-Beltran found that a hybridized, or mixed and open, language environment empowers students to collaborate and scaffold one another's language learning.

Unamuno's qualitative work (2008) based in Catalonia also highlights the role of a hybridized and collaborative environment for language learning. Using a sample of eight children, half of whom were language minority learners, Unamuno found that code-switching (or mixing more than one language) is a common practice both among children fully schooled in Catalonia and among those who enter its educational system at a later age. Unamuno also found that highly interactive contexts in which students engage with one another are essential in understanding and valuing how language minority students use language as a resource for learning.

Classroom Environment Summary. All four studies of classroom environment focused on linguistically diverse students. Three of the studies found that allowing students to mix their experiences and languages encouraged collaboration. These findings could also be applied to non-linguistically diverse students. All students come into a classroom from different background, experiences, and cultures, even if they speak the same language. Therefore, allowing students time to share their experiences with the class might help them to relate to each other and thus encourage collaboration. The fourth study found that a school and classroom environment of peer collaboration can encourage interactions between native and non-native speakers. Caution needs to be taken when placing non-native with native speakers because the first might become too dependent on the second ones. Again, these results can be applied to non-linguistically diverse students. Collaboration may be more productive if schools and classrooms create an environment of peer collaboration; however, care needs to be taken to ensure one group of students does not to become too dependent on another group for the academic success. Overall these four studies show that the classroom and school environment can help to encourage productive collaboration.

Social Context (non-content specific)

Another factor that can influence collaboration is social context, which is another term that can be difficult to define. The studies that are included in this section examine how race, gender, and peer status influence collaboration. Five studies met the criteria to be considered social context studies.

One study (Christianakis, 2010) examined how peer status, race, and gender played a role in peer writing events in a fifth-grade classroom. Field notes, audio, and writing samples that were collected during a yearlong ethnographic study revealed that peer status, race, and gender had an influence on peer-writing events. Peers with a higher social status were often sought after to be partners, while those with a lower social status were avoided. For females, high academic achievement was the major contributor to a higher social status, while athletics and friends determined which males were the most influential. The white children with a high social status were more influential during writing events than the children of immigrant, African American, and a low social status families

(Christianakis, 2010). The results for this study indicate that teachers need to be conscience conscientious of the roles peer status, race, and gender play in a collaborative process.

Parsons, Tran, and Gomillion (2008) examined how race affected student roles within racially heterogeneous science groups in an 8th-grade classroom. Students enrolled in a six-week science exploration elective course, where they were allowed to self-select their groups and were given a pre-test consisting of four standardized assessments measuring different aspects of spatial ability. Analysis of video, audio, and group worksheets revealed that the European-American students took the roles of a leader, supporter, and challenger in the small groups more frequently than their African-American counterparts of comparable abilities (Parsons, Tran, & Gomillion, 2008). These results further imply that race might have an effect on how students collaborate with each other in groups, thus requesting teachers to be mindful of this variable when placing students in collaborative groups.

In an observational study on collaboration with a sample of 22 multi-ethnic 7th grade Dutch students was conducted by De Hann & Elbers (2005). The authors sought to understand the relationship between ethnic diversity and student roles in a collaborative work. De Hann and Elbers found that in mixed-ethnicity groups, Dutch majority students always assumed the lead role, regardless of specific instructions from the teachers on shared leadership. Students' roles in collaborative groups could not be dictated by institutional demands or teacher requests; instead, the roles in collaborative group work had to be collectively negotiated by group participants. This study highlighted the socially complex nature of collaboration and suggested that teachers cannot simply "plunk down" a collaborative strategy in class and expect it to work.

Hakkarainen and Palonen (2003) studied patterns of participation in collaborative learning as a function of gender by comparing inquiry processes in two computer-supported elementary school classrooms (*n* = 58). The results of the study indicated that only one of the classrooms engaged in a progressive discourse focused on collaborative advancement (in research-focused inquiry task) of explanation whereas the other classroom performed more traditional learning tasks (used computers for traditional class work). The female students participated most actively in the progressive-discourse classroom whereas male students dominated discourse interactions in the other class. This study suggests that teacher should be aware of how a variety of factors, including gender, might have an influence on the extent to which students participate in computer-based collaboration.

Esiobu (2011) studied how cooperative learning effected gender equity and peace in a high school biology classroom. Students completed a gender equity and peace questionnaire, practiced cooperative learning for two weeks, participated in cooperative learning for an extended period of time, and then retook the gender equity and peace questionnaire again. Analysis of the questionnaires showed that students' scores on the gender equity and peace questionnaire increased after participating in cooperative learning. The increase in scores occurred for both genders and students of all ability levels (Esiobu, 2011). This implies that gender equity and peace in science classrooms may be promoted by extended cooperative learning experiences.

Social Context Summary. Four of the five studies on social context found that gender, race, and peer status can influence the manner in which students collaborate with each other. These factors often have a negative effect on collaboration. Therefore, teachers should be aware of these aspects when placing students into collaborative groups. One study found that long term opportunities for collaboration may increase gender equity and peace. This implies that collaboration may help students to better understand each other if they are given the time to do so. There are definitely many factors for teachers to consider when requesting students collaborate, but when these factors are accounted for, students might have a successful collaboration experience.

Technology (non-content specific)

A handful of studies focused on the influence of technology on student collaboration, but did not pertain to a specific discipline. These studies explored knowledge transmission in minimally invasive learning stations and student views on collaboration in an online setting. Because there are only two studies in this section, the individual studies appear together in one group.

Dangwal and Kapur (2009) explored how knowledge is exchanged, shared, and acquired by students engaged in minimally invasive education learning stations (MIELS). Minimally invasive education is a pedagogic method that uses the learning environment to engage learning in groups of children, with little, or no, intervention by a teacher. The learning stations, typically featuring an interactive screen, serve as provocations for student learning. The mixed methods study included low inference and high inference observational data, as well as individual interview data with 250 children ages 6 to 14 in India. The authors found no differences in quantity or quality of knowledge exchange and acquisition by gender. Children at the MIELS predominately engaged in learning strategies as a group that included trial and error, rehearsal, demonstration, verbal inputs, and observation. Findings revealed that children acquired knowledge on two social and individual levels. Children first interacted socially with peers in order to draw on others' experience and then worked with MIELS individually to consolidate learning.

Chan and Chan's quantitative study (2011) examined 521 secondary students' (ages 12-17) views on collaboration and online participation in the Knowledge Forum learning platform. Using survey and frequency data for Knowledge Forum participation, the authors found that students, who stated that they preferred collaborative learning to individual learning, were more inclined to engage in collaborative knowledge building within Knowledge Forum. Yet these students did not participate online more often than students who did not prefer collaborative learning. The findings suggest that even students, who are inclined to work collaboratively, need encouragement and specific scaffolding in order to participate more often in online contexts.

Technology Summary. The studies in this section describe the use of technology platforms (MIELS and Knowledge Forum) in supporting student collaboration. The MIELS allows children to gain knowledge both socially and individually. However, students who prefer collaborative learning did not participate in the Knowledge Forum any more than students who did not prefer collaborative learning. This implies that though technology may be a viable means of supporting knowledge growth, all students might need scaffolding in order to use technology to its fullest potential when collaborating.

Cultural and Linguistic Diversity (non-content specific)

The seven studies focused on cultural and/or linguistic diversity without a specific disciplinary context included a variety of approaches to research, with three qualitative studies, three quantitative studies, and one mixed methods study. The studies examined collaboration in cultural and linguistically diverse contexts. They also included culturally and linguistically diverse students such as ELLs and English as a Foreign language (EFL) students. The studies addressed the social and linguistic interactions among diverse students in collaborative settings and students' perceptions of collaboration.

*Cultural and Linguistic Diversity- Student-focused Studies***.** Xu, Gelfer, Sileo, Filler, and Perkins's (2008) qualitative study examined the influence of a class-wide peer tutoring intervention on seven ELLs and seven native English-speaking students (NES) in a primary classroom. Findings from classroom observations suggested that the peer tutoring intervention increased the amount of interaction amongst both ELLs and NES. Every child in the study showed a significant increase in all seven positive social interaction behaviors over the course of the study. Additionally, the incidences of negative behaviors were lessened in peer tutoring situations relative to non-intervention settings.

Gagne and Parks (2013) also examined children's interactions in collaborative learning settings. More specifically, the authors sought to understand how children in an intensive 6th grade ESL class in Quebec scaffolded each other during three cooperative learning tasks: numbered heads together, jigsaw, and round robin. Nine different types of scaffolding strategies emerged from the analysis of data received from video-taped recordings, observations, and student interviews: request for assistance, comprehension check, co-construction, confirmation check, continuer, instructing, marking of critical features, other-correction, and use of resources. Although the students invoked a variety of strategies, the two most frequently used were request for assistance and other-correction (53.9% and 23.9%, respectively). Combined together, these two strategies thus accounted for 77.8% of methods used. This analysis also revealed that 73% of scaffolding attempts were successful (scaffolding strategy that was initiated had a successful outcome- the error was corrected). The students invoked twice as many scaffolding strategies while carrying out the Round-robin task as neither the Heads Together or Jigsaw tasks, suggesting that perhaps certain cooperative approaches are more effective at promoting scaffolding than are others. Overall, the findings suggest that ESL learners are able to offer language scaffolding to peers in the context of cooperative learning settings.

Liang (2004) investigated immigrant students' (*n*=49) perceptions of cooperative learning experiences and the interactions with the students during cooperative learning activities in high school ESL classes in the United States. The students were from Taiwan, Hong Kong, and China. Using naturalistic observations and interviews, Liang found that the Chinese students in the sample reported multiple and contradictory views of cooperative learning. Both students had contradictory views on cooperative learning: with one student enjoying and the other student disliking working in groups. Observational data suggested that these students demonstrated cooperative and uncooperative behavior during collaborative work that seemed to be influenced by conflicting values and experiences from their cultural, socio-economic, and educational backgrounds. Overall, the findings suggested that a variety of factors mediate this group of students' preferences for and against cooperative learning.

Cultural and Linguistic Diversity Teacher-focused Studies. With a sample of 44 13- and 14-year old Korean female students who were learning English as a Foreign language, Kim and McDonough conducted a quantitative study (2011) that examined the influence of pre-task modeling on language-related episodes (LREs) and collaboration. An LRE describes a meta-awareness in language use, that is any part of a dialogue where language learners talk about the language they are producing, question their language use, or correct themselves or peers. The authors found that learners who received pre-task modeling from the teacher were significantly more likely to produce language, offered more LREs and correctly resolved a greater proportion of those LREs than learners who did not receive any models. Students who received pre-task modeling also demonstrated more collaborative interaction than learners who did not receive any models.

In another study, Brooks and Thurston (2010) studied the effects of teachers' grouping choices on academic language production for ELLs (n = 28) in grades six to eight. Using an eco-behavioral approach, the authors examined the percentage of time that students engage in academic behaviors during whole group instruction, small group instruction, one-to-one instruction, and individual instruction. The authors found that the most predominant grouping configurations (whole group and individual) were the least likely setting in which students would produce academic language. Students were more likely to produce academic language in small group and 1:1 instruction. Overall, the study documents the positive effect on academic language of small group settings for ELLs.

Cultural and Linguistic Diversity Technology-focused Studies. Chen, Chen, and Sun (2010) developed and evaluated an online Tag-based Collaborative Reading Learning (TACO) system to improve English reading comprehension and aid teachers in accurately evaluating English literacy of 56 EFL students at a senior high school in Taiwan. TACO makes use of Web 2.0 tagging capabilities in order to support English reading in a collaborative environment. Using a pre- and post-test experimental design, both the control and treatment groups were taught how to use the Intelligent Web-based Interactive Language Learning (IWiLL) platform. The treatment group was also taught how to use the TACO tagging method in IWiLL. After taking a pre-test both groups read the same assigned material. The experimental group used iWiLL and TACO to read the material while the control group used a standard reading approach and discussed the material using iWILL. After reading the material both groups took a post-test. Students in the experimental group scored significantly higher on the reading comprehension post-test than did students in the control group. Students also felt that the TACO system was easy to use and could help them increase their English reading comprehension. Additionally, manual scoring by experts was highly correlated with scoring by the TACO system indicating that the TACO system could be used by teachers to evaluate student progress (Chen et al., 2010). This study provides further evidence that collaborative online reading can be beneficial for students' reading comprehension.

Lin, Chan, Hsiao (2011) also studied the effect of technology on EFL students' English vocabulary learning, as well as students' perceptions of computer-supported collaborative environments for language learning. The experimental study included three groups of 8th-grade Taiwanese EFL students: individual students learning without computers, students engaged in collaborative learning without computers, and students involved in collaborative learning with computers. Students did not outperform other students when learning vocabulary through a computer. However, students who used the computers had a more positive attitude toward learning vocabulary. The findings suggest that while computers may not be a significant factor in EFL student vocabulary outcomes, students' positive perception of the computers as a tool for vocabulary learning may be an important factor to consider.

Cultural and Linguistic Diversity Summary. The literature focused on cultural and linguistic diversity. The collaboration addressed the benefits of collaborative work for language learners. It also examined other topics, such as: the potential for technology tools (e.g., TACO) and specific instructional strategies (e.g., round robin), to support the collaborative work of diverse students; and the importance of modeling expectations for collaborative work. The measured outcomes included student academic language production, language use, students' perceptions of collaboration activities, quality and quantity of student interactions, and vocabulary and reading achievement outcomes.

Assessment (non-content specific)

The eleven articles that focused on assessment in a variety of disciplines and learning contexts included a variety of approaches to research, with one qualitative study, five quantitative studies, four mixed methods studies, and one historical review. The studies examined the assessment of collaboration in K-12, undergraduate, and graduate contexts from the point of view of both students and teachers. Additionally, studies focused on assessing collaboration with and without technology, in both computer-supported collaborative learning (CSCL) and face-to-face environments.

*Assessment- CSCL-focused Studies***.** In a 2006 study with 119 ninth grade students in Hong Kong, Lee, Chan, and Van Aalst examined the role of portfolio assessment in student demonstration of knowledge building in a CSCL environment where students used Knowledge Forum for after class discussions. The study findings showed that portfolios contributed to students' conceptual understanding above and beyond academic achievement, Knowledge Forum database participation, and individual inquiry scores. Lee et al.'s (2006) research suggests that electronic portfolios allow for assessment of both content and the collaborative process and require students to both analyze collaborative work and refine their own understanding as they seek to explain knowledge building episodes in Knowledge Forum. This method of assessment, coupled with the use of Analytic Toolkit software to analyze database participation, may be easier for teachers to use to assess student reflection based on notes in Knowledge Forum, rather than having to sort through hundreds or thousands of notes to assess a level of collaboration themselves.

In a follow up study involving 189 ninth- through twelfth-graders, Van Aalst and Chan (2007) sought to describe specific elements in the knowledge building portfolio approach and pre/post changes in student domain knowledge related to a Knowledge Forum task. Study findings showed that student portfolios were able to demonstrate levels of understanding of the principles of their tasks. In addition, statistically significant correlations were found between teacher ratings of student portfolios and gain scores on the domain exam. Van Aalst and Chan provided five design principles for integrating learning, assessment, and collaboration, which include the following: (a) developing a culture of collaboration, (b) embedding assessment in learning activities, (c) making students assessors and maximizing student agency, (d) establishing criteria for self- and peer-assessment, and (e) designing reflective assessment tasks.

The above studies were an operationalization of Chan and Van Aalst's earlier work (2004), in which the authors discussed the dilemma of whether to assess knowledge or social gains in CSCL environments and Individual or group learning. Though much of the CSCL evaluation at the time, and currently, involves individual contribution to the dialogue, the analysis of dialogue does not necessarily gauge learning. Additionally, Chan and Van Aalst noted that CSCL assessment practices are often not as in-depth as learning practices, which creates a need to align them with learning, assessment, and collaboration. In other words, CSCL and other collaborative learning environments need to align social constructivist ways of learning, which view knowledge as a social construction, to how that constructed knowledge is assessed.

Guzdial and Turns (2000) conducted a study with 82 undergraduate engineering students exploring how individual student contributions progress over time in the Collaborative and Multimedia Interactive Learning Environment (CaMILE) in an undergraduate engineering course. Study authors used descriptive statistics to analyze the number of posts per discussion thread, the content of related topics, and the number of notes written per author. The authors found that most of the notes were written by students, with the duration of threads lasting an average of 3 notes. The limited thread duration suggested that CaMILE, and perhaps other CSCL environments, are not being used in a way that is conducive to learning, with limited conversations occurring between students. Study authors noted that this means of counting postings and thread duration, rather than analysis of individual student postings, though perhaps not sufficiently detailed, is both necessary and practical because “real teachers in real classrooms need measures that allow one to quickly gauge whether conditions conducive to learning exist” (p. 228).

Assessment. Non-CSCL-focused Studies. In a study with 4th through 6th grade students, Yarnall, Penuel, Ravitz, Murray, and Means (2003) investigated how handheld technology might be utilized to assess collaboration in a face-to-face classroom environment. Both students and their teacher used the TeamLab software to assess research-based aspects of collaboration. Analyzing pre/post teacher collaboration interviews, pre/post teacher and student usability interviews, and pre/post student collaboration surveys, the researchers discovered that both teachers and students found the technology easy to use while walking around observing. In addition, students adopted dimensions of the instrument as part of their collaborative practice. A final benefit noted by Yarnall et al. was that handheld technology supported collection of data over time that could be aggregated into larger data sets for both student and teacher reflection on group work practices. Challenges of using the handheld technology included the limited capability of the software and a limited number of assessment categories to capture the situation being observed. Researchers also found a mismatch between researcher, teacher, and student conceptions of the dimensions of collaboration.

Five studies utilized triangulations between multiple measures to assess various aspects of collaboration, including learning, the collaborative process, and feelings associated with collaboration. In a study with eight undergraduate computer science students, Fernandez-Breis, Castellanos-Nieves, and Valencia-Garcia (2009) examined how individual learning during group work might be assessed by comparing individual student semantic networks of his/her learning (similar to concept maps) related to a task to the semantic networks of the teacher and other students. Students were scored and ranked in terms of factors, including degree of overlap in the individual and group ontologies, innovation, the individual ontology compared to the group, and support received by other students. Students were also scored and ranked based on similarity of their ontology to the teacher ontology. The semantic network instrument was able to measure and rank student differences in quality of group work, individual work, and student contribution to the group using a comparison to the teacher's representation of material to be learned.

In another study with undergraduate students, Summers, Beretvas, Svinicki, and Gorin (2005) used multiple measures to assess the effects of collaborative learning on feelings of campus connectedness, academic classroom community, and effective group processing. The study utilized pre/post surveys on three measures: the Social Connectedness Scale, Academic Classroom Community Scale, and Group Processing Scale, with classes both engaged and not engaged in group work. Study authors found high internal consistency between the scales (Cronbach's alpha between .80 and .92) of the multiple measures, as well as high test-retest reliability between pre- and post-assessment in all three measures (between .73 and .76). Findings indicated that levels of perceived collaboration contributed to a heightened sense of community in undergraduate classes.

With a group of 471 nursing students and 167 small group problem-based tutors, Ladouceur, et al. (2004) developed a reliable and valid method of measuring individual student performance related to self-directed learning, critical thinking, and group process participation in small group tutorials in nursing education. The instrument, based on problem-based, self-directed small group learning, employed an integrated theoretical and psychometric approach. Study findings showed the instrument to be a valid and reliable measure of expectations of tutorials from the perspectives of both students and tutors. A correlation of 0.82 was found between tutors' assignment of grades to students and student scores on the instrument. Additionally, student feedback indicated that the instrument provided clear breakdown of expected tutorial performance. A drawback of the evaluation method includes the length of time it took to complete the instrument (about 10 minutes per student).

Wang, MacCann, Zhuang, Liu, and Roberts (2009) expanded the use of multiple measures of collaboration to their work with 159 high school students in order to determine whether a multiple method assessment system could reliably and validly measure teamwork in younger students. Students participating in the Ford Partnership for Advanced Studies (PAS) courses were tested using three instruments (Situational Judgment Test, self-report teamwork assessment, and student self-reported grades) in one 45-minute session. Correlations were found among teacher report, student self-report, and situational judgment test methods. Student age was significantly positively correlated with the Situational Judgment Test and the student self-report score, indicating that older students might have completed self-reports accurately and might have conducted an accurate judgment of the quality of a collaborative situation. This method of triangulation of assessment may provide advantages for classroom teachers, who are unable to appropriately rate student collaboration with the workload in a typical class, as it puts the majority of the workload for assessing collaboration on students instead. In addition, study authors noted that teachers might not be able to accurately capture all of the elements of collaboration through simple observation.

In a study using multiple measures conducted with 132 fourth and fifth grade students, Hurley and Allen (2007) explored whether process loss behaviors could be accurately assessed in the observed behavior of students working in groups of three on a math task. Using video coding, researchers analyzed *a priori* themes from the group process literature. Additionally, participants took a Process Loss Questionnaire and pre/post-math tests. Principle factor analysis was used to determine underlying relationships between the instruments and observed behaviors. The study found correlations between student self-reports of group work on the Process Loss Questionnaire and observed behaviors, indicating that it may be better to quantify specific actions rather than general behaviors, such as engagement. In addition, two of the assessed variables related to process loss outside of the group ("spacing out" or focusing on actions happening outside of the group), were negatively correlated to post-test performance, indicating that those behaviors do have both a measurable and observable effect on performance.

Finally, two studies examined teacher concerns related to the assessment of collaboration. Frydekal and Chiriac (2011) investigated teacher concerns related to assessment of learning during and after group work. The study analyzed interviews with 11 Swedish teachers of students aged 11-16. Using grounded theory combined with symbolic interactionism, researchers chronicled teacher concerns with assessing learning outcomes related to group work. The study discovered that teachers primarily used informal approaches, such as informal listening or matrices, and were only able to vaguely describe what was assessed. Teachers tended to focus more on assessment of collaboration rather than assessment of learning from collaboration. Challenges mentioned by teachers included the questions pertinent to assessment of group work, limited time for observations, and group work in different locations. In addition, teachers only assessed products at the group level and group work, but not at the learning level. Authors recommended (a) that teachers and students create assessment tools together; (b) that teachers take advantage of opportunities to discuss collaboration assessment issues; and (c) that teachers clarify the what, when, and how of assessment before a collaborative task is undertaken by students.

Ross and Rolheiser (2003) combined a survey of teacher concerns related to assessment of cooperation with a research synthesis on teacher-identified issues. In a survey of 79 teachers attending an educational conference, three major themes emerged related to assessment of collaboration: what to measure (cooperative skills versus content), how to measure (guidelines to observe cooperative groups), and with what to measure (techniques and tools for assessment). With regard to what to measure, the study highlighted Slavin's (1995) findings where both individual and group accountability showed medium effects (0.32) compared to measuring group or individual alone. Researchers cautioned against assigning group only grades as they inflate the scores of lower-achieving students and concurrently lower the scores of higher-achieving students. In a discussion of what to measure, authors suggested assessing both contributions of individual group members to group learning based on help-giving and help-seeking behaviors and contributions to group productivity. Finally, with regard to techniques and tools of assessing cooperation, researchers recommended that teachers involve students either in peer or self-assessment or in the creation of criteria for assessment. Both are correlated to achievement and motivation in collaboration. Portolio assessment, reviewed in other studies, may also provide students with a means of demonstrating their knowledge.

Assessment Summary. In a 2000 article on the historical role of assessment in learning, Shepard noted that as the role of learning has expanded into constructivist views, which includes collaborative learning, the role of assessment must also expand to include, “observations, clinical interviews, reflective journals, projects, demonstrations, collections of student work, and students' self-evaluations" (p. 8). The assessment literature focused on both the use of technology, such as electronic knowledge portfolios (Analytic Tool Kit software) to examine student interactions, and handheld instruments to assess the quality of student collaboration, and learning resulting from it. In addition, researchers also examined the need for the creation, use, validation, and correlation of multiple measures of both student collaboration and learning resulting from collaborative processes. From both researcher and practitioner perspectives, multiple measures contribute to creating a full picture of collaborative learning, which is a complicated process that cannot be solely captured by one form of assessment. There is a need to include all educational actors—researchers, teachers, and students—in the process of creating instruments that capture the collaborative process and what students are able to learn as a result of engaging in it.

Implications for Practice and Policy

In addition to the synthesis study findings, the research team conducted an analysis of the discussion section of each article as well as stated implications for practice. Tables 3.1- 3.8 provide the most salient aspects of effective collaborative practice from studies within each subject and focus area. Because there were not enough technology (non-content specific) studies to collapse findings across studies and develop research-based suggestions for practice, technology is not separately mentioned in this section.

In many cases, there are overlaps between subjects in terms of the important collaborative aspects. This is not a surprising finding, given that the importance of student collaboration and cooperation has been recognized by researchers and public and private institutions for over 30 years (Aronson, Stephan, Sikes, Blaney, and Snapp, 1978; IBO, 2013; Johnson & Johnson, 1975, 1987, 1989, Johnson, Johnson, & Holubec, 1998; SCANS, 1991; Slavin, 1983). Column three of Tables 3.1-3.8

illustrates Instances where our research synthesis findings were related to practices showing effect sizes in our meta-analysis of quantitative studies.

Table 3.1 Reading/Writing Implications for Practice

Discipline	Key Suggestions for Practice	Related Effect Size Measures
English Language/Reading	Successfully navigating collaborative work requires guidance and instruction from the teacher	Role of teacher**
	Students should be taught how to use metacognitive strategies when collaborating on reading tasks.	
	Teachers need training on how to scaffold students during collaborative activities.	Role of teacher**
	Teachers should give struggling readers an extended period of time to become comfortable in small groups.	
	When conducting collaborative writing activities, teachers may need to direct students to share their writing with a new partner. This might allow students to receive more beneficial comments and feedback then if they selected the same partner numerous times.	Role of teacher** Grouping method***
	Collaborative online reading can help to increase students' reading achievement.	Computer assistance***

*** High effect size, ** Moderate effect size, * Low effect size

Table 3.2 Humanities/Social Sciences Implications for Practice

Discipline	**Key Suggestions for Practice**	**Related Effect Size Measures**
Humanities/Social Sciences	Consider individual student characteristics when implementing collaboration in the classroom.	Grouping method***
	Teachers may need to be trained on how to effectively use collaboration in their classrooms. They, in turn, may need to train their students on effective collaboration practices.	Role of teacher**
	Technology can be used as a tool for collaboration. Some forms of technology, such as computer-supported collaborative learning environments, might be less successful depending on the setting in which they are used.	Computer assistance***
	Teachers need to remember that online collaborative learning environments are not socially neutral. Therefore, socio-cultural factors need to be considered even when using technology and online learning environments.	Grouping method*** Computer assistance***

*** High effect size, ** Moderate effect size, * Low effect size

Table 3.3 Mathematics Implications for Practice

Discipline	Key Suggestions for Practice	Related Effect Size Measures
Mathematics	Collaborative mathematics work must be situated in a culture of collaboration. Teachers can model this by assuming the role of facilitator and coach, rather than the leader of the discussions.	Role of teacher**
	Open-ended mathematical tasks tend to encourage more student collaboration and collaboration of higher quality.	Task type**
	Teachers need to provide explicit instructions, expectations, and modeling in order to set students up for success and equitable involvement in collaboration. Students do not "naturally" know how to work collaboratively in mathematics class.	Role of teacher**
	Students need extended time for collaboration, in addition to other tools, such as manipulatives, that allow students to make visible their mathematical thinking.	

*** High effect size, ** Moderate effect size, * Low effect size

Table 3.4 Science Implications for Practice

Discipline	Key Suggestions for Practice	Related Effect Size Measures
Science	Heterogeneous partners may help students construct new knowledge, but extreme high achievers should not be paired with extreme low achievers.	Grouping method***
	Collaborative and group talk can also help students construct new knowledge, but structure might need to be provided.	Structure of collaborative process**
	Teachers need to scaffold their students to ascertain that cooperative learning activities are being used appropriately and that correct knowledge is being constructed.	Role of teacher**
	Collaborative technology can be used to encourage collaboration, socially construct knowledge, and increase student achievement in the science classroom.	Computer assistance***

*** High effect size, ** Moderate effect size, * Low effect size

Table 3.5 Classroom Environment Implications for Practice

Discipline	Key Suggestions for Practice	Related Effect Size Measures
Classroom Environment	Teachers should strive to provide diverse students an open and accepting learning environment in which a multiplicity of language discourses, ways of being and ways of knowing are encouraged.	Role of teacher**
	Collaborative work and cooperative learning are not a value neutral teaching approaches. Teachers and schools should take into consideration students' socio-cultural and academic values, experiences, backgrounds, and experiences in planning and implementing student collaboration.	Role of teacher**

*** High effect size, ** Moderate effect size, * Low effect size

Table 3.6 Social Context Implications for Practice

Discipline	Key Suggestions for Practice	Related Effect Size Measures
Social Context	Mixed age and ability grouping for collaborative work vary in terms of outcomes. In grouping students for collaborative work, teachers need to be careful of student status and other individual variables that can affect collaboration.	Grouping method***
	Teachers should consider the social complexities of collaboration.	Role of teacher**
	Cooperative learning can increase gender equity and peace in a science classroom.	
	Teachers need to be mindful of race when they place students in collaborative groups as it might have an effect on how students interact.	Grouping method***

*** High effect size, ** Moderate effect size, * Low effect size

Table 3.7 Cultural and Linguistic Diversity Implications for Practice

Discipline	Key Suggestions for Practice	Related Effect Size Measures
Cultural and Linguistic Diversity	Teachers need to explicitly model language in cooperative learning tasks.	Role of teacher**

*** High effect size, ** Moderate effect size, * Low effect size

Table 3.8 Assessment Implications for Practice

Discipline	Key Suggestions for Practice	Related Effect Size Measures
Assessment	Use of multiple measures to triangulate student learning and performance	
	Involvement of students for self- and peer-assessment of collaboration	Role of teacher** Role of students*
	Comparison of student learning to pre-specified outcomes (may be based on comparison to teacher ontologies of learning)	Role of teacher**
	Measure both collaborative process and learning resulting from process	Task type**
	Consider inclusion of technology (handheld or analytic software) to collect data over time and efficiently analyze large electronic data sets	Computer assistance***
	Use of portfolios allows students to refine their own knowledge as well as represent and measure effective aspects of collaborative process with a group	Task type**

*** High effect size, ** Moderate effect size, * Low effect size

Conclusions

The best evidence synthesis of research on student collaboration in K-12 settings revealed several major themes of successful collaborative processes. The role of the teacher, found to have a moderate average effect size in the meta-analysis, was highlighted across implications for practice in all subject areas, present in a total of 13 of the 31 suggestions. The importance of the teacher's role in scaffolding and supporting students in any collaborative process, regardless of the type, cannot be understated.

Grouping method and specific grouping formats were mentioned in three of the five subject areas (reading/writing, humanities, and humanities) under 6 of the 31 implications for practice in three of the 5 subject areas (reading/writing, humanities, and twice in science). The analyses confirm that purposeful instructional decisions on how to put students into groups are both complex and critical to increasing student achievement and motivation with regard to collaboration.

Technological advances in recent years have made the educational use of technology not only more accessible by students in classrooms, but also critical to student success in an increasingly wired and networked world. Research on the role technology plays in enhancing student collaboration showed it to be an effective component of student collaboration. Shown to have a high average effect size in the meta-analysis, technology was mentioned in 5 of the 41 implications for practice across three of the 8 focus areas.

Even though the variables including the role of students, task type, and structure of the collaborative process were all shown to have at least some effect on student success in the meta-analysis, these 3 themes were not strongly related to implications for practice from the research synthesis. This is possibly due to the fact that teacher's role, grouping method, and technology might be primary considerations when designing a study on collaboration, while task type, individual roles for students, and structure of the collaborative process could be subsumed under those larger considerations.

In contrast to the above themes that showed a positive effect on student success, yet were not major themes emerging from the research synthesis, two themes not found to show effect sizes in the meta-analysis were present in studies from multiple subjects in the research synthesis. Findings of mathematics and cultural and linguistic diversity studies highlighted the importance of teacher's consideration of the social complexities of the collaborative process and students' socio-cultural and academic values, experiences, and backgrounds. Additionally, mathematics and reading/writing studies noted the importance of extended time provision for cognitive processes involved in collaboration, such as students reading together or building and showing external representations of their thinking to others.

CHAPTER 4: IB Curriculum Document Content Analysis

Overview of Documents

Curriculum documents provided by IB were coded based on *a priori* themes pertaining to student collaborative learning (CL). These themes were clustered into three components: overall aspects of collaboration, teacher factors related to collaboration, and student factors related to collaboration. The first component, *overall aspects*, included four themes: theoretical model on which collaboration is based, a definition of collaboration, description of technology used for collaboration, and mention of specific form(s) of assessment for collaboration.

The second component, *teacher factors* related to collaboration, was composed of seven themes. These included the following: role of the teacher in student collaboration; evidence of professional development or training for the teacher on student collaboration; scaffolding of student work for collaboration by the teacher; teacher modeling of collaboration for the students; teacher-led discussion or debriefing on the quality of student collaboration; grouping rationale to facilitate collaboration; and consideration of task structure on the enhancement of student collaboration.

The final component, *student factors* related to collaboration, contained five themes. These themes were: suggested group format (e.g., size); suggested group structure to enhance collaboration (heterogeneous/homogeneous by gender, ability, language, etc.); suggested individual roles within the group roles; expectations for group products during collaborative activities; and expectations for group process during collaborative activities.

In addition to a percent score for the three components for each document, an overall score for collaborative learning was calculated as a sum of all 16 themes, and a sum count of the terms “collaborative”, “collaborate”, and “collaborating” was made for each IB curriculum document. Mean, minimum, maximum, and standard deviation were calculated among the components for the purpose of comparison among categories. Comparisons were made among the PYP, MYP, and DP programmes. Comparisons were also made within each program among the different subject groups where appropriate (e.g., interdisciplinary, performing arts, social studies, language, science, and mathematics). In total, forty-three IB curriculum documents were coded using the *International Baccalaureate Student Collaboration Content Analysis* coding instrument. Table 4.1 summarizes the different categories within the 47 documents. Appendix F provides a list of all IB documents that were coded.

Table 4.1. IB Coded Curriculum Documents (Summary by Programme and Discipline)

IB Programme		
	General/All	3
	PYP	10
	MYP	10
	DYP	20
	IBCC	4
Content Area		
	Interdisciplinary	23
	Language	4
	Math	7
	Science	9
	Social Studies	2
	Performing Arts	2
Total		**47**

Every IB curriculum document examined for this study contained at least one reference to collaboration as a student expectation. This consistent reference among the documents comes from the IB Learner Profile. The IB Learner Profile is the core or foundational starting point for each IB programme. Under “communicator” in the Learner Profile, collaboration is specifically mentioned as such:

> They [students] understand and express ideas and information confidently and creatively in more than one language and in a variety of modes of communication. They work effectively and willingly in *collaboration* with others.

In addition, collaboration is a stated expectation under Approaches to Learning (ATL) specifically in the area of social skills. 'Approaches to learning' is an attribute of all the IB programmes but it appears to be more emphasized in the Diploma Programme. Collaborative is also proposed as a category under 'Approaches to Teaching' (Approaches to teaching and learning across the DP, p. 3).

Student collaboration is often inferred, or assumed, within discussions of inquiry and when describing groups of students working together. Cooperative learning, as well, is sometimes used in the curriculum documents interchangeably with collaborative learning. 'Students working in pairs or groups' is an assumed prerequisite for collaborative learning. 'Students working in groups', however, does not ensure that collaborative learning is taking place. Even though collaborative learning is a clearly stated expectation, evidence of what it is, why it is beneficial, or how to accomplish it is generally lacking in the documents analyzed. Variation among the documents and within the content areas exist. Some documents are more effective in addressing the why and the how of collaborative learning (for example "ATL in the DP") than are other articles. None of the documents analyzed provide a directly stated definition of student collaboration. The following sections discuss coding results by IB programme providing details on specific themes identified in the literature.

Content Analysis Findings

General IB Curriculum Documents

Three documents pertaining to the IB Learner Profile, applicable to all IB programmes, were analyzed for evidence of an emphasis on student collaboration. None of the three documents were applicable to student collaboration. The activities described were intended for adult stakeholders, but not for students. Collaborative learning strategies were present. However, these were considered as if they were intended for students. As a result, the Learner Profile documents had a strong element of student factors for collaboration. Specifically, there were explicit suggestions made for facilitating collaboration related to grouping, rationale for grouping, and expectations stated for group products and process. A general gap, observed throughout the IB curriculum documents, is that even though collaboration is a clearly stated expectation**,** description of what collaboration is and why collaboration is chosen as an instructional goal is not stated.

Primary Years Programme Curriculum Documents

Ten curriculum documents specific to the Primary Years Programme were analyzed. Six of the ten were general curriculum guides covering broad program standards/expectations, such as the PYP exhibition (a capstone project completed in the last year of PYP), transdisciplinary learning, and the role of information communication technologies (ICT) in the PYP. Four of the ten documents were content specific subject curriculum guides covering language, mathematics, science, and social studies. When coding for the 16 themes, coders marked one of three options: “direct” if a theme was explicitly stated and in relation to collaborative learning, “inferred” if a theme was implied or inferred and in relation to collaboration or “absent” if it was not present or, if present, had no relation to collaborative learning. Table 4.2 summarizes the coding results for the 10 PYP curriculum documents analyzed for this study.

Table 4.2 Summary of Coding Results for PYP Curriculum Documents

	General PYP curriculum guides (n=6)			**Content area PYP curriculum guides (n=4)**		
Theme	absent	inferred	direct	absent	inferred	direct
1. Theoretical model	4	1	1	4	0	0
2. Definition	5	1	0	4	0	0
3. Use of technology	5	0	1	4	0	0
4. Assessment	5	1	0	4	0	0
5. Role of teacher	0	5	1	4	0	0
6. Evidence of PD	5	1	0	4	0	0
7. Scaffolding student work	4	2	0	4	0	0
8. Modeling CL behaviors	4	2	0	4	0	0
9. Debrief on quality of CL	6	0	0	4	0	0
10. Grouping rationale	4	1	1	4	0	0
11. Task structure	5	1	0	3	1	0
12. Group size	1	3	2	3	1	0
13. Group structure	3	1	2	4	0	0
14. Group roles	5	1	0	3	1	0
15. Expectations for group products	3	3	0	3	1	0
16. Expectations for group process	3	3	0	3	1	0

Source. International Baccalaureate Student Collaboration Content Analysis.
Note. CL = Collaborative Learning; PD = Professional Development

General aspects of collaborative learning in the written curriculum are captured by the first four themes: discussion of a theoretical model or framework justifying the use of collaborative learning (the *why*), a definition of collaborative learning (the *what*), use of technology to facilitate student collaboration, and the role of assessment for collaboration. Two of the four general curriculum guides provided direct reference to general aspects of CL. None of the PYP content area guides made reference to general aspects. Themes related to the role of the teacher for facilitating student CL were often present in the general curriculum guides, but rarely (one event) present in the content area guides. Likewise, student factors for CL were often present in the general guides, but were rarely inferred in the content guides. These results reflect a trend in curriculum documents where the focus tends to be either on process (pedagogy) or on content—not often on both within the same document.

The word “collaboration” is mentioned multiple times in the general curriculum guides. Most often, however, it is in reference to teacher-to-teacher collaboration. A count of the word “collaborative” within a document does not adequately capture the extent to which student collaboration is described. As an example, “collaboration” is mentioned a maximum number of times (n=58) among the PYP documents in the *PYP Program Standards and Practices*. Each mention is referencing teacher group planning practices and is not related to student collaboration. Overall, within the PYP curriculum documents, student collaboration is a clear expectation. Details regarding how CL is to be understood or implemented in the curriculum, are less clear.

Middle Years Programme Curriculum Documents

Ten curriculum documents specific to the Middle Years Programme (MYP) were analyzed. Four of the ten were general curriculum guides covering broad program standards/expectations, such as interdisciplinary teaching and learning and the role of information communication technologies (ICT) in the MYP. Six of the ten documents were content specific subject curriculum guides covering language, mathematics, science, and humanities. Table 4.3 summarizes the coding results for the ten MYP curriculum documents analyzed for this study.

Table 4.3 Summary of coding results for MYP curriculum documents

	General MYP curriculum guides (n=4)			Content area MYP curriculum guides (n=6)		
Theme	absent	inferred	direct	absent	inferred	direct
1. Theoretical model	4	0	0	4	0	2
2. Definition	4	0	0	6	0	0
3. Use of technology	4	0	0	6	0	0
4. Assessment	3	1	0	6	0	0
5. Role of teacher	3	1	0	1	5	0
6. Evidence of PD	4	0	0	6	0	0
7. Scaffolding student work	3	1	0	4	2	0
8. Modeling CL behaviors	2	2	0	4	2	0
9. Debrief on quality of CL	3	1	0	4	1	1
10. Grouping rationale	1	3	0	3	2	1
11. Task structure	3	1	0	4	2	0
12. Group size	1	2	1	0	6	0
13. Group structure	3	1	0	5	1	0
14. Group roles	3	0	1	4	2	0
15. Expectations for group products	1	2	1	4	1	1
16. Expectations for group process	1	3	0	1	5	0

Source. International Baccalaureate Student Collaboration Content Analysis.
Note. CL = Collaborative Learning; PD – Professional Development

Justification for CL through description of a theoretical model is explicitly provided in two of the MYP content area guides (humanities and the language B guides). However, a clear direct definition for CL is not mentioned in any of the MYP documents. There is less disassociation in the MYP regarding CL between the general curriculum documents and the content area documents than what was present in the PYP documents. Teacher and student factors for CL are inferred with more frequency in the MYP documents than in the PYP. A general weakness across MYP documents is the generality of the statements that collaboration should be in place, without explicit reference to how it might be enacted. Many areas exist in the MYP written curriculum where CL could be explicitly emphasized. For example, in the science guide, student collaboration is expressed as an expectation under aims, attitudes, and social skills. Collaboration is a clearly stated skill group under approaches to learning. On page 8 of the science guide there is an example of a direct reference to the teacher debriefing on the quality of students' collaboration (teacher factors item 9):

> Social skills – discussions on how to work collaboratively, how to contribute to a team, how to acknowledge work by other team members, peer evaluation skills

No discussion, though, is made to define collaboration or to describe what it might look like in the science curriculum. Inquiry, likewise, is mentioned often and CL is sometimes inferred with inquiry. However, no explicit connection between inquiry and collaboration is made. Substantial room for CL emphasis is present in the science documents.

Overall, within the MYP curriculum documents analyzed for this study, student collaboration is a clear expectation. Details regarding how CL is to be understood or implemented in the MYP curriculum, are less clear.

Diploma Programme Curriculum Documents

Twenty curriculum documents specific to the Diploma Programme (DP) were analyzed. Six of the 20 reports were general interdisciplinary curriculum guides covering broad program standards or capstone courses, such as the Theory of Knowledge (TOK) course, the Creativity, Action, Service (CAS) course, and approaches to teaching and learning. The TOK and CAS are self-contained courses, but because of their interdisciplinary nature, they were analyzed as general curriculum courses. Fourteen of the 20 documents were content specific subject curriculum guides covering seven different science courses, five math courses, and two performing arts courses. Due to the number of science and math courses in the DP curriculum documents, analysis was made for comparison among the three content areas represented in the coded DP documents. Table 4.4 summarizes the coding results for the 20 DP curriculum documents analyzed for this study.

Table 4.4 Summary of Coding Results for DP Curriculum Documents

	General DP curriculum guides (n=6)			**Content area DP curriculum guides (n=14)**		
Theme	absent	inferred	direct	absent	inferred	direct
1. Theoretical model	3	3	0	11	3	0
2. Definition	5	1	0	13	1	0
3. Use of technology	4	1	1	7	3	4
4. Assessment	4	2	0	9	0	5
5. Role of teacher	3	2	1	14	0	0
6. Evidence of PD	4	2	0	14	0	0
7. Scaffolding student work	5	0	1	14	0	0
8. Modeling CL behaviors	4	1	1	14	0	0
9. Debrief on quality of CL	4	1	1	14	0	0
10. Grouping rationale	5	1	0	8	4	2
11. Task structure	5	0	1	13	1	0
12. Group size	3	3	0	9	5	0
13. Group structure	5	1	0	9	5	0
14. Group roles	3	2	1	13	1	0
15. Expectations for group products	2	3	1	9	4	1
16. Expectations for group process	4	1	1	11	3	0

Source. International Baccalaureate Student Collaboration Content Analysis.
Note. CL = Collaborative Learning; PD – Professional Development

A strong inference for CL is present among the DP curriculum documents in all three student collaboration categories (overall aspects teacher factors, and student factors). Within general aspects of CL (themes 1-4), a theoretical model justifying CL is found in six of the 20 documents. A definition for CL is hinted at in two of the DP curriculum documents. For example, in the content area guide for environmental systems, one finds a definition of team that infers collaborative learning within the definition of team (p. 64):

> **Aspect 2: working in a team**
>
> Working in a team is when two or more students work on a task collaboratively. Effective teamwork includes recognizing the contribution of others. There is an expectation that all team members contribute and are encouraged to contribute by the rest of the team. This will be demonstrated in the exchange of ideas, and an ability to integrate ideas into decision- making.

The definition of team infers a definition of CL even though it is not explicitly stated. In the teacher factors for CL (themes 5-11), teacher factors are implied or directly stated in several of the general DP curriculum guides, but essentially absent in the content area guides. The exception is in the area of suggestions for grouping rationale. The Group 4 guides in the sciences all included some discussion of grouping by subject area or mixed subject-area for the purpose of the Group 4 research activities. Only the guides for computer science, however, made explicit links between grouping rationale and the purpose of CL facilitation. In the third category, student factors for CL (themes 12-16), suggestions related to group size, structure, roles, and expectations are inferred in many of the general and content area guides. The majority of the discussion on student factors pertains to the Group 4 guides and often links to expectations for collaboration among different campuses, rather than student-to-student collaboration on the same campus or within the same classroom.

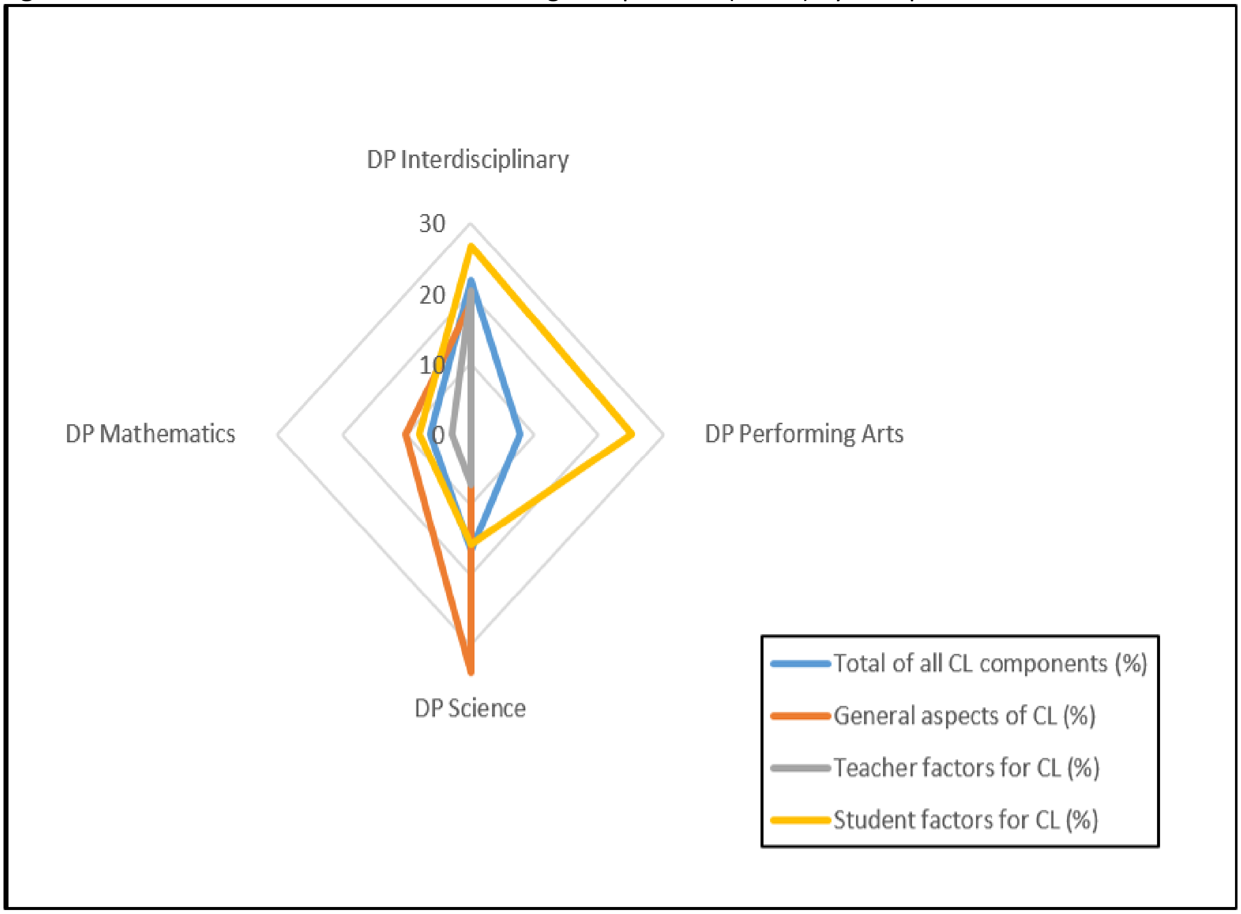
Due to the number of science and math courses in the DP curriculum documents, analysis was made for comparison among the three content areas represented in the coded DP documents. The science content area guides indicated a strong presence (33.9%) for general aspects for CL. This result is somewhat misleading. Under the Nature of Science within the science curriculum guides, there was substantial discussion on the importance of collaboration to scientific endeavor. However, when discussing student collaboration within the context of classroom activities, CL in the science classroom was not linked to collaboration as a scientific practice. Collaborative learning themes were unexpectedly absent in all of the mathematics content area guides. Table 4.5 summarizes average scores among the DP content areas by CL component, and Figure 4.1 illustrates these differences.

Table 4.5 Summary of Average Scores among the DP Content Areas.

Count of collaborative	Mean (n)	Min (n)	Max (n)	Std
DP Interdisciplinary	20.3	6	52	18.0
DP Performing arts	5.0	4	6	1.4
DP Science	29.9	7	50	15.0
DP Mathematics	6.4	1	28	12.1
Total of all CL components	Mean (%)	Min (%)	Max (%)	Std
DP Interdisciplinary	21.9	0.0	68.8	25.3
DP Performing Arts	7.8	6.3	9.4	2.2
DP Science	16.5	9.4	28.1	6.7
DP Mathematics	6.3	0.0	31.3	14.0
General aspects of CL	Mean (%)	Min (%)	Max (%)	Std
DP Interdisciplinary	18.8	0.0	37.5	20.5
DP Performing Arts	0.0	0.0	0.0	0.0
DP Science	33.9	12.5	50.0	15.7
DP Mathematics	10.0	0.0	50.0	22.4
Teacher factors of CL	Mean (%)	Min (%)	Max (%)	Std
DP Interdisciplinary	20.2	0.0	78.6	29.8
DP Performing Arts	0.0	0.0	0.0	0.0
DP Science	7.1	0.0	14.3	4.1
DP Mathematics	2.9	0.0	14.3	6.4
Student factors of CL	Mean (%)	Min (%)	Max (%)	Std
DP Interdisciplinary	26.7	0.0	80.0	30.8
DP Performing Arts	25.0	20.0	30.0	7.1
DP Science	15.7	10.0	30.0	7.9
DP Mathematics	8.0	0.0	40.0	17.9

Source. International Baccalaureate Student Collaboration Content Analysis.
Note. CL = Collaborative Learning; PYP = Primary Years Programme; MYP = Middle Years Programme; DP = Diploma Programme

Figure 4.1 Illustration of Collaborative Learning Components (mean) by Discipline within IB DP.



Source. International Baccalaureate Student Collaboration Content Analysis.
Note. CL = Collaborative Learning; DP = Diploma Programme

Overall, within the DP curriculum documents analyzed for this study, student collaboration has a more evident presence with guidance provided in the documents for a definition, theoretical framework, assessment, and specific strategies for CL. An exemplar document is the *Approaches to Learning in the DP.* Student collaborative learning is explicitly and repeatedly mentioned as a critical component to the IB approaches to learning. A theoretical model is implied. A specific strategy for facilitating CL is described (the SPIDER format (p. 10)), interaction is discussed as an element of CL (p. 13), and there is some discussion on distinguishing between CL and cooperative learning (p.15 & 17). A second quality example is the curriculum guide for the CAS course. Within this document collaboration is described as an explicit critical component of the CAS course under "service." This document could expand on CL by linking the implied theoretical model and definition (page 25) to CL. Collaborative learning phrases such as "interaction" and "all members being contributors"" were used but these could be intentionally linked to CL.

IBCC Programme Curriculum Documents

Four curriculum documents specific to the IB Career-related Certificate (IBCC) were coded based on *a priori* themes pertaining to student collaborative learning (CL) utilizing the International Baccalaureate Student Collaboration Content Analysis instrument. The IBCC is an "innovative education framework" for students aged 16 to 19 that incorporates the vision and educational principles of the IB into a unique programme specifically tailored for students who wish to engage in career-related learning (IB Organization, http://www.ibo.org/ibcc/). Even though IBCC is an independent program, separate from the IB DP, it exists in addition to an approved IB DP and allows IBCC students may take up to four DP courses to meet criteria for the IBCC.

Three of the four IBCC documents provided for coding were not applicable to student collaboration: IBCC General Regulations, IBCC Overview, and the IBCC Handbook. These were not curriculum documents. IBCC documents rather described the CC program, requirements, grading, and completion. The IBCC General Regulations did not mention collaboration. Collaboration is mentioned six times in the IBCC Overview, but never in relation to student collaboration. In the IBCC Handbook, collaboration is mentioned once in relation to teacher collaboration. There is room in the IBCC Handbook to emphasize student collaboration (p. 5), specifically when the 'approaches to learning' requirement is discussed.

The one curriculum document for IBCC that pertained to student collaboration was the IBCC Core Guide. Within the IBCC Core Guide, strategies related to teacher and student factors for collaboration are included. Specifically, the document discusses role of the teacher, task structure, group size, group roles, and expectations for group products in direct relation to collaborative learning. Even though there is no definition of collaboration provided, there are several places where a justification for student collaboration is inferred—hinting at a theoretical framework (pages 1 & 10). Table 4.6 and 4.7 summarize the coding results of the IBCC Core Guide.

Table 4.6 Summary of Coding Scores for the IBCC Core Guide

IBCC Core Guide (n=1)			
Theme	absent	inferred	direct
1. Theoretical model	1	0	0
2. Definition	1	0	0
3. Use of technology	1	0	0
4. Assessment	1	0	0
5. Role of teacher	0	0	1
6. Evidence of PD	1	0	0
7. Scaffolding student work	1	0	0
8. Modeling CL behaviors	1	0	0
9. Debrief on quality of CL	1	0	0
10. Grouping rationale	0	1	0
11. Task structure	0	0	1
12. Group size	0	0	1
13. Group structure	0	1	0
14. Group roles	0	0	1
15. Expectations for group products	0	0	1
16. Expectations for group process	1	0	0

Table 4.7 Summary of Category Scores for the IBCC Core Guide

IBCC Core Guide: Collaboration Components	
Overall Aspects (n)	0
Overall Aspects (%)	0.0
Teacher Factors (n)	5
Teacher Factors (%)	35.7
Student Factors (n)	7

Student Factors (%)	70.0

It is not reasonable to use one IBCC document to compare degree of emphasis on student collaboration in the IBCC program to the other IB programs. However, because the IBCC overlaps the IB DP in some areas, it is feasible that curriculum documents specific to IB DP are being utilized by teachers and administrators for the IBCC. Similar to the IB DP curriculum documents, room exists in the IBCC Core Guide where student collaboration could be explained more explicitly. Specific recommendations include adding an operational definition of collaboration and providing details, where appropriate, regarding how collaboration is to be understood, when it should be used, and how it may be facilitated in IBCC classes.

Comparison of Collaboration among IB Programmes in IB Curriculum Documents

Calculating an average score for each coded theme (general aspects, teacher factors, and student factors) allows for a general comparison among the IB programmes in regards to the degree themes of collaborative learning that are present in the coded curriculum documents. The DP curriculum guides were strongest in the general aspects of CL whereas the MYP documents emphasized the student factors component of CL the most. Table 4.8 summarizes the average scores and Figure 4.2 illustrates the differences among the themes for each programme.

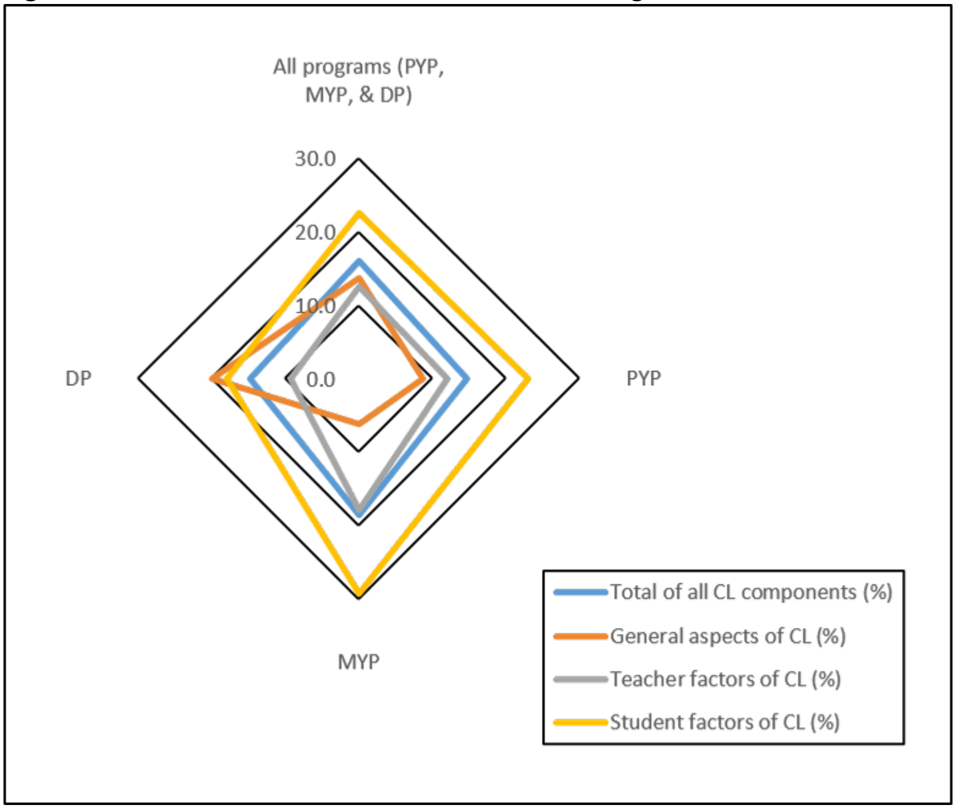
Table 4.8 Summary of Average Scores among the IB Programmes

Count of "collaborative"	Mean (n)	Min (n)	Max (n)	Std
All programs (PYP, MYP, & DP)	17.1	0	58	17.3
PYP	18.7	1	58	21.0
MYP	11.5	0	49	12.7
DP	18.7	1	52	17.1
Total of all CL components	Mean (%)	Min (%)	Max (%)	Std
All programs (PYP, MYP, & DP)	15.9	0.0	68.8	14.3
PYP	14.7	0.0	43.8	13.6
MYP	18.5	0.0	37.5	10.1
DP	14.7	0.0	68.8	16.3
General aspects of CL	Mean (%)	Min (%)	Max (%)	Std
All programs (PYP, MYP, & DP)	13.8	0.0	50.0	18.1
PYP	8.8	0.0	37.5	14.5
MYP	6.3	0.0	25.0	10.0
DP	20.0	0.0	50.0	20.8
Teacher factors of CL	Mean (%)	Min (%)	Max (%)	Std
All programs (PYP, MYP, & DP)	12.5	0.0	78.6	15.7
PYP	12.1	0.0	42.9	13.1
MYP	17.9	0.0	35.7	12.4
DP	9.3	0.0	78.6	17.5
Student factors of CL	Mean (%)	Min (%)	Max (%)	Std
All programs (PYP, MYP, & DP)	22.5	0.0	80.0	20.5
PYP	23.0	0.0	60.0	22.1
MYP	29.2	0.0	70.0	18.3
DP	18.0	0.0	80.0	19.9

Source. International Baccalaureate Student Collaboration Content Analysis.

Note. CL = Collaborative Learning; PYP = Primary Years Programme; MYP = Middle Years Programme; DP = Diploma Programme

Figure 4.2 Illustration of the Mean Differences among the CL Themes for Each IB Programme



Source. International Baccalaureate Student Collaboration Content Analysis.
Note. CL = Collaborative Learning; PYP = Primary Years Programme; MYP = Middle Years Programme; DP = Diploma Programme

Implications for Practice and Policy

Considerations for practice and policy were developed through an iterative process of constant comparison between the IB curriculum documents being coded and the *a priori* themes of the coding instrument. Early in the coding process, tentative linkages were developed between the theoretical themes of CL and evidence of the themes in the IB documents. As the coding progressed, and a clear understanding of what CL might look like in the documents developed, the coding process shifted towards verification. Documents were revisited and reviewed again as additional themes and evidence of CL emerged.

Suggestions for policy are made based on this iterative process of constant comparison. Table 4.9 summarizes findings for practice and policy derived from the curriculum document content analysis.

Table 4.9. Summary of Suggestions for Practice and Policy from the Curriculum Document Analysis

CL Theme	Key Suggestions for Practice
Overall Aspects	
Theoretical model	Identify/describe a specific theory of learning to justify an emphasis on CL in the curriculum document.
Definition	Provide a clearly stated operational definition of collaborative learning.
	Link the definition of CL to justification for CL (the theoretical model).
	Make a distinction, where appropriate, between students in groups for the purpose of facilitating CL and student group work.
	Make a distinction between the word "group" as it is used in the IB curriculum documents for subject groups/courses and when it is used to imply CL. For example, use "*group*" to reference subject groups/courses and "*team*" to reference students working collaboratively in groups.
Use of Technology	In sections that discuss ICT in the IB, include the use of ICT to facilitate CL.
Assessment of CL	Discuss suggestions for assessing CL.
	Emphasize the importance of assessing CL by stating a grading/scoring expectation for CL (ex. rubric for "working in a team" found in DP Group 4 Science Guides).
	Include suggestions for *peer evaluation* of CL within the context of the student group or team.
Integration of Content and Approaches to Learning (ATL)*	Integrate pedagogical expectations (approaches to learning and teaching) by discussing CL in context within the content area curriculum guides.
One General IB Document as a Reference for CL*	Create a general IB curriculum document for CL that can be referenced in other curriculum documents when additional information on CL is necessary. This would allow minor changes to existing documents with the addition of one new stand-alone general document.

(Table 4.9 continued)

Teacher Factors	
Role of Teacher	Clearly state the significance of the teacher's role for facilitating CL.
Evidence of PD	Discuss expectations for PD specifically for teaching and learning methods to enhance students' CL skills.
Scaffolding of Student Work	Describe specific methods or strategies for teacher scaffolding of students' CL (e.g., SPIDER method described in *ATL in the DP* curriculum document).
Modeling of CL	Within the context of activities for group work (e.g., Group 4 guides), describe methods that the teacher could use to model CL for students.
Discussion on Quality of CL	Provide suggestions for structuring class time for teachers to facilitate student reflection on the quality of student collaboration.
Grouping Rationale	Grouping rationale is the method by which students are grouped (e.g., pair-and-share, pre-assessment used to group by ability, pre-survey used to group by interests, self-selected versus teacher-selected). Suggest methods of grouping for the purpose of encouraging CL.
Task Structure	Task structure dictates the difference between collaborative learning within student teams and simply cooperative learning within groups. Discuss methods of structuring the task for the purpose of encouraging student collaboration.
Differentiate the Audience*	Clearly differentiate the audience of interest in regards to the emphasis on expectations for collaboration among teachers/stakeholders versus expectations for collaboration among students.

(Table 4.9 continued)

Student Factors	
Group Format	Suggest group size that is most appropriate for the collaborative activity/task
Group Structure	Grouping structure influences the quality and quantity of CL. Student groups are most successful at collaboration when they are in strategically formed teams. Discuss how students should be grouped, and why, for the purpose of encouraging CL.
Group Roles	Suggest students' individual roles within a collaborative activity/task.
Group Products	Describe expectations/criteria for products resulting from a collaborative activity/task.
Group Process	Describe expectations for how students should work and interact with each other during collaborative activities/tasks.
Purpose of the Group*	Group work does not avouch CL. Make an intentional distinction between groups of students for the purpose of collaborative learning and students in groups.

***** New themes that emerged during document coding
Note: CL = Collaborative Learning; PD = Professional Development

Conclusions

Every IB curriculum document examined for this study from the PYP, MYP, and DP programmes contained at least one reference to collaboration as a student expectation. This consistent reference among the documents comes from the IB Learner Profile. In addition, collaboration is a stated expectation under Approaches to Learning (ATL) specifically in the area of social skills.

Student collaboration is often inferred, or assumed, within discussions of inquiry and when describing groups of students working together. Cooperative learning, as well, is sometimes used in the curriculum documents interchangeably with collaborative learning. Collaborative learning requires students to work in groups. Group work, however, is not always collaborative. Where group work is mentioned, inferring an expectation for collaboration, description of what collaboration is or how it may be accomplished is generally lacking. Exceptions were present with a few of the documents stating a connection between group work and collaboration or providing a description of collaboration (for example "ATL in the DP"). None of the documents, however, provided a clearly articulated definition of collaboration.

Primary findings for the PYP curriculum documents are (a) none of the PYP content area guides made reference to general aspects, (b) themes related to the role of the teacher for facilitating student CL were often present in the general curriculum guides, but rarely (one event) present in the content area guides, and (c) student factors for CL were often present in the general guides, but were rarely inferred in the content area guides. These results reflect a trend among the IB PYP curriculum documents of a disassociation in regards to collaborative learning between content area guides, focused on *what* should be taught, and general curriculum guides focused more on *how* to teach it (e.g., approaches to learning).

Primary findings for the MYP curriculum documents are: (a) justification for CL through description of a theoretical model is explicitly provided in two of the twelve MYP documents; however, (b) a clear direct definition for CL is not mentioned in any of the MYP documents; (c) there is less of a disassociation regarding CL in the MYP between the general curriculum documents and the content area documents than what was present in the PYP documents and; (d) teacher factors and student factors for CL are inferred with more frequency in the MYP documents than in the PYP. The general nature in which collaboration is mentioned across MYP documents establishes an expectation for collaboration without direction as to how or why collaboration might be enacted. Within the MYP written curriculum, where collaboration is already mentioned or inferred, collaboration could be elaborated with additional description or with reference to a curriculum document specific to collaboration.

The primary finding for the DP curriculum documents is that student collaboration has a greater presence, as compared to the PYP and DP documents, with guidance provided in the documents for a definition, theoretical framework, assessment, and specific strategies for collaborative learning. An exemplar document is the *Approaches to Learning in the DP.* In this document, student collaborative learning is explicitly and repeatedly mentioned as a critical component to the IB approaches to learning. The DP Group 4 science guides are noted for providing specific tools for assessing team work (infers collaborative learning) and for explicit attention to the use of ICT in facilitating collaboration. However, when student factors for collaboration are explicitly noted or discussed, the document is often referencing collaboration among teachers or establishing collaboration between IB schools. Attention should also be given to discussing factors that facilitate student-to-student collaboration within the same classroom.

Within the DP content area guides, comparisons were made among the science and math curriculum documents. General aspects of collaborative learning were evident among the science documents. A theoretical framework was discussed in direct relation to collaboration as an element of scientific endeavor. However, similar to the disassociation between content and process evident in the PYP documents, collaboration was explicitly discussed in regards to what scientists do in order to gain new knowledge, but collaboration was not as evident in the discussions of what students and teachers should do in order to gain new knowledge about the sciences. Collaborative learning themes were unexpectedly absent in all of the mathematics content area guides.

Two key policy revisions are suggested in order to assist the IB in the process of making student collaboration a more evident and viable approach to teaching and learning within the existing curriculum documents. First, quality elements of collaborative learning that are already present in several of the IB curriculum guides could be integrated, where appropriate, into the content area guides. This would help to address the disassociation specific to facilitating collaboration between general guides and approaches to learning and guides for content. Second, the research team suggests creation of a stand-alone general curriculum guide on student collaboration that could be referenced throughout the existing IB documents where collaborative learning is stated as a teaching/learning expectation. The new general curriculum guide could address the themes identified from the literature review organized by the three components of student collaboration: general aspects, teacher factors, and student factors. Specific strategies for teaching, learning, and assessment of student collaboration could be provided as an appendix and could be specific to the different IB programmes.

CHAPTER 5: Summary and Conclusions

Summary of Findings

Overview of Reviewed Studies

In total, we analyzed 153 studies focusing on various aspects of student collaboration across grades K-12 in four core subject areas (Reading/Writing, Humanities/Social Sciences, Mathematics, and Science). Additional foci for analyses included articles focusing on classroom environment, social context, technology, culturally and linguistically diverse settings, and assessment. In order to uncover promising practices in student collaboration, 42 studies for which effect sizes could be calculated were included in a meta-analysis. To further detail the definitions, dimensions, models, skills, and dispositions of collaboration, the remaining 107 studies utilizing quantitative, qualitative or a mix of methods, were synthesized and described in detail by content area.

Eight major themes of successful collaborative processes emerged from the best evidence synthesis overall. Table 5.1 details each theme and related considerations.

Table 5.1 Major Themes of Successful Collaborative Processes

Theme	**Considerations**
Specific and focused teacher role	Achieved in many cases by targeted professional development related to specific collaborative practices
Purposeful means of grouping students	Considering variables such as purpose of activity, ability level of students, familiarity of students with one another, social status, and socio-cultural backgrounds and norms
Targeted incorporation of technology	Focused on a specific purpose with defined roles for students which can be achieved by scaffolding processes inherent in technology itself and/or collaborative scripts
Roles for individual students	Involves instructing students on how to be a productive member of the group and outlining individual expectations so all students contribute equally to the group's intended outcomes
Task that is open-ended and/or multi-faceted	Task must in some way require students to rely on one another for completion
Specific structuring of the collaborative process	Achieved by using a specific format, such as jigsaw, a collaborative script, or discourse format, as opposed to simply putting student in groups without consideration of the *whats*, *hows*, and *whys* of collaboration
Consideration of the social complexities of the collaborative process	Students' socio-cultural and academic values, experiences and backgrounds must be taken into account
Sufficient time for cognitive processes involved in collaboration	Time for student discourse, shared reading, and/or creating and sharing representations of thinking

Though separately reported, the major themes of successful collaboration are not a menu from which one can choose when designing collaborative opportunities in K-12 classrooms. Rather, the themes reflect a complicated, interdependent landscape of factors that must all be taken into account to some degree in order for students to truly work together, rather than simply work on a similar task side by side.

Overview of Content Analysis Findings

A total of 47 IB curriculum documents were coded based on *a priori* themes pertaining to research in student collaborative learning. The themes were clustered into three components: overall aspects of collaboration, teacher factors related to collaboration, and student factors related to collaboration. All documents examined, with the exception of three IBCC documents, contained at least one reference to collaboration as a student expectation from the IB Learner Profile. However there was a degree of variation between IB Programmes in terms of how often collaboration was mentioned and to what level of detail collaboration was discussed.

Across all programmes there needs to be more specificity about what collaboration is. This could be accomplished through creation of a stand-alone general curriculum guide on student collaboration that could be referenced throughout the existing IB documents where collaborative learning is stated as a teaching/learning expectation. Specific strategies for teaching, learning, and assessment of student collaboration could be provided as an appendix and may be specific to the different IB programmes. Additionally, to address the disassociation between general curriculum guides and content guides, quality elements of collaborative learning that are already present in several of the IB curriculum guides could be incorporated into the content area guides, where appropriate.

Study Strengths and Limitations

Several strengths were present in this study. With regard to the best evidence synthesis of research, we scanned thousands of articles using an inclusive list of key words to capture the most detailed picture of student collaboration in K-12 settings. Through utilization of the best evidence synthesis approach, we included studies with various methodologies, including quantitative, qualitative, and mixed methods studies in order todemonstrate both promising practices through effect size calculations and detailed descriptions of definitions, dimensions, models, skills, and dispositions of student collaboration.

Another strength was related to our research team's varied backgrounds. All team members have had experience in teaching and conducting research in K-12 setting. Several group members have conducted curriculum writing and teacher professional development across several content areas. This diverse experience allowed us to view research findings from diverse perspectives.

The final study's strength was the breadth of coverage of student collaboration across K-12 settings, in a variety of subject areas, through multiple research methodologies, and the subsequent analysis of IB curriculum documents' adherence to best practices from research. The study's comprehensive analysis of student collaboration, both within research and in IB practice, will allow IB stakeholders to make research and evidence-based conclusions about the present and future inclusion of collaborative practices within IB programmes.

The greatest study limitation was the "file drawer problem" (Rosenthal, 1979), commonly noted in research syntheses. The file drawer problem, or publication bias, refers to the fact that some studies fail to be published because their outcomes are not statistically significant. Although we attempted to minimize file drawer problem effects through the inclusion of published journal articles of varying methodologies; white papers, dissertations, and other unpublished materials were not included in the synthesis.

Additional study limitations are related to IB curriculum document coding. Though given access to IB's Online Curriculum Centre, researchers were unable to code every document available for each programme. A final limitation related to document coding was that, though outside the scope of the current study, no observations of actual collaborative practice or interviews with IB stakeholders were conducted to corroborate findings in the document analysis. Because curriculum documents do not always reflect teaching practice, it is possible to conclude that more or less collaboration exists in actual IB classrooms.

A final study limitation is related to the present study's lack of inclusion of articles specifically related to how the quality of student collaboration might be measured in a K-12 setting by an external regulatory organization, such as Ofqual. Though our research team expanded inclusion criteria and conducted additional searches to retain more assessment studies, more than half of the studies were conducted either with undergraduate students or teachers. Formal assessment of collaboration, particularly in K-12 settings, is an area in which not much research currently exists.

Conclusions and Recommendations

Detailed, multi-level analyses of 142 studies and 47 curriculum documents across the spectrum of K-12 instructional classroom practices in both IB and non-IB yielded important findings in terms of what practices contribute and/or detract from successful student collaboration. First of all, collaboration, a term sometimes confounded in both research literature and curricular documents, is a social process of constructing knowledge that requires students to work as an interdependent team towards a clear objective resulting in an agreed consensus or decision. For collaborative learning, tasks are structured so that teams of students must rely on one another to share cognitive resources (e.g., knowledge, experience, insight, skills), utilize meta-cognitive processes, and communicate with each other in order to complete a task and arrive at a consensus that none of the individual collaborators could accomplish without equitable participation of all members. Each student in a collaborative process must be provided avenues, through the structure of the task, structure of the group, consideration of their cultural norms, and scaffolding of their instructor, to participate in the collaborative process.

Successful collaboration requires both teachers and students to understand and have opportunities to discuss what collaboration looks like; why it is being utilized in a particular situation over another method, such as independent learning; and how collaboration should be taking place in the classroom. Through professional development on specific collaborative practices and grouping methods, teachers hone knowledge and skills related to collaboration beyond simply numbering students off, putting them into a group, and hoping collaboration will take place. Likewise, students need opportunities to see teacher models of what collaborative talk and work look like and worthy tasks on which to collaborate. Students, along with their teachers, must schedule debriefing time to assess the quality of not just the collaborative work and associated products, but also the quality of the collaborative process itself.

It is recommended that IB interpret the research findings most appropriate and representative of the needs of the organization and adopt a clear definition of collaboration for IB stakeholders, especially curriculum writers and practitioners. The above definition is a combination of research on both collaborative and cooperative practices shown by research to have effects on both the achievement and motivation of K-12 students. Once a definition is adopted, IB curriculum documents should be revised, where necessary, to include research-based aspects of successful collaboration most salient to particular student levels and subjects. Appendix H contains a Practitioner Guide summarizing study findings for IB teachers. This guide can serve as a stand-alone document to provide IB practitioners with information on the most critical considerations for creating successful collaborative environments in K-12 classrooms.

In order for successful collaborative practices to truly take hold in all IB programmes, professional development within each programme area on the definition and practice of successful collaboration will be needed, along with follow up, which could include classroom observations and/or other methods of data collection from teachers and students. Finally, even though quality research on replicable means of assessing collaborative practices in K-12 classrooms is limited, we did find some studies that examined the use of assessments of collaboration in both K-12 and higher education environments, such as nursing education (Ladouceur, 2004). Further research is needed to determine whether such assessment practices could be replicated with other groups of students.

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Appendix A: Key Words for Initial Search of Research Literature

Student collaboration terms	Content area term
(Student collaboration) (Peer collaboration) (Cooperative learning) (Peer interaction) (Collaborative learning) (Group work) (Team work)	AND Mathematics (or Math)
	AND (Cultural diversity) Diversity Multicultural (Diverse contexts)
	AND Science
	AND (Social studies) (Social sciences) History Civics Humanities
	AND (Linguistic diversity) (Language learner) (Second language) Multilingual Bilingual ESL ELL EL
	AND English (English language arts) Writing Reading (Readers Workshop) Writers Workshop) Literacy Composition Rhetoric Literature

Appendix B: Initial Coding Scheme

Initial Coding Scheme:

- Article focused on student collaboration skills (teaching, learning, assessment)
- Included core subject area(s
- Addressed technology
- Addressed cultural and/or linguistic context
- Sample included K-12 students (If yes, describe sample)
- Reported empirical data
- Type of research and method
- Relevant findings
- Effect size reported
- Reported 2003 or later
- Written in English
- Notes

Appendix C: Meta-Analysis Coding Sheet

Study Citation:
Report Information
R1. What is the report ID number?
R2. What type of organization produced this report? 1 = University 2 = Government entity (specify) 3 = Contract research firm (specify) 4 = Other (specify)
Participants
R3. What was the participants' grade level? 1 = K-2 2 = 3-5 3 = 6-8 4 = 9-12
R4. Where were the participants located? 1 = Urban 2 = Rural 3 = Mixed ? = unknown
R5. How were the participants described? 1 = gifted 2 = average 3 = academically at risk 4 = otherwise at risk 5 = underachieving/below grade level 6 = learning disabled 7 = Low SES 8 = Middle SES 9 = High SES 10 = English Language Learners (ELLs) 11 = Other (specify)
R6. What sexes were represented in the sample? 1 = males 2 = females 3 = no sex information given
Measures
R7. Were before and after measures used? 1 = Before only 2 = After only 3 = Both
R8. Was an intervention used? Yes or No
R9. Describe the intervention. 1 = Group method

2 = Task type 3 = Role of the teacher 4 = Role of the student 5 = other (specify)
R10. What type of outcome was studied? 1 = affective (i.e., attitude, motivation) 2 = cognitive (i.e., teacher made test, standardized test) 3 = behavior (i.e., attention, engagement) Specify the test used (STAAR, MRQ).
Study Description
R11. What was the setting of this study? 1 = in class 2 = in school but outside of class 3 = in clinic
R12. How were students evaluated? 1 = individual 2 = small group 3 = full class 4 = school wide 5 = district wide 6 = Other (specify)
R13. What was the research design? 1 = random assignment 2 = quasi-experimental 3 = non-random
R14. Was a control used? 1 = yes 2 = no
R15. What was the duration of the study? 1 = One day or less 2 = One week or less 3 = One month or less 4 = One marking period or less 5 = One semester (or summer) or less 6 = One school year or less 7 = more than one school year (specify)
Study Quality and Theory
R16. Was evidence presented regarding whether the validity/reliability of the outcome measure reached an acceptable criterion? Indicate type of validity/reliability measure (internal consistency, test-retest correlation) and place a 1 if acceptable, 0 if not, 9 if not reported. A statement indicating the internal consistency was "acceptable" is sufficient, even if the specific value was not reported. A citation to an external source is not acceptable.
R   R17. Were any threats to internal validity present?

1 = maturation 2 = testing 3 = instrumentation 4 = regression 5 = history 6 = selection 7 = other (specify)
R18. What theorists are cited? 1 = Johnson & Johnson 2 = Vygotsky 3 = Bandura 4 = Leont'ev 5 = other
R19. What theories are used as rationale for study? Specify 1 = Social Network Theory 2 = Activity Theory 3 = Social Learning Theory 4 = Other
Statistical Data
R20. Total sample sizes with page numbers
R21. Sample size for treatment group.
R22. Sample size for comparison (control) group.
R23. Treatment group pre-mean.
R24. Treatment group pre-standard deviation.
R25. Treatment group post-mean.
R26. Treatment group post-standard deviation.
R27. Comparison group pre-mean.
R28. Comparison group pre-standard deviation.
R29. Comparison group post-mean.
R30. Comparison group post-standard deviation.
R31. Was an effect size provided? 1 = yes 2 = no. If yes, list effect size with page numbers
R32. Was any raw data reported? 1 = yes 2 = no. If yes, briefly describe and provide page numbers
R33. What statistical analyses were used? 1 = T-test 2 = Correlations 3 = ANOVA with post-hoc 4 = ANOVA without post-hoc 5 = ANCOVA 6 = Regression 7 = Other (specify)

Coder Information
Coder initials:
Date completed __/__/____
Notes (provide below any notes about the study or concerns you had regarding your codes.

Appendix D: Meta-Analysis Tables

Table A.1

Weighted Effect Sizes, Standard Error, and Homogeneity Statistic

Theme	*K*	Effect Size	Standard Error	Homogeneity Statistic (*Q*)
Collaboration Process	16	.8046	.0435	424.7037***
Computer Assisted	1	.6	.1993	0
Grouping Method	10	.9353	.0659	91.67991***
No Intervention	3	.8158	.2017	14.70423*
Role of Students	4	.3706	.1186	3.878732
Role of Teacher	4	.6122	.1611	19.70902**
Task Type	5	.6105	.0886	41.51435***

*Note: K= number of effect sizes, *p < .05, **p < .01, ***p < .001*

Table A.2

Average Effect Size for Collaboration Process

Study (1st author's last name and year)	Hedges *g*	Control group *N*	Treatment group *N*	Total *N*	*w* (weight)	*wg* (weighted *g*)
Artut 2009	.34	17	17	34	8.38	2.88
Berger 2009	5.10	125	125	250	14.71	74.99
Ding 2011	.21	114.7	114.7	229.34	57.03	11.71
Ebrahim 2012	1.92	82	82	164	28.06	53.89
Fitch 2008	.78	62.5	62.5	125	29.06	22.58

Ghaith 2003	-.06	28	28	56	13.99	-.81
Hong 2010	-1.31	58	38	96	19.05	-24.96
Hwang 2013	.55	29	29	58	13.98	7.64
Ifamuyiwa 2008	2.25	110	120	230	35.15	79.16
Keramati 2010	.78	113	107	220	51.08	39.81
Kollofel 2011	9.19	47.5	47.5	95	4.81	44.19
Kramarski 2003	.95	96	96	192	43.12	40.95
Pell 2007	-.17	235	235	470	117.07	-20.03
Roschelle 2010	.22	87	86	173	42.99	9.42
Rummel 2012	.13	39	38	77	19.21	2.47
Souvignier 2007	-.09	69	69	138	34.47	-3.02
Mean	**.6405**	**82.04**	**80.92**	**162.588**	**38.75**	**24.82**
Standard Error (Mean)	**.1606**					

Table A.3

Average Effect Size for Computer Assistance

Study (1st Author's last name and year)	Hedges *g*	Control Group *N*	Treatment Group *N*	Total *N*	*w* (weight)	*wg* (weighted *g*)
Hoon 2010	.71	54	51.33	105.33	24.76	17.54

Mean	**.7082**	**54**	**51.33**	**105.33**	**24.76**	**17.54**
Standard Error (Mean)	**.201**					

Table A.4
Average Effect Size for Grouping Method

Study (1st author's last name and year)	Hedges *g*	Control Group *N*	Treatment Group *N*	Total *N*	*w* (weight)	*wg* (weighted *g*)
Acar 2007	1.07	20.5	20.5	41	8.97	9.57
Gillies 2003	.22	75	73	148	36.77	8.03
Hurley 2009	.87	44	44	88	20.10	17.47
Harskamp 2006	5.11	24.75	24.75	49.5	2.90	14.83
Isik 2009	1.49	37.5	38.5	76	14.68	21.85
Kolawole 2008	1.20	200	200	400	84.66	101.94
Mullins 2011	.18	35	24	59	9.96	1.82
Stamoviasis 2006	.33	19	19	38	11.96	3.92
Swenson 2008	.12	64	68	132	32.91	3.95
Zakaria 2013	3.85	30.5	30.5	61	5.35	20.58
Mean	**.8935**	**55.03**	**54.23**	**109.25**	**24.83**	**22.19**
Standard Error (Mean)	**.2007**					

Table A.5
Average Effect Size for No Intervention

Study (1st author's last name and year)	Hedges *g*	Control Group *N*	Treatment Group *N*	Total *N*	*w* (weight)	*wg* (weighted *g*)
Gillies 2008	2.00	19	22	41	6.80	13.62
Paradis 2003	.71	15.67	15.33	31	7.29	5.15
Thurston 2010	.12	21	21	42	10.48	1.28
Mean	**.816**	**18.56**	**19.44**	**38**	**8.77**	**7.15**
Standard Error (Mean)	**.3378**					

Table A.6
Average Effect Size for Role of the Students

Study (1st author's last name and year)	Hedges *g*	Control Group *N*	Treatment Group *N*	Total *N*	*w* (weight)	*wg* (weighted *g*)
Kose 2010	.62	34	34	68	16.23	9.99
Kutnick 2009	.97	12	11	23	5.14	4.97
Saab 2007	.21	12	17	29	7.00	1.50
Saleh 2007	.23	84	88	172	40.72	9.17
Mean	**.371**	**35.5**	**37.5**	**73**	**17.93**	**6.65**
Standard Error	**.2362**					

(Mean)

Table A.7
Average Effect Size for Role of the Teacher

Study (1st author's last name and year)	Hedges *g*	Control Group *N*	Treatment Group *N*	Total *N*	*w* (weight)	*wg* (weighted *g*)
Dekker 2004	.71	17.5	17.5	35	8.23	5.83
Gillies 2009	2.00	19	22	41	6.80	13.62
Krol 2004	-.18	16	24	40	9.56	-1.76
Oortwign 2008	.42	35	24	59	13.93	5.91
Mean	**.6127**	**21.88**	**21.88**	**43.75**	**10.45**	**6.40**
Standard Error (Mean)	**.3094**					

Table A.8
Average Effect Size for Task Type

Study (1st author's last name and year)	Hedges *g*	Control Group *N*	Treatment Group *N*	Total *N*	*w* (weight)	*wg* (weighted *g*)
Gomez 2013	.71	116	116	232	54.54	38.86
Schwartz 2007	.22	30	30	60	14.91	3.24
Schachar 2004	.23	28	28	56	13.91	23.41

Tarim 2008	.69	72	72	144	33.96	23.41
Shaaban 2006	.91	22	22	44	9.66	9.11
Mean	**.6129**	**53.60**	**53.60**	**107.2**	**25.60**	**15.69**
Standard Error (Mean)	**.1976**					

Appendix E: *A Priori Themes* and Operational Definitions for Content Analysis

Overall Aspects of Collaboration:	**Operational definition**	**Examples**
1. Theoretical model	An existing model for collaboration based on prior research	Constructivism, Johnson & Johnson, Slavin, Bruner, Vygotsky, etc. *in relation to collaboration*
2. Definition	Description of collaboration within a theoretical framework or document	Collaborative process, group work, team work, face to face collaboration, virtual collaboration, mediated collaboration
3. Use of technology for collaboration	Hardware or software that either enhances collaboration or allows it to take place	Wikis, handhelds devices such as iPads, websites, chat devices
4. Assessment of collaboration	Process for measuring the level or quality of collaboration, either formally or informally	Observation, discourse analysis, student self reflection, surveys, student self assessment questionnaires
Teacher factors related to collaboration:	**Operational definition**	**Examples**
5. Role of teacher	The teacher's level of input within students' collaborative activity	Monitoring, questioning, scaffolding student thinking, participating, listening to discussions
6. Evidence of professional development	Evidence of teacher training on methods or techniques related to collaboration	Reference to training in documents, adherence to a particular theoretical model emphasized elsewhere
7. Scaffolding of student work	Teacher-initiated efforts to aid or enhance collaboration between students	Questioning, prompting, redirecting, modeling
8. Modeling of collaborative behaviors	Teacher explanations or demonstrations of the collaborative process (can be done either before or during collaborative work)	Explaining group roles, helping behaviors, ways to communicate, how to give all members a voice, expectations for each member
9. Discussion/debrief on quality of student collaboration	Whole class or small group teacher- or student-led conversations about the effectiveness of the collaborative process after a particular activity	Opportunities for students and teacher to formally or informally discuss how or if collaboration is working

10. Grouping rationale	Teacher rationale and method for putting students into groups	Size of class, student ability, student behavior, difficulty of content, language proficiency
11. Task structure	Design of collaborative task	Structured vs. unstructured, open-ended vs. closed-ended, etc.
Student factors related to collaboration:	**Operational definition**	**Examples**
12. Group format	Number of students per group or type of group	Pairs, tripods, groups of four, peers, teams, etc.
13. Group structure	Composition of group based on teacher grouping method	Ability (high, low, other), gender (homogeneous, heterogenous), personality, language proficiency, self-selection into groups, etc.
14. Group roles	Academic and behavioral expectations of each student in the collaborative activity	Task roles, group “jobs” such as recorder, materials manager
15. Expectations for group products	Steps or principles students follow in order to successfully complete product	Work product guidelines, rubric or other means of providing expectations for product
16. Expectations for group processes/ways of working	Guidelines for ways in which students are to collaborate with other students	Helping behaviors, communication skills, etc.

Appendix F: Content Analysis Instrument

Document name and Programme (PYP, MYP, DP): ____

Content Area: ______________________________**Reviewer:** ______________________________

Collaboration count:_______________

Theme	2 Descriptive Evidence (directly stated or discussed)	1 Inferential Evidence (discussion/use of related terminology)	0 No Evidence	Field Notes/Rater Justification
Overall Aspects of Collaboration				
1. Theoretical model (such as constructivism, Johnson & Johnson, Slavin, Bruner, Vygotsky, etc. *in relation to collaboration*)	The document directly mentions a theoretical model on which collaboration is based.	The document provides evidence or use of related terminology that is related to a theoretical model on which collaboration is based.	The document does not directly or indirectly discuss a theoretical model on which collaboration is based.	
2. Definition	The document directly mentions a definition of collaboration.	The document provides evidence or use of related terminology that indicates a definition of collaboration.	The document does not directly or indirectly discuss a definition of collaboration.	
3. Use of technology for collaboration	The document directly mentions a specific form of technology to be used for collaboration.	The document provides evidence or use of related terminology that indicates use of technology for collaboration.	The document does not directly or indirectly discuss use of technology for collaboration.	

Adapted from *College Readiness Assignment Content Analysis Rubric* (Stillisano, J.R., Brown, D.B., Wright, K.B., Metoyer, S., Hodges, T.S., Rollins, K.B., & Waxman, H.C. (2013, August). Evaluation of college readiness assignments field test (CRAFT). Submitted to the Texas Higher Education Coordinating Board (THECB).

Theme	2 Descriptive Evidence (directly stated or discussed)	1 Inferential Evidence (discussion/use of related terminology)	0 No Evidence	Field Notes/Rater Justification
4. Assessment of collaboration	The document directly mentions a specific form of assessing collaboration.	The document provides evidence or use of related terminology that indicates assessment of collaboration.	The document does not directly or indirectly discuss assessment of collaboration.	
Teacher factors related to collaboration				
5. Role of teacher	The document directly mentions the teacher's role in student collaboration.	The document provides evidence or use of related terminology that indicates teacher's role in collaboration.	The document does not directly or indirectly discuss the teacher's role in collaboration.	
6. Evidence of professional development	The document directly mentions prior teacher training related to collaboration.	The document provides evidence or use of related terminology that indicates prior teacher training related to collaboration.	The document does not directly or indirectly discuss teacher training related to collaboration.	
7. Scaffolding of student work (questioning, prompting, redirecting)	The document directly mentions ways teacher should scaffold collaboration.	The document provides evidence or use of related terminology that indicates teacher scaffolding of collaboration.	The document does not directly or indirectly discuss teacher scaffolding of collaboration.	
8. Modeling of collaborative behaviors	The document directly mentions ways teacher should model collaborative process for students.	The document provides evidence or use of related terminology that indicates teacher modeling of collaborative process for students.	The document does not directly or indirectly discuss teacher modeling of collaborative process for students.	

Theme	2 Descriptive Evidence (directly stated or discussed)	1 Inferential Evidence (discussion/use of related terminology)	0 No Evidence	Field Notes/Rater Justification
9. Discussion/debrief on quality of student collaboration	The document directly mentions teacher or class debriefing on quality of student collaboration.	The document provides evidence or use of related terminology that indicates teacher or class debrief on quality of student collaboration.	The document does not directly or indirectly discuss teacher or class debrief on quality of student collaboration.	
10. Grouping rationale	The document directly mentions method by which teacher can or should group students for collaboration.	The document provides evidence or use of related terminology that indicates method by which teacher can or should group students.	The document does not directly or indirectly discuss how teacher might group students.	
11. Task structure	The document directly mentions the consideration of task structure on the enhancement of collaboration.	The document provides evidence or use of related terminology that indicates collaboration influenced task structure.	The document does not directly or indirectly discuss task structure to enhance collaboration.	
Student factors related to collaboration				
12. Group format (pairs, tripods, etc.)	The document specifies or suggests size or type of groups for collaborative activities.	The document provides evidence or use of related terminology that indicates consideration of size or type of group for collaborative activities.	The document does not directly or indirectly discuss group size.	
13. Group structure (heterogeneous/homogeneous by gender, ability, language)	The document specifies or suggests how students should be grouped for collaborative activities.	The document provides evidence or use of related terminology that indicates how students should be grouped for collaborative activities.	The document does not directly or indirectly discuss how students should be grouped.	

Theme	2 Descriptive Evidence (directly stated or discussed)	1 Inferential Evidence (discussion/use of related terminology)	0 No Evidence	Field Notes/Rater Justification
14. Group roles	The document specifies or suggests roles individual students should take in collaborative activities.	The document provides evidence or use of related terminology that indicates roles students should take in collaborative activities.	The document does not directly or indirectly discuss roles for students in collaborative activities.	
15. Expectations for group products	The document specifies or suggests expectations for what student products from collaborative activities should look like.	The document provides evidence or use of related terminology that indicates what student products from collaborative activities should look like.	The document does not directly or indirectly discuss expectations for student work products from collaborative activities.	
16. Expectations for group processes/ways of working	The document specifies or suggests expectations for how students should work/interact during collaborative activities.	The document provides evidence or use of related terminology that indicates expectations for how students should work/interact during collaborative activities.	The document does not directly or indirectly discuss expectations for how students should work/interact during collaborative activities.	

Total Score: _______________

Appendix G: IB Curriculum Documents Coded in Content Analysis

Document Name	Programme	Content
The IB Learner Profile in review - resources	General/All	all
IB Learner Profile updated	General/All	all
IB Learner Profile updated executive summary	General/All	all
Programme standards and practices	PYP	interdisciplinary
Exhibition guidelines	PYP	interdisciplinary
Making the PYP happen	PYP	interdisciplinary
PYP as a model of transdisciplinary learning	PYP	interdisciplinary
The Primary Years Programme	PYP	interdisciplinary
The role of ICT in the PYP	PYP	interdisciplinary
Language scope and sequence	PYP	language
Mathematics scope and sequence	PYP	math
Science scope and sequence	PYP	science
Social studies scope and sequence	PYP	social studies
MYP guide to interdisciplinary teaching and learning	MYP	interdisciplinary
Second-language acquisition	MYP	language
MYP- Teaching the disciplines in the MYP	MYP	interdisciplinary
MYP Technology and ICT	MYP	interdisciplinary
The Middle Years Programme-A basis for practice	MYP	interdisciplinary
MYP- Humanities guide	MYP	social studies
MYP- Language A guide	MYP	language
MYP- Language B guide	MYP	language
MYP- Mathematics guide	MYP	math
MYP- Science guide	MYP	science
CAS Sept 2013 for research	DP	interdisciplinary
DP - ATL in the DP Final	DP	interdisciplinary
DP - Theory of knowledge guide	DP	interdisciplinary
DP - Approaches to T&L across the DP	DP	interdisciplinary
DP - The DP, A basis for practice	DP	interdisciplinary
DP - The DP, From principles into practice	DP	interdisciplinary
DP - Theatre Guide	DP	performing arts
DP - Music Guide	DP	performing arts
Group 4 guides - Physics updated	DP	science
Group 4 guides - Chemistry updated	DP	science
Group 4 guides - Biology updated	DP	science
Group 4 guide - Environmental systems and societies	DP	science
Group 4 guide - Sports, exercise, health	DP	science

science		
Group 4 guide - Design Technology	DP	science
Group 4 guide - Computer science	DP	science
DP - Mathematics SL	DP	math
DP - Mathematics HL	DP	math
DP - Mathematical studies SL	DP	math
DP - Further mathematics HL	DP	math
DP - Computer science	DP	math
IBCC General Regulations	IBCC	Interdisciplinary
IBCC Overview	IBCC	Interdisciplinary
IBCC Handbook	IBCC	Interdisciplinary
IBCC Core Guide	IBCC	Interdisciplinary

Appendix H: Facilitating Collaboration in the IB Classroom: A Practitioner's Guide

Introduction

Student collaboration within the IB classroom is an expectation shared by all IB programmes. As *communicators*, IB students are required to collaborate effectively, listening carefully to the perspectives of other individuals and groups. As *inquirers*, they are also expected to know how to learn independently and with others. Collaboration promotes the development of other learner attributes such as knowledgeable, principled, and reflective. Collaboration is a cognitive and social skill that should be intentionally practiced in order for IB students to fully realize the IB Learner Profile attributes. The purpose of this guide is to provide the IB practitioner a definition of collaboration in the context of the IB curriculum, justification for collaborative learning in the IB curriculum, and suggestions for general classroom strategies or factors and specific methods that are likely to facilitate student collaboration.

Definition

Collaboration is a social process of knowledge building that requires students to work as an interdependent team towards a clear objective resulting in a well-defined final product, consensus, or decision. Collaborative tasks and groups are structured so that teams of students must rely on one another to share resources (e.g., materials, knowledge, experience, insight, and skills), utilize meta-cognitive processes, and communicate with each other in order to complete a task and/or arrive at a consensus best achieved with equitable participation of all members.

Justification

Collaborative learning, with its roots in Paigetian social constructivism, is based largely on the idea that knowledge is a joint construction of individuals working together (Smith & MacGregor, 1992). Student collaboration has been shown to have positive effects on several important outcomes such as academic achievement, motivation and effort, and engagement in learning (Hattie, 2009; Johnson et al., 2000; Webel, 2013; Williams, 2009). The positive effects of student collaboration appear to be robust across most subject areas, student age groups, and types of outcomes (Hattie, 2009).

Characteristics of Collaboration

In a collaborative classroom teachers and students can act as instructor, learner, and/or facilitator. The teacher, however, establishes the instructional goals. In collaborative learning, the teacher is responsible for setting the learning goals and for keeping the team activities and discussion focused on the content in a manner that both facilitates collaboration and ensures reasonable understanding of the content.

Teacher factors that characterize collaboration are scaffolding for collaborative learning, modeling collaborative process, facilitating dialogue regarding quality of collaboration, intentional grouping of students, and task structure that encourages interdependent knowledge construction. In classrooms where student collaboration exists, teachers plan for collaborative tasks by recognizing the critical role the teacher plays in setting collaboration as an academic and social expectation. This is accomplished by intentionally placing students in teams in a manner that encourages peer interaction and distributed expertise (Ferguson-Patrick, 2007; Brown et al., 1996); establishing and maintaining an atmosphere of individual responsibility coupled with communal sharing; designing collaborative tasks that require an active, constructive process where students work in teams on authentic tasks that require consensus (Michaelson, Knight, & Fink, 2002; Smith & McGregor, 1992); and planning for assessment of collaboration which includes individual assessment, peer assessment, teacher assessment, and discussion with students about the quality of collaboration.

In collaborative learning, students are asked to serve as teachers, editors, advisers, and mentors; teaching one another, making comments on one another's ideas and work, and participating as a team of learners with various degrees of expertise in a content area or topic. Student factors for collaboration are team (or group) size, team structure, individual role/responsibility within the team, expectations for the collaborative process, and group expectations for the final product. Even though these are termed student factors, the teacher establishes guidelines and expectations for many of the student factors.

In brief, student collaboration may be facilitated with the following factors or strategies:

Factors that facilitate collaboration	**Factors that may hinder collaboration**
Strategically formed groups of students	Unintentional grouping of students.
Interdependent individuals working as a team	Independent individuals working in a group
Task is structured with a clear concise objective.	Task is unstructured with a fuzzy open objective.
Task requires teams of students to rely on one another to successfully complete the task.	Task allows students to break down the assignment (divide and conquer) and work independently on the components.
Final product requires a single choice, decision, or product to be made through *consensus* by the team.	Final product does not require a single choice, decision, or product to be made by the group of students. No consensus is necessary.
The process of collaboration is made explicit and evident to the students through clearly stated expectations for individual contribution to the team.	The process of collaboration is not made explicit and it is not stated as an expectation.
Both individual and team contributions are assessed and both influence the student's grade.	Only the final (group) product is assessed and individual contributions do not influence the student's grade.
Both the collaborative process and products related to collaboration are assessed.	Though emphasis may be placed on collaboration, only products of collaborative process are assessed.

Methods for Collaborative Learning:

Several instructional methods for collaborative learning exist. A few examples are reciprocal teaching (Palincsar & Brown, 1984), jigsaw method (Aronson, 1978), SPIDER web discussion (Wiggins, http://spiderwebdiscussion.com/), and team-based learning (Michaelson, Knight, & Fink, 2002). The SPIDER web discussion and team-based learning (TBL) are briefly described with suggestions provided to find more information.

One example of a method that can be used when planning collaborative tasks is the **SPIDER web discussion™ method** created by Alexis Wiggins (IB DP Approaches to Learning, p. 9). The name is an acronym, describing specific aspects of the group task and its process:

Synergetic—a collaborative, group effort with a single group grade
Process—a process that must be practiced and honed
Independent—students work independently; teacher observes and gives feedback
Developed—a developed, sustained discussion that aims to "get somewhere"
Exploration—an exploration of ideas, texts or questions through discussion with a
Rubric—a clear, specific rubric against which the students can self-assess.

"Web" is used to describe two aspects of the SPIDER method: the appearance of the physical map of discussion looks like a web, and web as a metaphor for the process. Similar to the arms of a spider web, all individuals in a team must contribute equally, or the web will not be strong. For more information on the SPIDER web discussion method see http://spiderwebdiscussion.com/.

Team-based learning (TBL™) is a specialized model of teaching and learning that utilizes a structured cycle of learning events to create a motivational framework in which students increasingly hold each other accountable for being prepared. In TBL the traditional cycle of lecture, student review, homework and assessment is replaced by student review, homework, assessment, lecture (in an abbreviated form), and application (Michaelson, Knight, & Fink, 2002). TBL has three primary components: (1) forming teams, (2) ensuring readiness assurance for the application exercise, and (3) designing effective team application exercises. The readiness assurance process is designed to motivate students to adequately prepare prior to class and to capitalize on peer learning to encourage students to teach each other and address, as a team, gaps in understanding (Taylor *et al.*, 2012). It has four sequential steps: (1) pre-class preparation assignment, (2) individual readiness assurance test, (3) team readiness assurance test, and (4) appeals. A unique and beneficial feature of the TBL team test is use of the Immediate Feedback Assessment Technique (IF-AT) (Epstein Educational Enterprises). Similar to a lottery scratch-off card, the correct choice on the IF-AT answer sheet is indicated with a star under the letter choice. If the first choice is incorrect, students continue with the answer options until they find the correct choice, receiving partial credit. Learning is enhanced when students receive immediate and regular feedback (Cooper and Robinson, 2000). The IF-AT scratch-off card provides immediate feedback and encourages the team members to discuss the pre-assignment, teach each other through discussion and debate, and to reflect carefully on their response prior to scratching their choice.

The application exercise, which is completed in class within teams, is the synthesis and application of the information covered in the readiness assurance process.

A primary goal for TBL is shifting from passively conveying information to helping students apply course content to solve problems. The initial acquisition of course content occurs during the readiness assurance process while the application exercise extends learning to higher levels of cognition such as analyzing, evaluating, and creating. Effective application exercises are completed in teams, incorporate new concepts from the readiness assurance phase, and include four crucial elements: (1) addresses a significant problem, (2) requires one specific choice among clear alternatives, (3) all teams work on the same problem at the same time, and (4) the teams report their decision simultaneously and publicly to the class. The opportunity for comparison of choices among the teams is one of the major strengths of the TBL method. For more information on team-based learning see http://www.teambasedlearning.org/.

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