Collaboration Skills in the IB Middle Years

A Research Report Prepared for the International Baccalaureate Organization

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Contents

List of Abbreviations and Acronyms

Abbreviation/Acronym	Definition
CFA	Confirmatory Factor Analysis
GPA	Grade Point Average
IB	International Baccalaureate
IBO	International Baccalaureate Organization
IEP	Individualized Education Plan
MYP	Middle Years Program
NSF	National Science Foundation
PALS	Patterns of Adaptive Learning Survey
PRLS	Perceived Responsibility for Learning
SELF	Self-Efficacy for Learning Form
SRL	Self-Regulated Learning
SSRL	Socially Shared Self-Regulated Learning
STEM	Science, Technology, Engineering, and Math

Executive Summary

In this study, we aimed to examine the application of a model in the International Baccalaureate (IB) Middle Years Program (MYP) in science classrooms using two phases. Phase I was qualitative in nature and sought to clarify factors related to collaboration in middle school science classrooms to form a model. Phase II was quantitative in nature and tested the model that we derived from the factors of Phase I with a larger group of students and teachers. Together, Phase I and Phase II resulted in the development and refinement of a model that described tangible factors related to successful collaborative learning environments in the middle school science classroom. The model explained how key features of the learning environment, such as the role of the teacher and task and group structures and technology, influenced self-regulated learning (SRL), co-regulation, and communication skills in students that potentially led to positive educational outcomes. This model can be used by teachers and teacher educators to plan and implement collaboration practices so that students can learn and maintain collaboration skills.

Phase I focused on the MYP to identify classroom practices and instructional design elements that promote the development of student collaboration skills. First, we reviewed MYP documents found in the International Baccalaureate Organization (IBO) Program Resource Centre to understand messaging about collaboration in science classrooms that was shared with teachers. We found that the documents in the Program Resource Center provided an in-depth understanding of collaborative features of the MYP curricular framework. From these documents, we found that the socially shared self-regulated learning (SSRL) of collaboration skills was central to the information provided to teachers. The documents explained how teachers could establish SSRL for collaboration by helping students to explicitly understand what is

involved in positive collaborative interactions and how to observe these behaviors in other students. We also found that the ideas in the documents that were most closely related to SSRL were task structure, the role of the student, and problem solving. The documents made recommendations for teachers to structure tasks in a way that made deliberate attempts to scaffold collaboration among students and to have high expectations for students to work collaboratively in order to accomplish the learning task. Additionally, the documents made recommendations to contextualize learning in problem solving by providing real-world settings in which to solve problems. We found that when teachers create a learning environment that encourages collaboration, raises expectation that students take responsibility for positive collaborations, and create authentic problems to solve via collaborations enhanced the environment of sharing SRL strategies.

The next part of Phase I was to observe two MYP classrooms, interview the teachers, and hold focus groups with the students to understand more about collaboration in action in science classrooms. We observed MYP science classrooms from a single school within a mid-Atlantic suburban region of the United States to better understand how the instructions given in the Program Resource Center were implemented. After the observations, we interviewed the two teachers and conducted a focus group with seven students to gain insight into their perceptions and beliefs of collaboration practices that we observed.

We found from the observations and interviews that teachers use a variety of tools, structures, and expectations to gradually teach students to effectively collaborate in science classrooms, which aligned well with our findings from the Program Resource Center documents. Teachers deliberately set up activities to help students gain collaboration skills, such as providing them graphic organizers to express their ideas individually and to reference when they are working towards consensus in an activity. At the beginning of the year, the teachers gave students many of these types of supports to help them build listening and communication skills. As teachers noticed students becoming more proficient in the skills over time, they would fade the supports so that students would collaborate with other students independently. When teachers noticed students struggling with collaboration skills, they would provide the support again. While students gradually took on more responsibility in collaborating, teachers would spend extra time in class to carefully monitor and redirect students to help them work through conceptual misconceptions that may have occurred during collaboration.

In the focus groups, students expressed that collaboration helped them understand science content and skills. They also agreed with teachers that, though collaboration takes extra time, the efforts made have a positive outcome. Students noticed that they were more motivated in science class than in other classes because of the collaborative environment. Students also explained that because the learning was authentic, they understood how the skills they developed were useful outside of the science classroom.

In Phase II, we selected a larger sample of students (n = 210) from the same school to complete surveys regarding their perceptions of collaborative learning in science classrooms. We asked students to complete surveys about their self-efficacy for SRL and their perceived responsibility for learning, to self-report their teamwork behaviors, and to report their level of engagement in school.

Consistent with these qualitative findings, we found that quantitative analyses in Phase II showed that collaborative learning served as a mediator between student self-regulatory functioning and classroom goal-structures, which in turn predicted school engagement and student achievement. These findings underscore the importance of the IB curricular framework in fostering collaborative learning environments that lead to student engagement and learning in science education contexts.

Overall, we found that the IB curricular framework provided the foundation for creating collaborative settings in science education that opened the opportunity for students to learn from their peers through discussion and peer teaching. The three main takeaways from this research as it relates to implications for practice can be summarized as follows:

1. Collaboration is a key to success in the classroom for various reasons—building student self-efficacy, helping students build skills in self-advocacy, and building both self- and co-regulated learning—all of which might play an instrumental role in student success both academically and beyond.
2. Peer interactions in a co-regulated environment during learning can lead to a greater exchange of knowledge and engagement in school, which could help build an innate level of enjoyment towards science and other STEM related fields.
3. Promoting a goal mastery mindset (being persistent, learning from failed attempts) could lead to better educational outcomes, as well as increased school engagement.

Table 1
Overview of Collaboration Skills in the IB Middle Years

Research Questions	**Findings**	**Recommendations**
Which features of the IB Middle Years Program (MYP) are expected to foster the development of collaboration skills in students?	There were four clusters of ideas found on the network model: • *Socially Shared Regulated Learning, Task Structure, Role of Student, and Problem Solving.* • *Grouping Rationale, Scaffolding Student Work, and Agentic Engagement.* • *Behavioral Engagement and Interdisciplinary Inquiry Learning.* • *Explaining Ideas to Others, Emotional Engagement, Student Knowledge of the Learning Process, and Cognitive Engagement.*	The documents on MYP provide detailed explanations for teacher roles and student expectations for collaboration in science. However, there is little about the use of assessment and technology to support student collaboration in the documents. IBO may want to explore how to communicate this to MYP educators.
In what ways do students develop collaborative skills in the MYP?	Students reported that they feel they need time to understand their peers before collaboration can be effective.	IBO can support students by making teachers aware that they can support collaboration by starting with explicit instructions in a non-science context and then shift student collaboration skills to a science context.
What strategies and classroom practices do teachers apply to develop collaboration skills in the MYP?	Teachers facilitate collaboration among students by using graphic organizers, structures, and expectations that they gradually teach to the students.	IBO can support more student collaboration in science by providing professional development to teachers on (a) structures they can use in the classroom to support students and (b).

To what degree are IB middle school students' perceptions about mastery goal structures and self-regulation related to collaborative learning, engagement and achievement in science education contexts?	IB middle school students' perceptions about mastery goal structures and self-regulation/co-regulation are related to collaborative learning, student engagement, and achievement in science education contexts.	building student mastery goal orientation and self/co-regulated learning skills.

Collaborative Learning in Science Education Contexts

Self-regulation refers to student self-generated thoughts, beliefs, and actions geared towards the attainment of goals. SSRL is a process where multiple people regulate their collective task. In this case, goals and standards are co-constructed, and the anticipated product is socially shared cognition (Hadwin & Oshige, 2011). Collaboration occurs when students take on roles and interact with one another in groups to actively construct solutions to authentic tasks that require higher-order thinking (Shear et al., 2010). Specifically, collaborative interactions involve taking on leadership roles, decision-making, building trust, communicating, reflecting, and managing conflicts (Carpenter & Pease, 2013). These types of interactions promote the use of regulation strategies (e.g., goal setting, self-monitoring, and self-evaluation), which contribute to the construction of shared understanding and group motivation, as well as the development of collaborations skills (Rogat & Linnenbrink-Garcia, 2011). While communication and collaboration allow a student to work with others to build their conceptual knowledge and work towards a solution to their real-world problem, knowledge construction is a personal and contextualized process that students undergo. Furthermore, self-regulation, in conjunction with communication and collaboration, guides their individual connections, reflections, and revisions between knowledge construction and real-world problem solving (Stehle & Peters-Burton, 2019).

In this study, we explore the role of the IB MYP curricular framework and instructional features in fostering student collaboration and achievement in science education contexts. The IB MYP is an internationally followed framework that focusses on real-world problem solving, holistic student growth, and critical reflective skills at a personal, local, national, international, and global level. We chose to conduct this research in science classrooms as science naturally lends itself to the collaborative learning process. In science learning, 33% of general aspects utilize collaboration (Wright et al., 2013); this can range from group experiments to dissections. The science classroom is designed to organically promote peer discussions, which provide a space for critical thinking, real-world problem solving, and the development of scientific concepts (Gijlers & de Jong, 2005). To our knowledge no studies have directly examined the role of collaborative learning on student self-regulation, engagement and learning in the context of science education with IB MYP students.

When thinking about the features that contribute to the development of collaborative skills in students, the structure of tasks and groups, teacher and student roles, and the availability of technology all play sizeable parts in the effectiveness of collaboration. For example, one study demonstrated that when middle school science teachers designed activities that included both concrete and abstract elements, they inspired group talk among the students that led to improved student understanding (Zinicola, 2009). In another study, middle school students deepened their mathematics understanding and problem-solving abilities when they collaborated with peers. Findings showed that students' ability to collaborate effectively was the most potent predictor of performance (Ardito et al., 2014). In addition, students who participated in structured discussion forums experienced significant improvements in their collaborative skills compared to students who participated in the unstructured discussions (Tibi, 2015). Therefore, placing middle school students in academically heterogeneous groups when engaging in a science investigation may lead to richer collaborative discussions than when students are placed in academically homogeneous groups (Gijlers & De Jong, 2005).

Research has shown that when students engage in educational activities involving collaboration, they have increased academic gains. For example, in a study by Gomez-Lanier

(2018), a flipped classroom pedagogy was taken when developing collaboration within a classroom. A flipped classroom approach is a non-traditional method of teaching where lecture content is provided to the students outside of the classroom, therefore the allotted class time is spent in discussion and group-oriented activities that support the content. In their study, Gomez-Lanier found that integrating collaborative activities during a flipped classroom experience promoted improved time management skills and, therefore, provided students with greater opportunities to complete in-class assignments (2018). These improved time management skills helped students gain a better understanding of course material while enhancing their verbal and analytical skills. Furthermore, students had an overall positive outlook on working with others, as well as the opportunity to nurture their own creativity (Gomez-Lanier, 2018). In another study, students who engaged in groups and were able to use regulatory processes such as reading notes, seeking consensus, summarizing, and expressing their feelings of knowing experienced greater gains in content knowledge when using a hypermedia learning environment (Winters & Alexander, 2011). Student dyads who used a thinking aloud pair problem-solving approach in science scored significantly higher than students working as individuals, as well as students working in pairs without the thinking aloud approach (Jeon et al., 2005). Other structured collaborative approaches such as [1]Jigsaw and the [2]Natural Field Approach have been shown not only to increase academic performance, but also to improve student motivation (Eilks, 2005; Rozenszayn & Asssaraf, 2011).

[1] In a Jigsaw approach, each individual in a group of students is assigned a portion of the learning content, then from there they would be responsible for gathering knowledge (i.e., becoming the group expert) by discussing with peers outside of their group who were assigned the same content, and finally the students return to their original groups and share their findings.

[2] In a Natural Field Approach, students are actively developing their ideas and gaining knowledge of science through the process of scientific inquiry.

Purpose of the Current Study

With the above findings in mind, we designed a logic model for this study (see Figure 1) grounded on current literature regarding the cultivation of learning environments (e.g., role of the teacher) when fostering SSRL, therefore improving real-world problem solving. The present research study used a two-phase approach to address a series of research questions (see Appendix A for chronological order of procedures). Phase I focused on the MYP, identifying what practices promote the development of collaboration skills; and Phase II explored the MYP school's collaboration skills and motivational beliefs. We explored the following research questions, with the first three questions addressing Phase I and the final question addressing Phase II:

1. Which features of the IB Middle Years Program (MYP) are expected to foster the development of collaboration skills in students?
2. In what ways do students develop collaborative skills in the MYP?
3. What strategies and classroom practices do teachers apply to develop collaboration skills in the MYP?
4. To what degree are IB middle school students' perceptions about mastery goal structures and self-regulation related to collaborative learning, engagement and achievement in science education contexts?

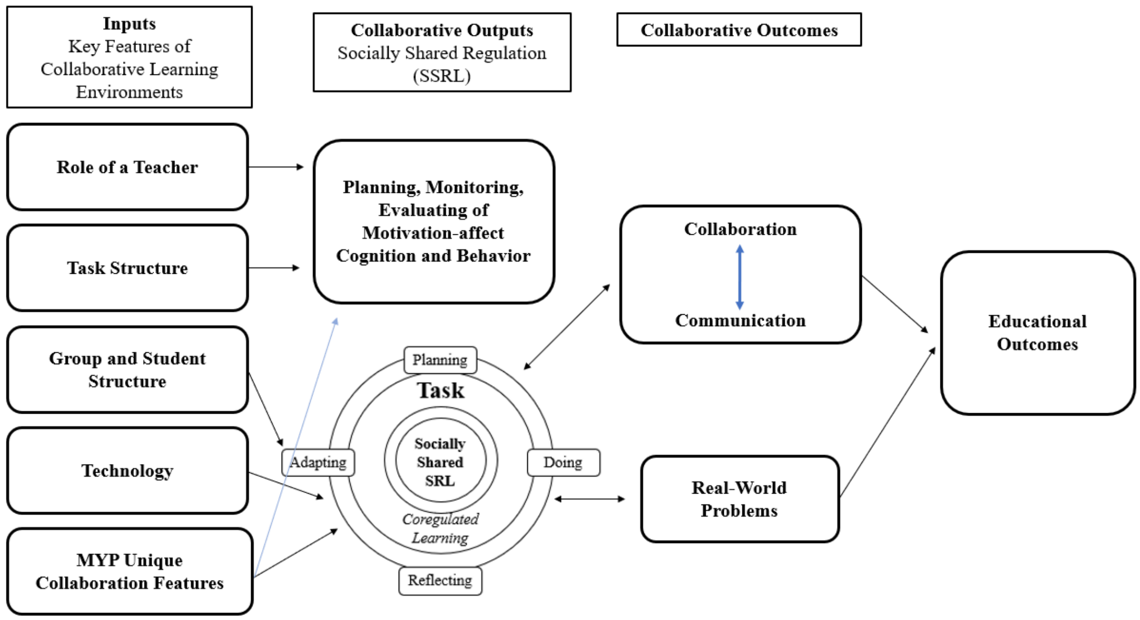

Figure 1

Hypothetical Model of Collaborative Learning in MYP Classrooms

Phase I: MYP Features and Implementation of Collaboration in the Science Classroom

Method

Phase I consisted of two approaches in which we focused on the identification of design and practices that promoted development of student collaboration skills in science classrooms. During the first approach we conducted a document analysis (Bowen, 2009) that examined the design features for collaboration in an MYP science classroom. We identified and analyzed documents from the Program Resource Center to determine the main constructs and the connections among those primary constructs present in the documents. In the second approach used in Phase I, we conducted a case-study of the implementation of collaboration by two science teachers and their students in an MYP school (Yin, 2003). We selected two MYP classrooms from one school in a suburban area of the mid-Atlantic U.S.—one 7th grade classroom and one 8th grade classroom. The two classroom teachers consented to participate in the study and submitted their lesson plans for analysis, engaged in an observation, and were individually interviewed separately for roughly one hour online over Zoom. Finally, we asked three students from the 8th grade classroom and four students from the 7th grade classroom who assented to participate in the study for participation in two 60-minute focus groups on student perceptions of collaborative activities in science classrooms. The teachers selected these students based on their academic abilities, gender, and ethnicity to ensure for the sample's maximum variability in student characteristics. Once collected, we used the qualitative data from Phase I to examine for both convergence and divergence across all sources. We also took note of *a priori* and emergent coding for interactions and collaboration characteristics.

MYP Document Sample

To answer the first research question—Which features of the IB MYP are expected to foster the development of collaboration skills in students? —we performed a document analysis. The purpose of the document analysis was to determine the connection of the logic model for this project with the MYP documents found in the Program Resource Center.

We first casted a wide net for the documents produced by IBO for schools regarding collaboration to analyze. From there, we developed a list of documents likely to be related to collaboration by examining all the documents in the Program Resource Center. Next, we presented the list of documents (see Table 2) to the Program Officer at IBO and she confirmed that we captured all relevant documents. Finally, we developed a codebook for the coding process based off the logic model for the project, where we used the initial codebook developed before the coding process as a "start list" of pre-set codes (*a priori* codes).

Table 2

List of Documents Requested from Program Officer at IBO

Content portal	Document name	URL
Science	MYP Sciences Guide	https://resources.ibo.org/data/m_4_scien_guu_1405_7_e.pdf
Interdisciplinary Teaching and Learning	Fostering Interdisciplinary Teaching and Learning in the MYP	https://resources.ibo.org/data/m_g_mypxx_mon_1408_2_e.pdf
Interdisciplinary Teaching and Learning	MYP- Teaching the disciplines in the MYP	https://resources.ibo.org/data/m_0_mypxx_guu_1301_1a_e.pdf
Learning and Teaching	MYP: From Principles into Practice	https://resources.ibo.org/data/m_0_mypxx_guu_1405_4_e.pdf
Learning and Teaching	Teaching and Learning with Technology	https://ibpublishing.ibo.org/server2/rest/app/tsm.xql?doc=g_0_iboxx_amo_1512_1_e&part=1&chapter=1
MYP Projects	Projects Guide	https://resources.ibo.org/data/m_0_persp_guu_1405_7_e.pdf
ATL	Approaches to learning	https://resources.ibo.org/data/approaches-to-learning_bf2206ce-4674-432e-89ca-2b0b838570ce/PRC-approaches-to-learning-en_be3532bb-6c3e-4cc5-9bd6-39fb1270534b.pdf
Further guidance for ATL	Further guidance for ATL	https://resources.ibo.org/data/m_0_mypxx_fcl_1409_1a_e.pdf
Learner profile	The learner profile	https://resources.ibo.org/data/general__1114201935745PM.pdf

Coding Phase for Document Analysis

We used [3]Dedoose to analyze the qualitative data. During the coding, first we recorded any pre-existing thoughts, ideas, and/or biases that may influence the coding process. Next, we read each document fully prior to coding. This allowed for a preview of the documents, the chance to formulate a method of approaching the following steps, and an additional opportunity to revisit the first step should any influential biases be missed.

We developed a codebook for the coding process from the logic model for the project. The initial codebook was a “start list” of pre-set codes (*a priori* codes). We derived these initial codes from the conceptual framework of the study by reviewing related academic literature, and further dissected them using [4]parent and child codes. We used an Excel file as the codebook. The first sheet had the steps of the coding process documented with the step number, the step itself, and a description, details, and notes about that individual step. The second sheet in the file contained the parent and child codes, with each pre-existing code having the title of the code, the definition of the code, and a description of any qualifying and disqualifying factors. Each document had its own separate sheet, divided into four columns: from left to right, first there was a space for the excerpt and citation, then a space for the interpretation, followed by a space for the parent codes, and then finally a space for the child codes. The initial codebook can be found in Table 3. After the coding process, we identified two [5]emergent codes (School Climate and School Culture) that we placed in the codebook to be an *a priori* code for the classroom observations and interviews.

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[3] These ideas were noted in a separate document from the rest of the coding performed. To maintain this level of reflexivity, we maintained the notes throughout the coding process.

[4] Child codes are sub-ideas and are subordinate to the parent codes. When we used child codes to code excerpts, we also recorded the parent code.

[5] Emergent codes are those ideas, concepts, actions, relationships, and meanings that come up in the data and are different than the pre-set codes. Each variable identified in the logic model was considered a code.

Table 3

Initial Codebook for Phase One

Code Labels	Definitions	Qualifications/Exclusions
Role of Teacher (P)	Explanation of how the teacher fosters collaboration	
- Modeling collaboration behaviors (C)	Explanation of how teachers model collaboration for students	
Task Structure (P)	Explanation of the learning environment and task for learning	Must be both learning environment and task, or can be only task, but not just learning environment
Group Structure (P)	Ways students are grouped to support collaboration	
- Scaffolding student work (C)	Methods of helping students reach their zone of proximal development	
- Grouping rationale (C)	Evidence of reasons for group structure	
- Group size (C)	Explanation of size of group and rationale	
Role of Student (P)	Supports or student-generated ideas for structured ways students can collaborate	
Technology (P)	Ways that technologies support student collaboration	
MYP Unique Collaboration Features (P)	Factors explained in MYP documents that are not found in other sources	
Socially Shared Regulated Learning (P)	Explanation of when multiple people regulate their collective task	
Student Knowledge Building (P)	Ways that collaboration builds student knowledge	Must be knowledge building through collaboration, not individual knowledge building
- Expectations for group product	Explanation of expectations for group products	

- Explaining ideas to others (C)	Instances when students explain ideas to others that result in knowledge building	
Peer Discussion (P)	Instances when there is student-to-student discussion	
- Expectations for group process (C)	Evidence of ways that groups work together	
Problem solving (P)	Ways students solve problems collectively	Must involve collaboration, not individual problem solving
Student Engagement (P)	Instances when students are motivated to participate in collaboration	
- Behavioral engagement (C)	Instances when student engagement can be observed	
- Emotional engagement (C)	Instances when students engage emotionally	Usually self-reported
- Cognitive engagement (C)	Instances when students are academically engaged	Usually self-reported
- Agentic engagement (C)	Instances when students advocate for themselves	
Student knowledge communication (P)	Instances when students explain what they know to a listener	
Code for emergent concepts (P)		

Note. This codebook is derived from reviewing related academic literature and from the logic model presented for this project. These initial codes are strictly seen as *a priori*; (P) = parent code, (C) = child code.

The second step was to identify relevant phrases, sentences, or paragraphs from the document based on the coding scheme explained in the codebook (Maxwell, 2015). These narrative segments were called excerpts. The length of the excerpt depended on the content itself and the amount of context needed to give a full picture of the themes embedded in that excerpt. During step three, we took anything that we read as related to the topic at hand and inserted into the codebook with a citation such that it could be located later should it need to be revisited. Step four in the coding process involved recording the interpretation of the excerpt, alongside any additional notes and reasoning for this interpretation (Saldaña, 2015). This typically manifested as a summary or paraphrase of the excerpt, alongside a short explanation of parallels drawn between the excerpt and the topic at hand. For shorter documents, or documents with less relevant information, we typically conducted these steps separate and one at a time. For longer and denser documents, the steps were done simultaneously: an excerpt was extracted and documented, and immediately an interpretation and notes were documented. An example set of codes, excerpts, and interpretations is found below in Table 4.

Table 4
Excerpts from Documents

Description	Interpretation	Parent Code
"The roles and processes between integration and implementation are not strict. Roles also develop and change on a spectrum, and, in some cases, it is beneficial to combine roles to create a seamless relation between pedagogy and devices." (Teaching and Learning with Technology: A Guide of Basic Principles: Integration versus Implementation: Understanding technology integration versus technology implementation: Roles in schools)	Roles and processes, and potentially a combination thereof, are important to the use of technological devices in collaborative learning	Group Structure; Role of Student; Technology; Socially Shared Regulated Learning
"Every member of the school community shares a responsibility to foster technology literacy in all learners." (Teaching and learning with technology, an executive summary: Policies, or "mindsets in text")	Learner technology literacy, including with regards to collaboration, is a responsibility of the whole school community	Role of Student; Socially Shared Regulated Learning; MYP Unique Collaboration Features; Code for Emergent Concepts

Note. These excerpts are based on relevant phrases, sentences, or paragraphs in relation to the coding scheme presented in the codebook.

Prominence Analysis. Once we recorded all the excerpts with the relevant code or codes, we analyzed the codes for their prominence. The purpose of the prominence analysis was to determine which codes occurred most frequently and which occurred least frequently, providing empirical evidence for the ideas in the logic model that were most frequently communicated in the documents. Not only did we perform the frequency count of the codes, but we also identified the documents in which the excerpts for the codes were found. This provided an additional layer of information as to which documents in the Program Resource Center most and least frequently communicated ideas about collaboration in the classroom.

Utility Analysis. In this analysis, we used a new Excel file to organize the data. We organized the six columns from left to right as follows: "codes"; "properties/interpretations of codes"; "relationship with other codes"; "examples from documents"; "document"; and "citation". In the "codes" column, each code present in the codebook was listed, one per row; this column was filled out first. The second column included "examples from documents" column. We took these quotations from the original Excel spreadsheet; inserting each excerpt associated with a code, adding rows as needed for each group of codes. At this time, we also inserted into the Utility Phase Excel file the document the excerpt came from as well as the rest of the excerpt's citation.

We filled in the next column with the "relationship with other codes" column. To do this, we searched for each quotation in the original Excel spreadsheet. When we found the quotation, we noted which codes were associated with the excerpt. We inserted this collection of codes in the "relationship with other codes" cell next to an excerpt that was associated with a specific code; We copied and inserted this collection for each iteration of the excerpt throughout the utility phase file. Finally, we filled out the "properties/interpretations of codes" column by reading each quotation and compared it to the original proposed logic model, noting an interpretation, including vocabulary from the logic model when appropriate. As we noted this, we reflected on the column "relationship with other codes" and made changes as appropriate.

Interpretation Phase. During the Interpretation Phase, we examined all of the codes and their interpretations (see Findings). We grouped the interpretations into broader themes and accounted for all of our interpretations of the codes.

Case-Study Sample

The second research question – In what ways do students develop collaborative skills in the MYP? – included the same participants as in the qualitative phase a middle school ($N = 1211$; 53% 7th grade; 47% 8th grade) in a mid-Atlantic suburban region of the United States. Fiftyseven percent of the students in that middle school identified as White, 17% as Hispanic or Latino, 13% Asian, 7% Other, and 6% Black. Of these students, 11% were enrolled in the free and reduced-priced meals program, which can be used as an approximation for whether students are living in poverty.

Participants

Teachers. Teachers submitted their demographic information during the survey portion of this phase (see Table 5). Information collected from teachers included name, ID number, email address, age, gender identity, racial background, as well as information on teacher education (i.e., degrees earned and major, experience in years, amount of time teaching at their current school, subjects taught, number of students, average class size). A list of demographic items can be found in Appendix B.

Table 5
Teacher Demographics, Phase I and II (n =3)

Variable	n	(%)
Grade Levels		
7th	2	(66.7%)
8th	1	(33.3)
Years of Experience Teaching		
0-5	1	(33.3%)
6-10		
11-15	1	(33.3%)
16-20	1	(33.3%)
Years at Current School		
0-5	2	(66.7%)
6-10	0	(0%)
11-15	1	(33.3%)
Degrees		
Bachelors	0	(0%)
Bachelors and Masters	3	(100%)
Hispanic or Latino		
Yes	1	(33.3%)
No	3	(66.7%)
Race		
White	3	(100%)
Gender		
Male	2	(66.7%)
Female	1	(33.3%)
Age		
20-29	1	(33.3%)
30-39		
40-49	2	(66.7%)
Class Size		
25-30 Students	2	(66.7%)
30-35	1	(33.3%)

Students. Along with the two science teacher participants, seven selected students participated in Phase I (75% student response rate). Students submitted demographic information (see Table 6) along with collected survey data. Information collected included teacher name, grade, age, gender identity, racial background, free and reduced lunch status, disability status, language proficiency, and self-reported achievement information. Student demographic items can be found in Appendix B.

Table 6
Phase I Student Demographic Information (n =7)

	n	(%)
Age		
12	3	42.86
13	3	42.86
14	1	14.28
Grade		
7	4	57.14
8	3	42.86
Gender		
Male	3	42.86
Female	4	57.14
Hispanic or Latino		
No	6	85.71
Yes	1	14.29
Race		
White	5	71.42
Asian	2	28.58
Fluent in Other Languages		
No	5	71.42
Yes	2	28.58 (Japanese and Spanish)

Qualitative Instruments

Classroom Observations

We used the classroom observation tool to rate overall characteristics of collaboration in a classroom for three variables: peer interaction, teacher role, and product of collaboration. We adapted the observation tool from Glassman (2016). Each variable had a list of indicators. Observers, one of the researchers, and a graduate student scored the indicators as no indicators observed (score of 0), few indicators observed (score of 1), sometimes indicators present (score of 2), half of the indicators present (score of 3), most of the indicators present (score of 4), and all indicators present (score of 5). Each task that was observed in the class received a score for the indicators. For example, if a class had three collaborative tasks during the class period, the observation score would be three scores averaged over the class period.

Teacher Interviews

We interviewed each of the three teachers selected for Phase I of the study for approximately one hour. The purpose of the semi-structured interview (see Appendix B for interview protocol) was to ascertain information that we may not be able to observe during our school visits. The interview protocol was then adapted for the purposes of this study from a semi-structured interview protocol used in a National Science Foundation (NSF)-funded project exploring science, technology, engineering, and mathematics (STEM) practices in high schools (Lynch et al., 2018). We asked the teachers questions related to time spent during collaboration activities, categories of collaboration activities, and the structure of group meetings during their classes, along with motivational factors and goals for conducting collaboration in the science classroom. Teacher preparation for collaboration was an important factor in replicating effective collaborative activities in other classrooms; therefore, we asked questions about teacher background and training on establishing collaborative environments during the interview.

Student Focus Groups

We recruited one group of seven students with the teachers' assistance for both grade levels. Another school educator introduced students to the study and asked them to participate. The purpose of the focus group was to gain insight on the students' perspectives on classroom environment, technology use, contributing to teamwork, and personal experiences in collaboration activities in science. We adapted the semi-structured focus group protocol for the purposes of this study from a semi-structured interview protocol used in an NSF-funded project exploring STEM practices in high schools (Lynch et al., 2018). The purpose and examples of the questions in the protocol can be found in Appendix B.

Qualitative Results

We found eight overall themes within the codes (see Appendix C for a full account of each code with embedded themes):

- Real-World Knowledge Application Across Contexts and Outside the Classroom
- Social-Emotional Learning
- Interdisciplinary Learning Environments
- Inquiry
- Responsibility
- Respectful Communication
- Holistic Student Growth
- Critial Reflection and Action

Network Model

Due to the fact that COVID-19 delayed our collection of Phase I data, we spent this time exploring ways to describe the information given to teachers and schools on collaboration in science classrooms from IB documents found in the Program Resource Center. This model provided a visualization that explains variables that were central to the ideas communicated in the MYP documents and the ways in which those ideas cluster to form cohesive and reinforcing information.

Codes found within these themes are as follows (Table 7). We used the connections between the codes to develop a network model (Figure 2) to help us interpret the quantity and type of connections between all of the codes. This information helped us to refine the logic model.

Table 7
Codes Found within Themes

Themes	Codes within Theme	
Real-World Knowledge Application Across Contexts and Outside the Classroom	• Role of Teacher • Scaffolding Student Work • Technology • MYP Unique Collaboration Features	• Student Knowledge Building • School Climate • Cognitive Engagement • Student Engagement • Emotional Engagement
Social-Emotional Learning	• Role of Teacher • Role of Student • Problem Solving • Emotional Engagement	
Interdisciplinary Learning Environments	• Modelling Collaboration Behavior • Task Structure • MYP Unique Collaboration Features	
Inquiry	• Task Structure • Scaffolding Student Work • MYP Unique Collaboration Features • Student Knowledge Building • Cognitive Engagement	
Responsibility	• Group Structure • Role of Student • Socially Shared Regulated Learning • Expectations for Group Product	• Problem Solving • Student Knowledge of the Learning Process • Behavioral Engagement • Student Engagement
Respectful Communication	• Role of Student • Socially Shared Regulated Learning • Expectations for Group Product • Explaining Ideas to Others • Peer Discussion	• Expectations for Group Process • Student Knowledge of the Learning Process • Behavioral Engagement • Student Engagement • Emotional Engagement
Holistic Student Growth	• MYP Unique Collaboration Features • Socially Shared Regulated Learning • Behavioral Engagement	
Critical Reflection and Action	• Behavioral Engagement • Socially Shared Regulated Learning • Student Knowledge Building • Explaining Ideas to Others	• Peer Discussion • Problem Solving • Agentic Engagement • Student Knowledge of the Learning Process • Emotional Engagement

Interpretation of Network Model

In any network model, there are three visual characteristics that can be identified: clusters among codes, centrally located codes, and distances between codes. Clusters indicate codes that are found across MYP documents that are closely related. Centrally located codes are ideas that connect with other codes most frequently, thus indicating ideas in the MYP documents that axially connect ideas. The distances between codes displayed on a network model indicate either closely associated ideas (short distances between codes on the model) or distally associated ideas (long distances between codes on the model).

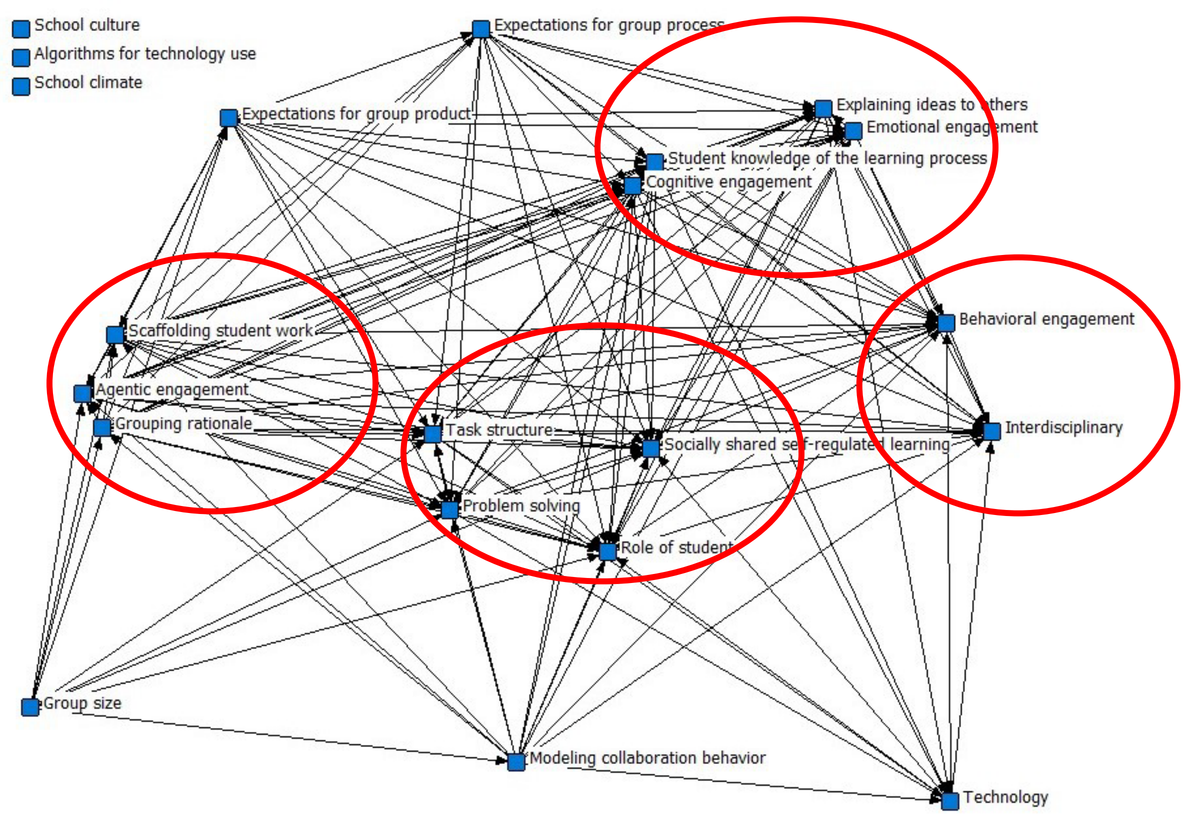


Figure 2

Network model of ideas from MYP documents regarding collaboration

We found four clusters of ideas on the network model:

- *Socially Shared Regulated Learning, Task Structure, Role of Student, and Problem Solving*. This cluster showed that various ideas about working in a group are presented cohesively in MYP documents. This was also the central cluster, which indicated these ideas were the most frequently connected with the other ideas in the network model. The four ideas in this cluster matched the ideas in the logic model developed from the literature on collaboration in science classrooms.
- *Grouping Rationale, Scaffolding Student Work, and Agentic Engagement*. This cluster indicated that MYP documents discussed the ways teachers set up groups for success are related to student agency.
- *Behavioral Engagement and Interdisciplinary Inquiry Learning.* The ideas in this cluster indicated that MYP documents discussed engaging in meaningful learning from the perspective of student engagement and real-world problem solving.
- *Explaining Ideas to Others, Emotional Engagement, Student Knowledge of the Learning Process, and Cognitive Engagement.* This cluster of ideas indicated that MYP documents discussed the ways students understand their own learning processes are connected to engagement and communication.

In addition to the clusters, there seemed to be a perimeter of constructs such as group size, technology, teacher expectations, and modeling of collaborative behavior connected to other clusters, but only peripherally. This indicated that these ideas are presented in the MYP documents but were not often connected with other ideas presented in the network model. Finally, the three ideas that were not connected to others in the network model--School Culture, Algorithms for Technology Use, and School Climate--were not connected in the MYP documents with ideas about collaboration in science classrooms.

MYP Document Codes

We compared the codes (i.e., variables in the logic model) established from the literature to those of the MYP documents. We verified that the produced codes matched what we found in the MYP documents, providing evidence that all necessary elements were in our initial logic model. However, we found emergent codes. The emergent codes added two variables to the logic model in unique MYP features, School Culture, and School Climate.

The following table illustrates the frequency of the codes found in the MYP literature (see Table 8). The table is listed from the most frequently found code to the least frequently found code. The second column displays the types of documents where the code was found, and the third column describes the frequency of the code in that particular document.

Table 8

Frequency of Codes in the MYP Literature

	Role																									
Document	Role of Teacher	Student Engagement	Socially Shared Regulated Learning	Role of Student	Student Knowledge Building	Peer Discussion	MYP Unique Collaboration Features	Behavioral Engagement	Technology	Agentic Engagement	Student Knowledge of the Learning Process	Task Structure	Problem Solving	Explaining Ideas to Others	Emotional Engagement	Cognitive Engagement	Scaffolding Student Work	Group Structure	Expectations for Group Process	Expectations for Group Product	School Culture	Group Rationale	Modeling Collaboration Behavior	Algorithms for Technology	Group Size	School Climate
Approaches to Learning	1	30	23	30	13	22	0	29	0	20	10	2	14	7	21	3	0	3	9	7	0	0	0	0	0	0
Fostering Interdisciplinary Teaching	4	6	6	2	4	3	7	3	0	0	3	2	2	2	2	2	0	0	1	0	0	0	1	0	0	0
From Principles into Practice	47	60	59	48	51	39	26	17	1	27	27	29	16	27	17	31	5	13	1	1	0	6	6	0	2	3
Further Guidance for Developing	11	3	3	1	2	2	17	3	0	3	2	10	2	0	3	0	4	4	0	2	11	0	0	0	0	0
Projects Guide	2	24	21	18	23	17	6	4	0	10	12	18	9	13	3	8	6	11	8	11	0	6	0	0	2	0
Sciences Guide	2	10	11	12	12	14	7	9	0	3	12	3	9	11	2	4	1	2	2	0	0	0	1	0	0	0
Teaching Disciplines in the…	16	30	11	18	27	24	2	9	0	10	15	18	11	12	4	15	8	8	2	2	0	1	0	0	0	0
The Learner Profile	3	17	18	12	11	15	8	17	0	15	9	1	15	2	17	1	1	1	3	1	0	0	1	0	0	0
Website	28	16	18	27	6	3	46	13	95	7	5	7	0	3	0	3	0	1	0	0	12	0	1	10	0	1
Total	272	196	170	168	149	139	119	104	96	95	95	85	78	77	69	67	48	43	26	24	23	13	10	10	4	4

Note. Totals in Table 8 may not directly add up due to double-coding instances.

As seen in Table 8 above, the following codes were most prominent in the MYP literature:

- Role of the teacher – 272
- Socially Shared Regulated Learning – 170
- Role of the student – 168
- Cognitive engagement – 162
- Student knowledge building – 149

Excerpts about the role of the teacher were found most frequently in the "From Principles to Practice" guide and were mentioned only once in the "Approaches to Learning" document. The five least prominent codes in the MYP literature were:

- Group size – 4
- School climate – 4
- Algorithms for technology use – 10
- Modeling collaborative behavior – 10
- Grouping rationale – 13

The least frequent code, "Group size" was only found in two documents on the MYP website: Principles to Practice and the Projects Guide. We analyzed each code for their underlying meanings and placed it into a code report, which can be found in its entirety in Appendix C. We created the code report to summarize the core meanings of the collapsed and aggregated codes that resulted in themes. In the following section, we explain the themes we developed from the document analysis with the help of the code report.

Themes Developed from the Document Analysis

When we collapsed the codes and reorganized them into themes, we found eight themes generated from collaboration-relevant codes:

- Responsibility
- Critical Reflection and Action
- Holistic Student Growth
- Inquiry

- Interdisciplinary Learning Environments
- Real-World Knowledge Application Across Contexts and Outside the Classroom
- Respectful Communication
- Social-Emotional Learning

The themes from the document analysis were reflected in the model developed from the literature, which indicated that the model components (see Table 9), to this point, were stable. Although all the themes were represented in the model, the document analysis provided depth of understanding of each of the components. The coding and thematic analysis allowed for a rich understanding of the component derived from the literature.

Table 9

List of Themes and Model Components

Model Component	Theme: Critical Reflection and Action	Holistic Student Growth*	Inquiry*	Interdisciplinary Learning Environments	Real-World Knowledge Application Across Contexts and Outside of the Classroom*	Respectful Communication*	Responsibility*	Social-Emotional Learning*
Planning	■							■
Monitoring	■							■
Evaluating	■							■
Motivation	■							■
Doing	■							■
Adapting	■							■
Reflecting	■							■
Knowledge of Learning Process		■	■					
Collaboration		■	■					
Communication		■	■			■		
Real-World Problem Solving		■	■		■			
Role of Teacher				■				
Task Structure				■			■	
Group and Student Structure				■			■	
Technology				■				
School Culture/Climate				■				■

Note. Themes which emerged from the IBO's document are represented with an *; model components that that are associated with the listed themes are indicated in green.

Critical Reflection and Action. The theme of critical reflection and action emerged from MYP documents. This theme referred to the ways in which the MYP encouraged students to look at the thoughts, perspectives, and actions of themselves and others during collaborative learning in science classrooms for the sake of learning and growth. This was done through activities established to provide students with the opportunity to work through a problem-solving process. In this context, peers communicated about their thoughts and perspectives and share their existing knowledge to build their knowledge collaboratively. In explaining these ideas and communicating what they knew about the learning process, students critically reflected and acted during teamwork. To this end, students must also socially share the regulation of the learning process to be able to critically reflect and act. To effectively reflect and act, students must be engaged in their decisions regarding their approach and their self-reflection, they must be engaged regarding their behavior and how they listen and communicate with others as they reflect and adapt their actions, and they must be emotionally engaged to empathize with others in order to critically reflect and adapt their actions.

Holistic Student Growth. This theme referred to the ways in which the MYP supported student cognitive, emotional, physical, and social growth during collaborative learning in science classrooms. This was a unique aspect of emphasis in the MYP classroom, and demonstrated how the whole student, not just one part, needed to be engaged in the collaborative task through their actions in order for the student to be able to grow. This full engagement and growth enabled the group to regulate their learning task together.

Inquiry. This theme referred to the ways in which the MYP fostered students' skills to ask and investigate their questions about the world during collaborative learning in science classrooms. Inquiry was a unique emphasis of the MYP. Its roots began with the structure of the task provided by the teacher, allowing the teacher to scaffold student work and growth during the collaborative task. This structure, allowing students to ask and investigate questions of relevance to the student and group, promoted student cognitive engagement and facilitated the building of student content knowledge.

Interdisciplinary Learning Environments. This theme encompassed the MYP's goal of providing learning environments and activities for students that involve more than one subject area. Interdisciplinary learning environments allowed students to engage in collaborative activities and ask questions about topics that not only take place across contexts, but also involved generalizable skills and are applicable in different situations. Teachers in these environments provided clear instruction to the students regarding their activities, as well as examples of what they should be doing and how and why the concepts and skills are relevant. This relevance was not only emphasized within the classroom, but students were shown how the ideas were applicable in the real world, as well.

Real-World Problem-Solving Application across Contexts and Outside the Classroom. This theme referred to the ways in which the MYP enabled students to generalize the skills obtained during collaborative learning in science classrooms. Teachers played a role as they developed collaborative activities that worked on generalizable skills and created contexts where students' efforts on these skills were scaffolded. Technology that students may have encountered outside the classroom was also used during collaborative MYP activities to enhance real-world applicability. Furthermore, building students' content knowledge was a core idea of building real-world applications. In addition, the climate of a school created a community-based learning environment that supported the generalization of skills. The MYP classroom also used student engagement, especially cognitive and emotional engagement, to support the application of skills across contexts. Finally, this focus on applying knowledge from the classroom to other contexts was a unique focus of the MYP.

Respectful Communication. This theme referred to the ways in which the MYP fostered students actively, inclusively, and considerately listening and speaking with others during collaborative learning in science classrooms. This responsibility fell primarily on individual students; however, as a group, students were expected to use this skill to assist them in regulating the learning process. Furthermore, when communicating their ideas to others, telling others what they know about the learning process, and setting guidelines and boundaries regarding what is expected of the collaboration process and the final product, students were expected to communicate respectfully throughout. Students also used this communication behavior to show their emotional and overall engagement in the collaborative task.

Case-Study Findings

Our findings from the case-study indicated that teachers facilitate collaboration among students by using graphic organizers, structures, and expectations that they gradually teach to the students. Based on our data, teachers supported students' collaboration skills and helped them work through misconceptions by monitoring and redirecting discourse, as well as helping students use these tools by having them collaborate on a non-science topic and then shift to a science topic. Teachers also reported that they realize that collaboration takes a bit more time, but feel it is worth the investment. Teachers mentioned feeling supported by their district with their attempts to be proactive about planning for collaboration. Students noted that they feel their collaboration skills help them understand science content and related skills. Students reported that they feel they need time to understand their peers before collaboration can be effective. However, across both teacher and student data sources, our data indicated that that technology did not play a big part in fostering and supporting collaboration throughout the duration of our study. Detailed findings from teacher interviews, student focus groups, and classroom observations are described below by topics named in the logic model.

Role of the Teacher

Teachers saw their role as being able to help students interact appropriately with other people and provide them with a structure to have meaningful conversations about the content. They operationalized this by closely monitoring student discussion during collaboration. As described by a teacher,

> *I'm monitoring what they're doing, and you know if they are you know there's often times where a loud persuasive individual will have the content wrong, so it's my role to step in and make sure that they're getting the content correct that their argument is on point and accurate for what we're trying to do. Generally, I will go around and build in enough time to check in with the groups and see what kind of trends we're having. I can change any misconceptions at a small group level, but then, if there is a pervasive misunderstanding, then I stop to clear things up and get them back on track and I'll do that in a large group, if necessary, or small group if that's what is called for.*

In classroom observations, it was difficult to distinguish some groups as they began their learning tasks. Some groups began measuring for the investigation before any discussion of roles, and some groups were interacting as planned. However, once underway, we observed that students were responsive to feedback from their classmates about improving data collection. Collaboration improved as the students became more comfortable with the task. Classroom management, such as redirecting off-task behavior, was effective due to the students working in smaller groups.

Assessment

While students were collaborating in science, teachers tended to focus their assessments on the science skills and knowledge being learned, rather than assessing collaboration skills. Although formal assessments in science class aligned with the content and skills of the discipline, informally teachers assessed and gave feedback to students on their collaboration skills.

> *On average, the students enjoy the opportunity to engage with others and not sit and listen to me talk about it… where they can bounce your ideas off of so we don't actually have anything that formally grades students on their collaboration. So, we don't have participation scores, or we don't have anything as part of our grading philosophy at* [REDACTED] *school, we don't have anything that counts as a participation grade.*

Since the assessment of collaborative skills were not apparent in Phase I data, this could be an opportunity for the IBO to enhance student experiences in science. The IBO could provide some guidance in their documentation to MYP schools about the key components of collaboration in science. From these key components, teachers could design classroom assessment tools to build their students' skills in collaboration.

Group Size, Structure, and Rationale

Our teachers recommended that there should be two to four students per group. These students would more effectively collaborate if they had a shared understanding of the learning goal and understand their individual role in the group. The most effective situations for collaboration were those where the students are interdependent on each other to accomplish the learning goal. As described by a teacher,

> *So, the actual data collection couldn't have been done by one student or even a pair of students. They needed a team to set up and capture things and record and you know get the stopwatches going so collaboration gives students a chance to learn from each other.*

Teachers described the rationale for using student collaboration in their science classroom as reaching more students and allowing all students to participate given structure and expectations.

> *I think it saves a lot of the day-to-day headaches you have if you're trying to fight teenagers to be quiet and listen to one person that's going to be a fight forever if you give them the opportunity to blow off steam, even if they've got 60 seconds to do a task and 45 of those are off-task they've kind of recharge their batteries, and they're ready for what's next and they've talked about it for 15 seconds, which is great.*

In our classroom observations, teachers clearly outlined expectations and responsibilities to the student groups. Students reported that they mainly stay on task because the teachers monitored their work, but there was a little time when they would have off topic discussions. This off-topic time was useful for team building. As described by students in a focus group,

> *Like, normally, it's pretty hard to have conversations without getting off topic because it just makes you focus on science. (students laugh) It's good because we use some of the outside stuff to connect with each other and get along with each other. I mean you definitely work better when you can talk with your group about stuff outside of the subject.*

Teachers agreed with the students,

> *Even if you're talking off-topic, I find your [the student's] opinions and your values very important to me, so I want to get to know that person, and so any information that they have, that they, anything they have is very important because that's their way of seeing.*

In classroom observations, we found that teachers closely monitored student work and intervened when students were confused, needed feedback, or when they were off task.

Modeling Collaboration Behaviors for the Students

The teachers were proactive about developing collaboration in their classrooms. With the help of the district level science supervisor, they worked on structures and expectations for group collaboration for roughly the past ten years. Veteran teachers reported collaboration as being part of the culture in the science department at their school, and new teachers were expected to design collaboration into their science classes. One of the teachers reported:

> *I've been trained on collaborative discourse from district headquarters and I've done turnaround training with other science teachers in the county and then within my own building.*

Teacher Support for Collaboration

Teachers used graphic organizers and student roles to support collaboration between students.

> *We use a lot of actual structures based on the work in the book, Academic Conversations. We've structured a lot of specific things that we have the students do.*

> *But with a formalized kind of setup where we have a structure, or we give each student a specific role or they determine the roles that they need to do all those different kind of collaborative tricks, I would say we are using that about once a lab which would be once every week or two so we'll say—give you a ballpark 16 to 20 times per year—we're doing a more formalized structured collaboration.*

> *You know, we use a structure called the consensus placemat to give them a tool and how to come to a group decision where they can all feel comfortable with their group answer. But we only do that at the beginning of the year and once we have momentum we get from that.*

Teachers helped students use these tools by having them collaborate on a non-science topic and then shift to a science topic.

> *My advice would be if you're using a formal structure, teach the structure independently of the content and then you can plug the content in. So normally when we do that, we'll teach them a structure and we'll make sure to come back to that structure two or three times throughout the course of the year, so that they already know the rules of the game*

and then they can plug in the content, when they do that.

We also found that students learn about the strengths and weaknesses of their classmates over time and used this in deciding how to assign the roles within their groups.

> *And if there's like more roles than group members, we don't want to give, like, Timmy a thousand jobs to do, so, like, you don't want to like, have the exact number of roles? Like, like, if you have like 8 things and, like, 4 group members, and something is like, just, like, holding a pencil you want to give him—you want to give that person like something else to do, like—*

> *So, for the first few days of the group that we're in, people are going to be more open, more extroverted, and you're going to get to know the people and how they work, and especially because the work gets harder after that first week of each unit, you need to understand what strengths and weaknesses every group member has.*

Technology

Technology in the classroom at the middle school level seemed restricted. The teachers did not report the use of technology and students reported a no-phone policy in class. School laptops were restricted to district-approved websites.

Expectations for Group Process

Despite reporting an occasional difficulty with students who refuse to work collaboratively, teachers had an abundance of success in supporting student collaboration with standardized structures across the school that facilitated expectations for collaboration. These structures, such as roles for each group member or flowcharts to help organize ideas, set clear expectations for positive ways students can collaborate. Ultimately, teachers reported that they wanted their students to gain the skills and regulation to be able to work with anyone in the room.

> *We don't necessarily focus on having them become experts in the structures that we use, but we want them to leave eighth grade with the ability to work with non-preferred partners. But it is nice too when you walk around and you hear them talking like using the science words and seeing the relationships and/or questioning what's happening.*

And they have to work as a team everybody has an assigned role, and they have to teach each other, the actual roles as the roles shift over time. We try to add more as we go through the year so we kind of reduce the structures and increase the demands on them, but it's not a shock to say all of a sudden.

All of our middle school science concepts and skills spiral back around, so the skills and ideas they developed in seventh grade are going to come back next year when they're freshmen in their biology class and then hopefully some of the skills that we work on.

Expectations for Group Product

Collaboration gave teachers the opportunity to be creative with the products they expected as an outcome but noted that students should be producing individual products, as well. Teachers explained that at this age, it is difficult to get equal participation from each group member, as the students are still learning their identity. As a result, we found that teachers planned for students to produce individual work products to demonstrate their personal mastery of the content and skills.

But what can be a drawback is the inequity in group work, so we try to get away from group work and we try to use collaboration as generating ideas and getting the students sharing their thoughts.

Student Engagement

In terms of student engagement, our data showed that teachers reported the need to embrace a different type of classroom management approach when using a great deal of collaboration in the middle school science classroom. They tried to empathize with the workload students had outside of the classroom as well as their maturity level in middle school.

If [the class activity takes] *a long time they're going to be tired and they're gonna like zone out a little bit, and you know you shouldn't scold them for doing that.*

I would add to that that collaboration is kind of like a reset button for the teenage brain, and just to give them that that opportunity to turn and talk and kind of snap out of that compliant behavior, or listening, or zoning out. And they actually have an audience and *have to listen to someone that they're interacting with face-to-face.*

For successful student collaboration, teachers realized that their classroom would be louder than in a traditional classroom, and that they must monitor students for off-task behavior and misconceptions. However, teachers reported that the benefits of student collaboration in science outweighed the drawbacks.

> *I think collaborative discussion really does help that kind of stuff. I don't think, you know lecture style notes, is really effective or normal to be meaningful outside of the classroom I think this helps to develop meaning outside of the classroom.*

External Pressures

Teachers identified several external pressures that they needed to reconcile in order to set up a classroom that fostered effective student collaboration. They noted that in using collaboration in science, the time it took to teach increases, and they felt pressure fulfilling the curricular framework.

> *For collaborative tasks in the end, I would be prepared to go a little bit backwards before you go forwards on to the next task like you have to go back and check somehow what misconceptions students have. The most frustrating thing is that, if there is a misconception that was developed in the classroom and then they sometimes kids, especially in middle school age, they really locked into that one idea and you don't want to move forward after this.*

However, since students' grade point averages (GPAs) at the middle school level did not inform college admission, the teachers felt as though they were uniquely positioned to work on skills without the external pressure of assigning grades for college admissions.

Communication

Teachers felt that small group collaboration provided an opportunity for students to feel safe to talk with each other. They explained that students in small groups feel less exposed when they communicate ideas than they do in a whole class setting. Nonetheless, we derived that students did not engage in effective collaboration naturally and needed training over time.

> *Well, in first quarter, we kind of build a responsibility throughout the year, and first quarter, we just want to get, as we said maximum mouths moving per minute, so we want to have the kids have an opportunity to bounce ideas off of and learn. You know, how to have a structured productive conversation working towards a goal.*

Teachers explained that there were behaviors that they look for so that they can maintain a productive environment of student collaboration. Team-building exercises helped students feel that they can trust their peers so that they can share ideas. For example, a teacher stated:

> *And if you have students in the same group, and they start getting frustrated, and then that those emotions kind of build on each other and you know that's very … it spreads very quickly. If you don't have them in groups that work well, then that's when things go poorly quickly, but I do think that we've been doing a lot of team-building activities…*

Students seemed motivated to collaborate because the conversations and perspectives were interesting to them.

> *The teacher asks questions that make the group think, and make the group have interesting conversations with their teacher, because a teacher that just teaches you and gives you a test is not a good teacher. That is boring. So, a teacher that will actually interact with their students and ask them questions that will interest students more.*

Students in the focus group demonstrated ways that they give and perceive constructive criticism. They learned about these skills in their collaborative groups.

> *If someone is, like, if it's something where you're receiving feedback, especially if it's something where you're writing your answer down, well, you don't want somebody to be like, "Oh, your answer sucks." You want them to be like, "Oh, no, here's what you should change," "Here's what I think." So that way we can, like, mold our ideas together to make another idea.*

Problem Solving

Students in the focus group explained that even if there are students who are shy or students who do not like to work in the group, they have ways to resolve problems. We saw that the classrooms took on problem solving in a variety of structures ranging from loosely structured to guided. Students in a loosely structured problem-solving scenario were adding different types of plants and animals to an aquarium and asking questions about how the environment needed to change to support the life. Students in a guided problem-solving classroom structure received small tasks to accomplish such as measuring the time it takes for a ball to roll down a ramp and were then asked to set up the ramp so that the ball would be traveling a certain speed.

Discussion of Qualitative Findings

Which features of the IB Middle Years Program (MYP) are expected to foster the development of collaboration skills in students?

From our document analysis of the features of the MYP, eight themes were developed (see Table 10). These themes represented phenomena that teachers could support through carefully designed learning environments, but ultimately focused on student knowledge, attitudes, and behaviors. IBO might consider creating a broader, more coherent message to schools about the use of technology. Information could be placed in the Project Guide, Science Guide, and From Principles to Practice documents. Similarly, IBO could examine any of the document distribution results for a particular code and determine the extent to which the code is communicated to school personnel.

In what ways do students develop collaborative skills in the MYP?

Findings also showed that collaboration activities provided students with greater opportunities to complete in-class assignments, resulting from improved time management skills, along with assisting students in gaining a better understanding of course material while enhancing their verbal and analytical skills. Not to mention, students who engaged in groups and were able to use regulatory processes such as reading notes, seeking consensus, summarizing, and expressing their feelings of knowing, experienced greater gains in content knowledge when using technology enhanced environments (Cleary & Kitsantas, 2017; Hadwin & Oshige, 2011; Raviv et al., 2019).

This might engage students in knowledge construction while incorporating real-world problem solving. Collaboration has a prerequisite of a rich problem-solving classroom environment, and students in these environments will need to learn about background knowledge in order to solve problems (Dare et al., 2018). Our data complimented the idea that science teachers focused on collaboration provide students opportunities to engage in problem solving that drew on the strengths of diverse student experiences. The diversity of student backgrounds coupled with diverse student experiences in problem solving can result in effective knowledge construction (Peters, 2012).

What strategies and classroom practices do teachers apply to develop collaboration skills in the MYP?

Teacher perceptions toward collaborative learning played a fundamental role in the success of the task such that if the teacher had a positive attitude towards this form of pedagogy, then the likelihood of student success and their own attitudes towards collaboration would improve. These findings were consistent with prior findings in the literature (Buchs et al., 2017; De Hei et al., 2015; Wang & Lin, 2007). When discussing collaboration, it was found that cooperation during teamwork was tied to behavior and emotion during school engagement, insinuating the importance of peer-to-peer interactions when cooperating during collaborative moments. It was also implied that incorporating collaborative opportunities, just as the IBO Program does, not only led to students understanding content through peer interactions and agency, but also built skills towards self-advocacy (Herreid, 1998; Jansen, 2012; Le et al., 2018).

We learned that the teachers in Phase I of this study had over ten years of experience with using student supports in the form of graphic organizers and classroom protocols to engage in collaboration. These organizers and protocols helped students to take on leadership roles, build trust, communicate, and manage conflicts, similar to the work done by Carpenter and Pease (2013). The teachers agreed that there were particular tools that were effective for supporting all students in collaboration. For example, the teachers used what they called a "consensus placemat" for students to discuss their conception of scientific phenomena or findings of an investigation. The purpose was to give students a structured way to discuss differences in their thinking, giving all students an equal time to speak. Once everyone made their case for their way of thinking, then the consensus placement provided a structured way for students to map out the ideas that converged and the ideas that diverged. Ultimately, students decided on the idea that had the most evidence and reasoning behind it. Students agreed that tools such as the consensus placement helped them to understand the science knowledge better because they had to justify their answers and think more deeply about the ideas. One area for improvement was the assessment of the strategies that led students to effective collaboration. Phase I data did not reveal any evidence of teachers supporting the growth of collaboration strategies with assessments such as rubrics designed to assess key skills in collaboration.

Table 10 highlights the main findings from the themes developed from the document analysis and shows how teacher and student actions are related to the theme. For example, in the theme of inquiry, teachers enabled this theme by setting up environments that fostered students' skills to ask and investigate their questions about the world during collaborative learning in science classrooms. Meanwhile, students engaged in inquiry by asking questions and engaging in investigations individually and within their group.

Table 10
Themes Developed During Document Analysis

Theme	Teacher Relationships to Theme	Student Relationships to Theme
Critical Reflection and Action	Create activities for students to work through a problem-solving process. In this context, peers communicate about their thoughts and perspectives, and share their existing knowledge to build their knowledge together.	Consider the thoughts, perspectives, and actions of themselves and others during collaborative learning in science classrooms for the sake of learning and growth. Socially share regulation of the learning process to be able to critically reflect and act. To effectively reflect and act, students must be engaged in their decisions regarding their approach and their self-reflection, they must be engaged with regard to their behavior and how they listen and communicate with others as they reflect and adapt their actions, and they must be emotionally engaged to empathize with others to critically reflect and adapt their actions.
Holistic Student Growth	Design learning environments that support student cognitive, emotional, physical, and social growth during collaborative learning in science classrooms. Takes into consideration how the whole student, not just one part, needs to be engaged in the collaborative task through their actions for the student to be able to grow.	Full engagement and growth enables the group to regulate their learning task together.
Inquiry	Foster students' skills to ask and investigate their questions about the world during collaborative learning in science classrooms. Designs the structure of the task to scaffold student work and growth during the collaborative task.	Students to ask and investigate questions of relevance to the student and group.
Inter-Disciplinary Learning Environments	Teachers in these environments provide clear instruction to the students regarding their activities, as well as examples of what they should be doing, and how and why the concepts and skills are relevant. This relevance is not only emphasized within the classroom, but students are shown how the ideas are applicable in the real world as well.	Students to engage in collaborative activities and asking questions that do not only take place across contexts, but also involve generalizable skills and are applicable in different situations.

Real-World Knowledge Application Across Contexts and Outside the Classroom	Teachers ensure collaborative activities help students work on generalizable skills, and they create contexts where their effort on these skills are scaffolded. Technology that students may encounter outside the classroom is also used during collaborative MYP activities to enhance real-world applicability. Furthermore, building student content knowledge is a core idea of building real-world applications. The climate of a school creates a community-based learning environment that supports generalization of skills.	Student engagement, especially cognitive and emotional engagement, helps students with the application of skills across contexts.
Respectful Communication	Teachers foster students actively, inclusively, and considerately listening and speaking with others during collaborative learning in science classrooms.	This responsibility falls primarily on individual students, but as a group, students are expected to use this skill to assist them in regulating the learning process. Furthermore, when communicating their ideas to others, telling others what they know about the learning process, and setting guidelines and boundaries regarding what is expected of the collaboration process and the final product, students are expected to communicate respectfully throughout. Students can also use this communication behavior to show their emotional and overall engagement in the collaborative task.
Responsibility	Teachers foster students' owning their actions and portions of the task at hand during collaborative learning in science classrooms. Groups are structured during collaborative learning such that each individual shares a portion of the collaborative task, rather than placing the responsibility ambiguously on the group as a whole.	Individual students then establish the roles they play and what responsibility they contribute to the group. This allows the team to use this social structure to regulate their learning together, particularly when students are engaged with what groups and individuals need and engage in behaviors supportive of the group. All of these responsibility tools let the group together outline their own expectations for their results, as well as meet the results outlined by the teacher. In addition, this establishment of responsibility of roles in members of a group facilitates the group's ability to problem solve, particularly when students share their understanding of the learning process.

Phase II: MYP Student Perceptions of Collaboration in the Science Classroom

Method

Participants

Two hundred and ten (*N*=210) students, male (*N* = 107) and female (*N* = 95), from a mid-Atlantic suburban region of the U.S. who were enrolled in the IBO's MYP participated in Phase II of the study. Student response rates to the questionnaire were extremely high, with the original sample consisting of 244 students. However, we excluded 34 cases due to a number of reasons (e.g., 25 were special education students/students with an individualized education plan [IEP], or incomplete questionnaire data). The students ranged in age from 12 to 15 (*M* = 12.74, SD=1.08) and were of a diverse ethnic background (56.7% White, 13.8% Multi-Racial, 11.9% Asian, 8.6% Other, 6.2% African American, 1.9% Native American, and 1% Pacific Islander) with 20.5% identifying as Hispanic or Latino. Seventy-four percent of the students spoke English as their native language and 20% of them spoke a native language other than English. We selected participating students from three classroom teachers—teacher one (*n* = 99), teacher two (*n* = 8), and teacher three (*n* = 103), who taught sixth (*n* = 3), seventh (*n* = 103), and eighth (*n* = 104) grades, respectively. On average, the students had a mean of 3.26 (*SD* = .65) as their first quarter grade point average (see Table 11).

Table 11
Student Demographics, Phase II (N = 210)

Variable	*n*	(%)
Grade Levels		
6th	3	(1.4%)
7th	103	(49%)
8th	104	(49.5%)
Age		
12	78	(37.1%)
13	106	(50.5%)
14	22	(10.5%)
15	1	(.5%)
N/A	3	(1.4%)
Teacher		
1	99	(47.1%)
2	8	(3.8%)
3	103	(49%)
Hispanic or Latino		
Yes	43	(20.5%)
No	167	(79.5%)
Race		
African American	13	(6.2%)
Asian	25	(11.9%)
Native American	4	(1.9%)
Pacific Islander	2	(1.0%)
White	119	(56.7%)
Multi-Racial	29	(13.8%)
Other	18	(8.6%)
Gender		
Male	107	(51%)
Female	95	(45.2%)
Other	8	(3.8%)
English as Native Language		
Yes	155	(73.8%)
No	42	(20%)
English and Other	6	(2.9%)
N/A	8	(3.8%)
Other Language		
Yes	38	(18.1%)
No	172	(81.9%)

Measures

Quantitative Instruments

We described each instrument in detail below. For a detailed summary table of each quantitative instrument, see Appendix B.

First Quarter Grades/Student Academic Background. We asked students to report the grades they received during the first quarter in reading/language arts, mathematics, science, and social studies/history/civics. We correlated these self-reported measures against the latent variables in the study. Then, we conducted a confirmatory factor analysis (CFA) to examine the measure's item structure and suitability for use with the population of interest.

Self-Regulation. We identified self-regulation for this study's purpose as a latent variable through self-efficacy of SRL, perceived responsibility for learning, how frequently SRL was included, as well as how well the student was able to learn in a group, co-regulated, context. Again, we conducted a CFA on each of the self-regulation measures to examine the measure's item structure and suitability for use with the population of interest.

Self-Efficacy for Learning Form (SELF; Zimmerman & Kitsantas, 2007). The SELF-A was used to measure student self-efficacy for self-regulated learning based upon the idea that students with higher self-efficacy are more motivated to learn. The scale was composed of 12 items, such as *"I have a goal when I study."* All items can be answered using a 5-point frequency scale (1 = "Never"; 2 = "Not very much"; 3 = "Sometimes"; 4 = "A lot"; 5 = "Always"). The scale showed acceptable internal consistency (Cronbach's alpha = .90) with the current study's sample.

Perceived Responsibility for Learning Form (PRLS; Zimmerman & Kitsantas, 2005). The Perceived Responsibility for Learning Scale (PRLS) was used to assess whether the students think teachers or students place responsibility for certain outcomes more in the hands of the teachers or students. There were five items in the scale - for example, *"Who is more responsible for a student finishing their homework?"* Participants responded on a 5-point rating scale, where 1 = "Mostly the teacher"; 2 = "A little more the teacher"; 3 = "Both the teacher and student equally"; 4 = "A little more the student"; and 5 = "Mostly the student". The scale showed acceptable internal consistency (Cronbach's alpha = 0.97) with the current study's sample.

The Self-Regulated Learning Survey (DiDonato, 2013). This instrument was designed to capture the frequency and the extent to which a student is capable of setting goals, as well as how effectively they monitor and control progress towards those goals. The survey consisted of 13 items (Cronbach's alpha = .80 with the current study's sample), all measured by a 4-point frequency scale beginning with Never (1), followed by Sometimes (2), Most of the time (3), and finally All of the time (4). Sample items included *"Each day I read our plans carefully before I begin working on our project," "I made sure I understood before we moved on to the next part of our project,"* and *"I paid attention to and knew the purpose of what I was working on."*

The Co-Regulated Learning Survey (DiDonato, 2013). This instrument consisted of 19 items (Cronbach's alpha = .83 with the current study's sample), that measured a student's capability towards setting goals, as well as how well they monitored and controlled the progress towards those goals in a co-regulated, group, setting. The survey used a 4-point frequency scale (1= "Never," 2= "Sometimes," 3= "Most of the time," and 4= "All of the time") and included items such as *"Each day we read our plans carefully before we begin working on our project," "When we planned, we talked about if our plans were realistic,"* and *"We managed our time efficiently, so we were not rushing around to finish at the last minute."*

Goal Mastery/Classroom Structures.

Personal Goal Orientation and Classroom Goals (Patterns of Adaptive Learning Survey: PALS; Midgley et al., 2000). The Patterns of Adaptive Learning Survey (PALS), as used in this study, assessed student levels of mastery and performance-approach achievement goal orientations; as such, we only used the Personal Mastery Goal Orientation subscale and the Perception of Teacher's Goals—Teacher Mastery Goals subscales.

The Personal Mastery Goal Orientation subscale was composed of five items, such as *"It's important to me that I learn a lot of new concepts this year."* The Perception of Teacher's Goals—Teacher Mastery Goals was also composed of five items, including *"My teacher thinks mistakes are okay as long as we are learning."* All items were answered with a 5-point rating scale, from 1 = Not at all true to 5 = Very true. We found the items to be internally consistent (Cronbach's alpha = 0.79 with the current study's sample) through CFA, after dropping one item "My *teacher recognizes us for trying hard*" it demonstrated a suitable model.

Collaborative Learning. Collaborative learning as a latent variable in this study portrayed students' perceptions of how they collaborate as a team in terms of advocating and influence, cooperation, and negotiation.

Self-Report Teamwork Scale (Wang et al., 2014). The Self-Report Teamwork Scale was used to assess student perceptions of how they engage in collaborative activities, as successful teamwork is an important classroom skill to build not only for higher quality learning, but also to take into the workforce. It was composed of three subscales: Cooperation, Advocating/Influence, and Negotiation. We found the items to be internally consistent (Cronbach's alpha = 0.78-0.88 with the current study's sample through CFA), demonstrated a suitable model.

The Cooperation subscale was composed of 12 items (e.g., *"I enjoy building team relationships"*). The Advocating/Influence subscale was composed of nine items (e.g., *"I believe*

I am a good leader"). The Negotiation subscale was composed of nine items, (e.g., *"I am a good listener"*). All items can be answered using a 6-point frequency scale: 1 = "Never"; 2 = "Rarely"; 3 = "Sometimes"; 4 = "Often"; 5 = "Usually"; 6 = "Always". After dropping two items–one in the cooperation subscale and the other in negotiation–we determined the subscales to be suitable, according to our CFA.

School Engagement. We used school engagement as a latent variable where the students self-reported on their behavior, emotional engagement agency, and cognitive engagement. We performed a CFA was performed to examine the measure's item structure and suitability for use with the population of interest.

The School Engagement Scale (Jang et al., 2016). This scale was used to measure a student's perceived experience of engagament within a science classroom. The scale consisted of 19 items measured on a 7-point Likert scale (Strongly Disagree: 1; Disagree: 2; Slightly Disagree: 3; Neither Agree nor Disagree: 4; Slightly Agree: 5; Agree: 6; and Strongly Agree: 7). Items pertain to four engagement subscales: behavioral (five questions), emotional (five questions), agentic (five questions), and cognitive (four questions). For example, sample items included *"I work as hard as I can"* (behavioral), *"I feel interested"* (emotional), *"I express my preferences and opinions"* (agentic), and *"I try to connect the ideas I am reading about with what I already know"* (cognitive). The Cronbach's alphas for these subscales ranged from 0.79-0.90.

Procedure

We distributed the surveys to the middle school students enrolled in the MYP at the selected school during their normal school day. The surveys consisted of multiple instruments and took approximately 10-20 minutes to complete via an online Qualtrics form. We selected some students to participate in a 60-minute focus group, assuring all that their responses were confidential and only identifiable by an ID number that could only be accessed by the researchers.

Quantitative Results

We calculated means and standard deviations for all measures (see Tables 12 and 13), as well as a correlations table (see Table 14) to depict the relation among the targeted variables along with the students' first-quarter grades. We found significant relations among all the variables ($p < .05$) except PRLS and Teamwork (Advocating/Influence; $r = .06$). We also found strong correlations between the school engagement constructs (behavior, emotional, agentic, and cognitive) and self- (behavior [$r = .65$]; emotional [$r = .63$]; agentic [$r = .66$]; cognitive [$r = .70$]) and co-regulated learning (behavior [$r = .57$]; emotional [$r = .62$]; agentic [$r = .66$]; cognitive [$r = .62$]). Finally, a strong correlation emerged between first-quarter grades and self-efficacy for SRL ($r = .61$) and we found significant, but weaker, correlations between perceived responsibility for learning (PRLS) and first-quarter grades ($r = .23$), teamwork (negotiation; $r = .14$), and self-efficacy for SRL ($r = .19$).

Table 12
Student Educational Background, Phase II (N = 210)

	Mean	(SD)
First-Quarter Grades in…		
Reading/Language Arts	3.36	(0.78)
Mathematics	3.03	(0.84)
Science	3.31	(0.82)
Social Studies/History/Civics	3.36	(0.84)

Note. A=4, B=3, C=2, D=1

Table 13
Student Surveys, Phase II (N = 210)

	Mean	(SD)	[Minimum, Maximum]
First-Quarter Grades	3.26	(0.65)	[1.25, 4]
Self-Regulation			
SELF	3.23	(0.73)	[1, 5]
PRLS	4.26	(0.80)	[1, 5]
SRL Scale	2.80	(0.59)	[1, 4]
Coregulated Survey	2.85	(0.58)	[1, 4]
Goal Mastery			
PALS			
Personal Mastery	3.99	(0.87)	[1, 5]
Teacher Mastery	4.01	(0.83)	[1, 5]
Collaborative Learning			
Teamwork Scale			
Cooperation	4.41	(1.02)	[1, 6]
Advocating/Influence	4.03	(1.04)	[1, 6]
Negotiation	4.27	(0.84)	[1, 6]
School Engagement			
Behavior	5.55	(1.13)	[1, 7]
Emotional	5.15	(1.40)	[1, 7]
Agentic	4.75	(1.41)	[1, 7]
Cognitive	5.06	(1.39)	[1, 7]

Note. Self-efficacy for Learning Form (SELF); Perceived Responsibility for Learning Scale (PRLS); Patterns of Adaptive Learning Survey (PALS); Self-Regulated Learning (SRL) Scale

Table 14
Pearson's Correlation, Students Phase II

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. First Quarter Grades	--	.61**	.23**	.31**	.24**	.39**	.32**	.29**	.24**	.24**	.42**	.28**	.23**	.31**
Self-Regulation														
2. SELF		--	.19**	.58**	.50**	.54**	.39**	.44**	.41**	.40**	.52**	.42**	.50**	.47**
3. PRLS			--	.31**	.21**	.39**	.36**	.19**	.06	.14*	.38**	.30**	.26**	.25**
4. SRL				--	.79**	.50**	.46**	.52**	.56**	.57**	.65**	.63**	.66**	.70**
5. Co-regulation					--	.47**	.45**	.47**	.54**	.53**	.57**	.62**	.66**	.62**
Goal Mastery														
6. PALS (Personal Mastery)						--	.53**	.54**	.41**	.35**	.64**	.57**	.52**	.53**
7. PALS (Teacher Mastery)							--	.37**	.31**	.30**	.51**	.51**	.43**	.43**
Collaborative Learning														
8. Teamwork (Cooperation)								--	.64**	.66**	.53**	.52**	.49**	.49**
9. Teamwork (Advocating/Influence)									--	.69**	.45**	.45**	.58**	.56**
10. Teamwork (Negotiation)										--	.46**	.43**	.43**	.46**
School Engagement														
11. School Engagement (Behavior)											--	.75**	.67**	.69**
12. School Engagement (Emotional)												--	.74**	.66**
13. School Engagement (Agentic)													--	.74**
14. School Engagement (Cognitive)														--

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$; Self-efficacy for Learning Form (SELF); Perceived Responsibility for Learning Scale (PRLS); Patterns of Adaptive Learning Survey (PALS); Self-Regulated Learning (SRL) Scale

CFA of Latent Variables

We tested *essential unidimensionality* (i.e., one dominant factor) for each of the five latent variables (constructs) involved in the structural equation modeling (SEM) path model design to validate their scores in the corresponding SEM analysis. We retained the best-fitting CFA model by testing for data fit of a (a) one-factor model, (b) two-level (second-order) model, and (c) bi-factor model. The goodness-of-fit indices of the retained model for each latent variable (construct) are shown in Table 15. There was a tenable data fit for each model in Table 15, based on the relaxed "*two-index rule*" (Hu & Bentler, 1999), according to which a tenable fit is reached under one of the following two conditions (a) CFI > 0.90 and SRMR < 0.08, or (b) RMSEA < 0.08 and SRMR < 0.08.

Table 15
Testing for Fit of Five CFA Models of Latent Variables (Constructs) Used in SEM Analysis

CFA Model	χ^2	df	CFI	SRMR	RMSEA
Model 1	50.566	25	0.97	0.037	0.07
Model 2	2,344.349	1,123	0.80	0.072	0.07
Model 3	935.187	322	0.84	0.077	0.08
Model 4	377.001	133	0.93	0.046	0.09
Model 5	3.567	2	0.99	0.020	0.06

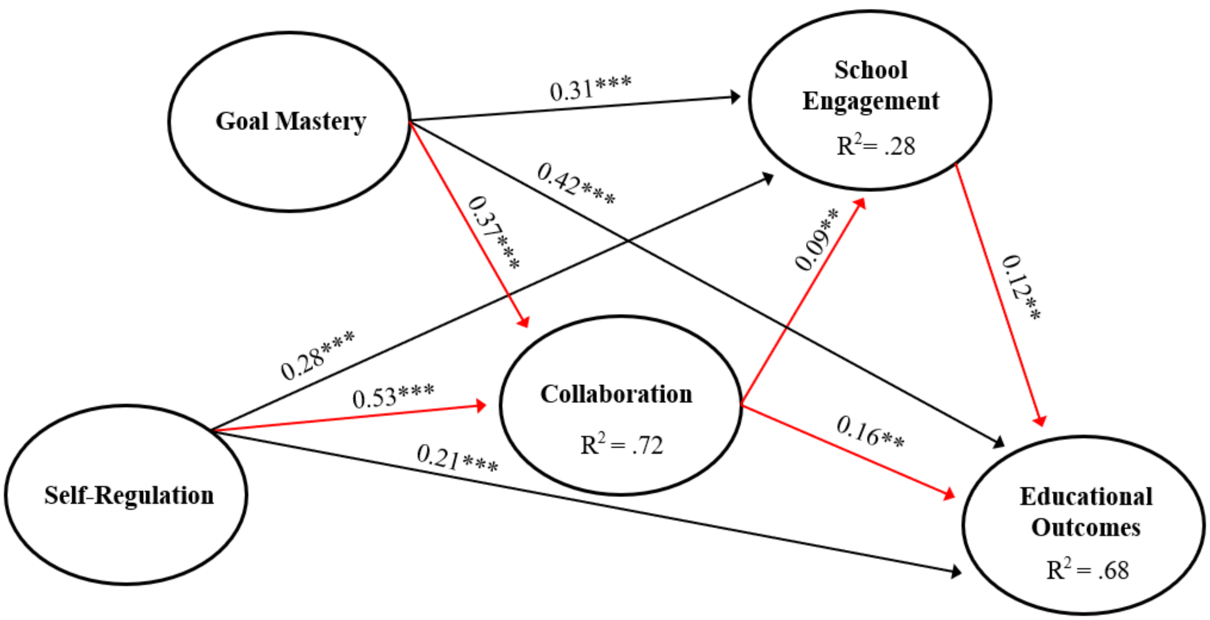
Note. Model 1: Two-level model for mastery goal structures (One item deleted: PALS_P3);
Model 2: Two-level model for *self-regulation*;
Model 3: Bifactor model for *Collaborative Leaning* (2 items deleted: TeamC5, TeamN7);
Model 4: Bifactor model for *School Engagement*;
Model 5: One-factor model for *Educational Outcomes* (Reading/Language Arts, Math, Science, and Social Studies/History/Civics).

Testing the SEM

We conducted SEM exploratory analysis to test the degree to which middle school students' perceptions about mastery goal structures and self-regulation are related to collaborative learning, engagement, and achievement in science education. Through the path analysis (see Figure 3), we found that self-regulation directly contributed to both school engagement (β = .28) and educational outcomes (β = .21), and displayed an indirect effect with collaboration (β = .53). Goal mastery also had a direct effect on school engagement (β = .31) and educational outcomes (b = .42), however an indirect relationship was established with collaboration (β = .37). In turn, collaboration (R^2 = .72) indirectly effected school engagement (β = .09) and educational outcomes (β = .16). It was also shown that educational outcomes (R^2 = .68) was indirectly affected by school engagement (R^2 = .28; β = .12).

Figure 3

Structural Equation Model Path Analysis



Note. Red lines indicate an indirect relation.

Table 16
Standardized Estimates for Direct Effect Pathways

Direct Pathways	Estimate	S.E.	Est./S.E.
Collaboration ➔			
Goal Mastery**	.37	.06	6.62
Self-Regulation**	.53	.06	9.64
School Engagement ➔			
Collaboration	.08	.11	.70
Goal Mastery*	.26	.10	2.63
Self-Regulation*	.23	.11	2.18
Educational Outcomes ➔			
Collaboration *	.16	.07	2.24
Goal Mastery **	.42	.07	6.34
Self-Regulation**	.21	.07	2.86
School Engagement**	.15	.05	3.32

Note. * $p < .05$; ** $p < .01$, *** $p < .001$

Table 17
Standardized Estimates for Indirect Effect Pathways

Indirect Pathways	Estimate	S.E.	Est./S.E.
Goal Mastery ➔			
School Engagement	.03	.04	.70
Educational Outcomes*	.06	.03	2.12
Self-Regulation ➔			
School Engagement	.04	.06	.70
Educational Outcomes*	.08	.04	2.18

Note. * $p < .05$; ** $p < .01$, *** $p < .001$

Discussion of Quantitative Findings

Quantitative findings showed that the IB middle school students' perceptions about mastery goal structures and self-regulation/co-regulation were related to collaborative learning, student engagement, and achievement in science education contexts. In fact, these variables accounted for 68% of the variance in student grades. This finding means that other variables beyond the ones explored in this study could only contribute 32% to student academic learning and achievement. Collaborative learning—which requires students to work within small groups with the goal being to utilize the strengths and abilities of each individual student (including their own) towards a goal—served as a mediator in the model. This indicated the pivotal role that collaborative learning can play in fostering student self-regulation, co-regulation, engagement, and student engagement. These findings were consistent with prior research, which showed that collaborative learning promotes the sharing of responsibility and authority among all group members and their actions (Carpenter & Pease, 2013; Rogat & Linnenbrink-Garcia, 2011).

Connection of the Phase I and II Findings to the Logic Model

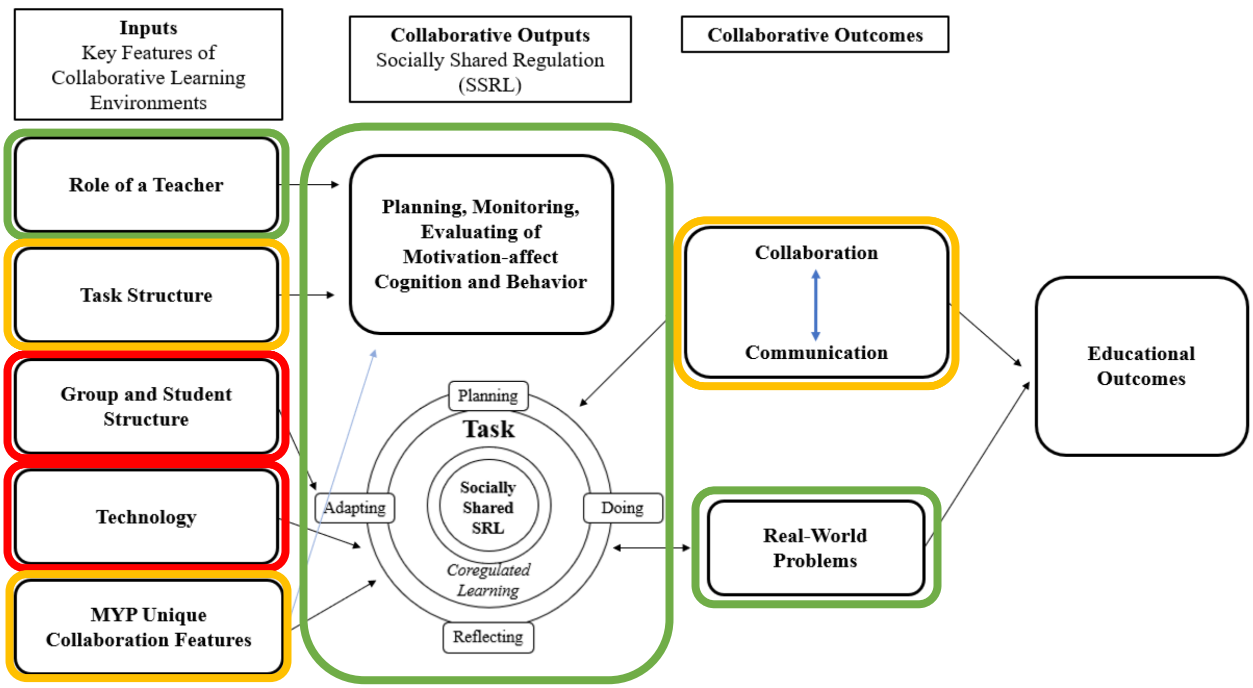
By testing this model in supporting student collaborative skill development within an MYP, we hoped that the findings would provide recommendations for middle school teachers on how to best promote and support student collaboration skills by enhancing co-regulation, motivation, and a supportive classroom and school climate. Overall, our findings of the present study showed that the IB curricular framework provided the foundation for creating collaborative settings in science education that opened the opportunity for students to learn from their peers through discussion and peer teaching.

Findings from the document analysis in Phase I supported all the elements in the hypothetical model; however, some of the elements were more prominent than others in the

MYP documentation. As seen in Figure 4, model elements outlined in green (e.g., role of a teacher, SSRL) were prominent in the MYP documents. Model elements outlined in yellow (e.g., task structure) were present but not at the same rate as the elements in green. Model elements outlined in red were rarely found in the MYP documents but were still present.

Figure 4

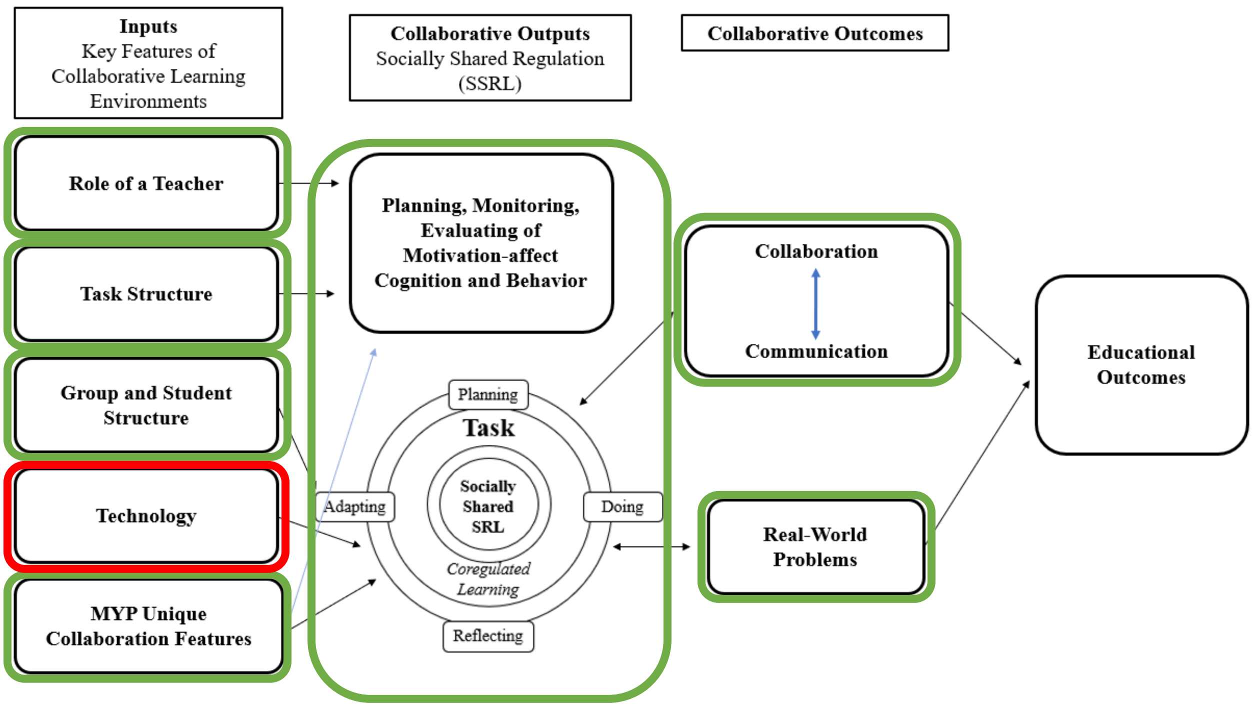
Relative Emphasis of Ideas Found in MYP Documents on Model for Collaboration



Findings from the case study of the MYP classrooms demonstrated one context for implementation of the collaboration ideas shared in the MYP documents. As seen in Figure 5, there were direct connections with almost all the model elements demonstrated in the case-study themes, such as role of the teacher, task structure, and modeling (outlined in green). Technology was the only element of the model not observed in the case-study data. The teachers acknowledged that the use of technology could benefit collaboration, but that they were unable to use innovative platforms for a myriad of reasons, such as a lack of infrastructure, time needed for learning something new, and products that were age-appropriate for middle school.

Figure 5

Relative Emphasis of Themes from Case-Study on Model for Collaboration



Differences between what is highlighted in Figure 4 and Figure 5 illustrate what was communicated by the MYP documents and what was expressed by MYP teachers and students regarding collaboration in science. The MYP documents communicated mainly the role of the teacher, elements of socially shared regulated learning and a real-world problem context. Whereas the students and teachers discussed all the elements of the model except technology. This indicated a great deal of opportunities for IBO to add information in the MYP documents related to the other elements found in the model. There were also opportunities to explore ways technology can support collaboration in science in both the MYP documents and in MYP classrooms.

Recommendations for Practice

This research has several important implications for practice in the field of education. First, educators and practitioners are encouraged to place an equal emphasis on the cognitive and collaborative components of coregulated learning, such as elaboration, explanation, and interpretation. Providing students with the opportunity and guidance to collaborate effectively on cognitive tasks and classroom projects can enhance student learning and understanding through multiple perspectives, as well as provide opportunities for co-regulation in the classroom. Due to the critical importance of collaboration in the classroom and the implications of the development of these skills for the classroom and beyond, teachers and administrators should consider the development of a collaboration rubric designed to assess these important skills in students. Receiving clear feedback on collaboration skills and areas of improvement may assist students in actively working to improve these skills.

For teachers to be able to effectively train their students in the use of collaboration skills and methods, we recommend that school administrators take into consideration that educators are provided with skills training and other professional development opportunities centered around collaboration and social skills for the students. Teachers may have varying levels of experience or acceptance of the use of collaboration skills in the classroom; thus, training teachers not only in the importance of these skills for their students but also in how these skills can be effectively implemented and incorporated into the classroom is of critical importance for teachers of all experience levels. Additionally, professional development opportunities focused on the incorporation of various technologies into the classroom to assist in the collaborative process may also prove to be beneficial. Teachers in this study reported a lack of knowledge around collaborative technologies, as well as a feeling that the demands of the framework were such that they did not have time to learn the technologies and teach them to their students. Since technology can be a useful tool in collaborative classroom learning environments, we suggest that teacher training may make the use of these technologies in the classroom more feasible. Since the assessment of collaborative skills was not apparent in Phase I data, this could be an opportunity for the IBO to enhance student experiences in science. The IBO could provide some guidance in its documentation to MYP schools about the key components of collaboration in science. From these key components, teachers could design classroom assessment tools to build their students' skills in collaboration.

The three main takeaways from this research as it relates to implications for practice can be summarized as follows:

1. Collaboration is a key to success in the classroom for various reasons—building student self-efficacy, helping students build skills in self-advocacy, and building both self- and co-regulated learning—all of which might play an instrumental role in student success both academically and beyond.
2. Peer interactions in a co-regulated environment during learning can lead to a greater exchange of knowledge and school engagement at the cognitive, agentic, behavioral, and emotional levels, which could help build an innate level of enjoyment towards science and other STEM related fields.
3. Promoting a goal mastery mindset could lead to better educational outcomes as well as increased school engagement.

Limitations and Future Research

The findings of the present study should be replicated in other MYP and non-MYP contexts, as the structure of the IB program might provide a foundation for cultivating students' self-regulatory skills to engage in collaborative learning. Additionally, researchers may want to explore these constructs in content areas other than science to determine how collaborative practices might be useful and implemented effectively in other classrooms and subject areas. This study also had a small sample size drawn from a single school location, which may limit the generalizability of these findings. The applicability of these constructs in other contexts should be examined. Self-reported data also poses additional limitations that may have had an impact on the results of the study.

Finally, it is worth noting that this study was conducted during the COVID-19 pandemic. This delayed our data-collection process and may have reduced the number of willing participants due to the other things participants may have been dealing with in their lives. Additionally, due to social distancing, student absences, public health restrictions, and more, teachers may not have been able to fully structure their classrooms in as collaborative a manner as they might have otherwise done. Despite these limitations, the findings of our study have important implications for practice and future research.

Conclusion

Overall, the findings show that the materials for the IBO's MYP support and promote collaborative learning in middle school science classrooms. Based in our findings, we have provided recommendations for middle school teachers, and school staff on how to best promote and support student collaboration skills by enhancing co-regulation, motivation, and a supportive classroom and school climate. The eight themes extracted from the document analysis provided a lens into the overarching goals of the MYP with respect to fostering cognitive and collaborative skills in students. We conclude that reconciling the *a priori* codes and components of the model that were found to be present infrequently in the documents could be a potential priority of the IBO. For example, the communications involving the use of technology is only found on the website (10 instances). Furthermore, teachers indicated the need for more support and guidance with respect to the implementation and use of technology in the classroom to support collaborative experiences. This is something the IBO may wish to pursue in greater depth.

Beyond this, we saw that the idea of Group and Student structure was apparent throughout the majority of the case-study but was not as strong of an idea within the document analysis. To a lesser degree, task structure followed this same pattern. It may be helpful for the IBO to collaborate with MYP educators to expand on these ideas within the context of the available IB documents. This would help provide consistency and fidelity in how teachers implement these ideas in MYP science classrooms. This would equitably foster these skills in MYP students. Students who may not have had experiences with collaboration skills can benefit from explicit instruction of both collaboration skills and self-regulated learning skills. Thus, all students have an entry point to become a skillful collaborator and a self-directed learner. Facilitating these ideas around science collaboration in students according to the IBO's values may potentially serve to further foster student engagement and increase academic outcomes for these middle school learners, with important implications for academic success in high school and beyond.

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Appendix A

Explanation of Research Procedures in Chronological Order

Phase I Procedures	
Document identification	Located IBO MYP documents related to collaboration in science in consultation with IBO program officer
Document coding	Coded documents for factors in model and emergent codes
Network model development	Calculated frequencies of co-occurrences of codes and created a visual network model to explain connectedness of ideas found in MYP documents
Classroom Observation	Two researchers observed two MYP science classrooms for collaboration activities
Student focus groups	Focus groups were asked about collaboration activities and perceptions
Teacher interviews	Two MYP teachers were asked about planning and implementation of collaboration activities in science
Phase II Procedure	
Survey administration	Students responded to survey

Appendix B
Overview of Demographic Questions and Data Collection Instruments for Phase I and II Instruments

Phase I and II Teacher and Student Demographic Questions

Teacher Demographics

- What is your name?
- What is your E-mail address?
- * What is the full name of your school?
- What grade levels do you teach? Select all that apply
    - 6th grade
    - 7th grade
    - 8th grade
- How many years of teaching experience in total (including this year) do you have?
- How many years have you been at your current school?
- Approximately how many students are you teaching this year?
- What are the degree(s) you have earned, including major (include all if more than one degree of one type is held)?
    - Bachelors
    - Masters
    - Doctorate
    - Other (certificates, licenses, etc.)
- Are you of Hispanic, Latino or Spanish origin?
    - No, not of Hispanic, Latino, or Spanish origin
    - Yes, of Hispanic, Latino, or Spanish origin
- What is your race?
    - African American
    - Asian
    - Native American
    - Other
    - Pacific Islander
    - White
    - Multi-Racial
- What is your native language?
- Are you fluent in any other languages in addition to your native language? If yes, please list those languages. If no, please put “N/A”.
- What is your age?
- What is your gender?
    - Female
    - Male
    - Other
- Check all that apply. Is your school considered?
    - Public
    - Private
    - Title I
    - Charter School
    - Other: Please specify
- Is your school location considered? (check only one)
    - Urban
    - Suburban

- Rural
- What is your average class size?
  - Dropdown
  - Under 15 students
  - 15-20 students
  - 20-25 students
  - 25-30 students
  - 30-35 students
  - 35-40 students
  - Over 40 students

Student Demographics

- What is the full name of your school?
- How old are you?
- What grade are you in school?
  - 6th
  - 7th
  - 8th
- What is your gender?
  - Male
  - Female
  - Other
- Are you of Hispanic, Latino or Spanish origin?
  - No, not of Hispanic, Latino, or Spanish origin
  - Yes, of Hispanic, Latino, or Spanish origin
- What is your race?
  - African American
  - Asian
  - Native American
  - Pacific Islander
  - White
  - Multi-Racial
  - Other
- What is your native language?
- Are you fluent in any other languages in addition to your native language? If yes, please list those languages. If no, please put "N/A".
- What grades did you receive in the first quarter of the following subjects this year?
- Select one choice for each row (if applicable; A, B, C, D, F)
  - Reading/Language Arts
  - Mathematics
  - Science
  - Social Studies/History/Civics
- What was the grade on your 5th grade science SOL test? (circle one)
  - Fail
  - Pass
  - Pass Advanced

Note. * represents demographic questions that were only present in Phase II of the study

List of Qualitative Measures in Phase I

Name	Purpose	Analysis
IBO Document Analysis	• Determine the connection to the logic model • Locate MYP-related documents that pertain to collaboration	A codebook was developed for the coding process based off of the logic model

Teacher Observations	Rates overall characteristics of collaboration in a classroom for three variables: peer interaction, teacher role, and product of collaboration Indicators for- **Peer Interaction**: - Students listen to each other - Students get help and support from each other - Students participate in peer assessment/peer feedback - Peer feedback consists of substantial comments for areas of improvement - Group members treat each other with respect - Group members come to consensus using credible evidence **Teacher Role:** - Teacher sets clear expectations for students - Teacher gives explicit plans for productive student-to-student dialog - Teacher monitors all groups as a formative assessment - Teacher minimizes unproductive behavior - Teacher encourages student-to-student interaction rather than giving answers **Product of Collaboration:** - Importance or relevance of the science learning in the task is clarified - Examples are relevant to students' experiences	Indicator Scores: • Indicators not observed (score of 0) • Few observed (score of 1) • Sometime present (score of 2) • Half of the indicators present (score of 3) • Most of the indicators were present (score of 4) • All of the indicators were present (score of 5)

	- Task incorporates a real-world problem or scenario	
Teacher Interviews	To ascertain information that we may not be able to observe during our school visits	One-hour, semi-structured interviews that focused on: • time spent during collaboration activities • categories of collaboration activities • structure of group meetings during their classes • motivational factors • goals for conducting collaboration Example questions: *What do you think is your role as a teacher in developing student collaboration?* *What does collaborative learning look and sound like in your classroom?*
Student Focus Groups	To gain insight on the students' perspectives	Groups of 4-5 students, for 30-miutes, discussed: • classroom environment • technology use • contributing to teamwork • personal experiences in collaboration Example questions: *How do you know that you are communicating well in a group? What does that look like?* *How does the group communicate with the teacher during the activity? After the activity?*

List of Quantitative Measures in Phase II

Name (Author, year)	Subscales	Number of Items	Scale of Measurement	Reliability
The Self-Report Teamwork Scale (Wang et al., 2009) *	Cooperation Advocating/Influence Negotiation	12 9 9	6-point frequency scale (1 -being never; 6- being always)	Cronbach's alpha = 0.78-0.88
Self-Efficacy for Learning Form (Zimmerman & Kitsantas, 2007)		12	5-point frequency scale (1-Never, 2- Not very much, 3-Sometimes, 4-A lot, 5-Always)	Reliability indices= .90
Perceived Responsibility for Learning Form (Zimmerman & Kitsantas, 2005)		5	5-point rating scale (1-Mostly the teacher, 2-A little more the teacher, 3-Both the teacher and student equally, 4 -A little more the student, 5-Mostly the student)	Cronbach's alpha= 0.97
The Self-Regulated Learning Survey (DiDonato, 2013)		13	4-point frequency scale (1-Never, 2-Sometimes, 3- Most of the time, 4-All of the time)	Cronbach's alpha= .80
Co-Regulated Learning Survey (DiDonato, 2013)		19	4-point frequency scale (1-Never, 2-Sometimes, 3-Most of the time, 4-All of the time)	Cronbach's alpha= .83
Patterns of Adaptive Learning Survey (Midgley et al., 2000)	Personal Mastery Goal Orientation Perception of Teacher's Goals-Teacher Mastery Goals	5 5	5-point rating scale (1-Not at all true to 5-Very true)	Cronbach's alpha = 0.79
The School Engagement Scale (Jang et al., 2016)	Behavioral Emotional Agentic Cognitive	5 5 5 4	7-point Likert scale (1-Strongly Disagree, 2-Disagree, 3-Slightly Disagree, 4-Neither Agree nor Disagree, 5-Slightly Agree, 6- Agree, 7-Strongly Agree)	

Note. * represents quantitative scale used in both Phase I and Phase II of study

Appendix C

Coding Scheme of Teacher Interviews

Code: **Role of Teacher**

Using Pedagogy to Know/Understand Students

With inquiry there is a greater focus on the student starting from a position of knowledge—they already bring knowledge and understanding with them—and there is a reduced emphasis on the teacher being the keeper and transmitter of knowledge. There is an acknowledgment that a collaborative process of creating knowledge takes place in a learning community, as recognized in constructivist pedagogy.

Applicability of Lessons Outside of the Classroom

One of the key features of the MYP is its emphasis on interdisciplinary teaching and learning. This trait emerges as a consequence of the challenges and opportunities of educating students in, and for, a complex and highly interconnected world.

Social-Emotional Learning

Focused on effective teamwork and collaboration. This includes promoting teamwork and collaboration between students, but also refers to the collaborative relationship between teachers and students.

They also place a great deal of emphasis on relationships. This reflects the IB's belief that educational outcomes are profoundly shaped by the relationships between teachers and students, and celebrates the many ways that people work together to construct meaning and make sense of the world.

Systematic Innovation

Driven by inquiry, action and reflection, IB programs aim to develop a range of skills and dispositions that help students effectively manage and evaluate their own learning. Among these essential approaches to learning are competencies for research, critical and creative thinking, collaboration, communication, managing information and self-assessment.

Code: **Student Engagement**

Student Responsibility to the Group

They act with integrity and honesty, with a strong sense of fairness, justice and respect for the dignity of the individual, groups and communities. They take responsibility for their own actions and the consequences that accompany them.

Respectful Communication

Promoting open communication based on understanding and respect, the IB encourages students to become active, compassionate lifelong learners.

Problem Solving in Real-World Communities and Contexts
In a world of increasing interconnection and complexity, learning in context provides students with opportunities to explore multiple dimensions of meaningful challenges facing young people in the world today, encouraging them to develop creative solutions and understandings. The MYP encourages teachers to design units around a range of ideas and issues that are personally, locally, nationally, internationally and globally significant. Developed in local and global contexts. Teaching uses real-life contexts and examples, and students are encouraged to process new information by connecting it to their own experiences and to the world around them.
Group Inclusivity IB programs support inclusion as an ongoing process to increase access and engagement in learning for all students. Learning communities become more inclusive as they identify and remove barriers to learning and participation. Commitment to access and inclusion represents another aspect of the IB learner profile in action.

Code: **Socially Shared Regulated Learning**

Roles, Responsibilities, and Relationships
Values the importance of teamwork and leadership as crucial aspects in the development of social relationships that are respectful, fair, responsible and productive.
Respectful Communication For example, while developing respect for others our students are becoming “caring” as well as “communicators” as they are learning to listen effectively and respect their peers.
Critical Reflection and Action Challenging learning environments help students to develop the imagination and motivation they require to meet their own needs and the needs of others. Principled action means making responsible choices, sometimes including decisions not to act. Individuals, organizations, and communities can engage in principled action when they explore the ethical dimensions of personal and global challenges. Action in IB programs may involve service learning, advocacy, and educating oneself and others.
Holistic Student Growth An IB education is holistic in nature—it is concerned with the whole person. Along with cognitive development, IB programs and qualifications address students’ social, emotional and physical well-being. They value and offer opportunities for students to become active and caring members of local, national and global communities; they focus attention on the processes and the outcomes of internationally minded learning described in the IB learner profile.
Assessment and Evaluation

Peer and self-assessment are often valuable formative assessment strategies. "Differentiation may include offering students with various modes of interpreting materials, whether visually, aurally or kinesthetically, and allowing students to choose alternative modes of presentation for their performances of understanding (for example, oral presentation, writing, or a practical method such as leading a peer-to-peer workshop)."

Code: **Role of Student**

Social-Emotional Learning We are more conscious of how others may feel, acting in a more reflective way by proposing and discussing the different options, and choosing the best solution for ourselves, our group and the environment. Schools need to ensure that the relationships students establish with each other and with teachers, which are of central importance to development and learning, will flourish.
Roles and Responsibilities Is beginning to identify fairness and equality in situations independently. Recognizes that there are differences in beliefs, points of view, and ideas. Values the importance of teamwork and leadership as crucial aspects in the development of social relationships that are respectful, fair, responsible, and productive. The relationships between teachers and students and the approaches to teaching profoundly shape educational outcomes: teachers are intellectual leaders who can empower students to develop the confidence and personal responsibility needed to deepen understanding. IB programs emphasize “learning how to learn,” helping students interact effectively with the learning environments they encounter and encouraging them to value learning as an essential and integral part of their everyday lives.
Respectful Communication Consistently shows respect by listening to others, valuing and accepting points of view and different opinions. Listens to the need of others and acts upon it. Makes decisions based on fairness and equality. Knows that there are differences in beliefs, points of view, and ideas, and is able to state own opinion without hurting others’ feelings.

Code: **Student Knowledge Building**

Critical Reflection Analyzes and evaluates ideas and arguments, valuing a variety of perspectives, its implications, limitations and epistemological dimensions.

Reflection also involves being conscious of potential bias and inaccuracy in their own work and in the work of others.
Generalization of Knowledge Across Contexts Transfers what was learned in a variety of ways and uses different methods and knowledge of specific disciplines in different contexts, situations, and realities. Holistic learning, intercultural awareness, and communication are implied in, or are a part of, the IB learner profile, especially in the attributes “balanced”, “open-minded” and “communicators”. "Contexts offer the possibility of new perspectives, additional information, counter-examples and refinements of understanding...Contexts help to create productive discussion within and outside of the classroom."
Learning through Inquiry and Scientific Investigation With inquiry there is a greater focus on the student starting from a position of knowledge—they already bring knowledge and understanding with them—and there is a reduced emphasis on the teacher being the keeper and transmitter of knowledge. There is an acknowledgment that a collaborative process of creating knowledge takes place in a learning community, as recognized in constructivist pedagogy. Accordingly, it is important that all framework units include opportunities for students to collect evidence, construct explanations or arguments (often in groups emulating the scientific community) and share those explanations or arguments in class discussions where they can publicly debate and critique different ideas.

Code: **Peer Discussion**

Respectful Communication For example, while developing respect for others our students are becoming “caring” as well as “communicators” as they are learning to listen effectively and respect their peers. Values the importance of teamwork and leadership as crucial aspects in the development of social relationships that are respectful, fair, responsible, and productive.
Critical Reflection "Driven by inquiry, action and reflection, IB programs aim to develop a range of skills and dispositions that help students effectively manage and evaluate their own learning. Among these essential approaches to learning are competencies for research, critical and creative thinking, collaboration, communication, managing information and self-assessment."
Multimodal Communication

We express ourselves confidently and creatively in more than one language and in many ways. We collaborate effectively, listening carefully to the perspectives of other individuals and groups.
Scientific Debate Accordingly, it is important that all framework units include opportunities for students to collect evidence, construct explanations or arguments (often in groups emulating the scientific community) and share those explanations or arguments in class discussions where they can publicly debate and critique different ideas.

Code: **MYP Unique Collaboration Features**

Interdisciplinary Teaching and Learning One of the key features of the MYP is its emphasis on interdisciplinary teaching and learning. This trait emerges as a consequence of the challenges and opportunities of educating students in, and for, a complex and highly interconnected world
Inquiry Inquiry questions should engage students and show that inquiry itself is worthy of time and interest. They should allow students to explore the intersection of disciplinary domains by engaging with the statement of inquiry. Some questions might also be needed for developing the disciplinary grounding necessary for effective interdisciplinary learning. Inquiry questions can be classified as factual, conceptual, and debatable. "Inquiry based approaches to teaching encourage students to share ideas with others and to listen to, and learn from, what others think. In this process, students' thinking and understanding is shaped and enriched."
Holistic Approach to Student Growth Holistic learning, intercultural awareness, and communication are implied in, or are a part of, the IB learner profile, especially in the attributes "balanced", "open-minded" and "communicators".
Emulation of and Application to the Real World "In the MYP, learning contexts should be (or should model) authentic world settings, events and circumstances."

Code: **Behavioral Engagement**

Responsible Action Across Contexts Transdisciplinary theme: Sharing the planet: An inquiry into rights and responsibilities in the struggle to share finite resources with other people and with other living things; communities

and the relationships within and between them; access to equal opportunities; peace and conflict resolution. We are more conscious of how others may feel, acting in a more reflective way proposing and discussing the different options and choosing the best solution for ourselves, our group, and the environment.
Respectful Communication We express ourselves confidently and creatively in more than one language and in many ways. We collaborate effectively, listening carefully to the perspectives of other individuals and groups.
Holistic Growth An IB education is holistic in nature—it is concerned with the whole person. Along with cognitive development, IB programs and qualifications address students' social, emotional and physical well-being. They value and offer opportunities for students to become active and caring members of local, national and global communities; they focus attention on the processes and the outcomes of internationally minded learning described in the IB learner profile.

Code: **Technology**

Consistent School Approaches IB schools benefit from sharing common understandings, policies, and frameworks to develop their own concepts and choose the things that will work best with the IB curricular framework. These things and concepts are presented here in this series as "IB technologies" to model the idea that the distinction between things and concepts aid in thinking about technology and how it functions in our communities: evident but seamless in the framework; accessible to all learners, used to facilitate classroom environments that are inclusive and diverse by design, and useful in enhancing the framework's design and lesson planning; adaptive to many contexts: cultural, physical, and educational; supportive of intercultural understanding, global engagement and multilingualism—specific hallmarks of an IB education; helpful in fostering the collection, creation, design, and analysis of significant content. Mindsets are the ways of thinking and doing that reflect a school's culture, community and values. Many schools are hindered in their attempts to implement technology because of mindsets that do not encourage effective use of technology.
Integration into Lessons Lenses are the specific perspectives that we use to view the curricular framework or school culture. Using a technology lens means that you are planning and thinking with technology-related things and concepts in mind. Visual frameworks reinforce the idea that you are "viewing" the framework and planning with particular ideas of what you want to accomplish.

Technology integration concerns the role technology plays in learning as well as how we incorporate technology literacy concepts into teaching and learning.
Everyday Applicability New technologies that are potentially disruptive in schools are essential to daily life for many students: if they do not appear in school, this can leave the impression with students that "school" and "life" are not necessarily the same. An IB education reflects the environment in which it is developed and prepares students to participate in the larger world.

Code: **Agentic Engagement**

Approaches to Learning Activity Values the importance of teamwork and leadership as crucial aspects in the development of social relationships that are respectful, fair, responsible and productive. Principled action, as both a strategy and an outcome, represents the IB's commitment to teaching and learning through practical, real-world experience. IB learners act at home, as well as in classrooms, schools, communities and the broader world. Action involves learning by doing, enhancing learning about self and others. IB World Schools value action that encompasses a concern for integrity and honesty, as well as a strong sense of fairness that respects the dignity of individuals and groups."
Strategy Use Challenging learning environments help students to develop the imagination and motivation they require to meet their own needs and the needs of others. Principled action means making responsible choices, sometimes including decisions not to act. Individuals, organizations and communities can engage in principled action when they explore the ethical dimensions of personal and global challenges. Action in IB programs may involve service learning, advocacy and educating one's self and others. Through further analysis of information, data, and with deliberation, students can be invited to edit and improve their models. In fact, scientists engage in precisely this kind of argumentation and debate, analyzing each other's evidence and theories to identify the most satisfactory theories and models.
Reflection We understand the importance of balancing different aspects of our lives--intellectual, physical, and emotional--to achieve well-being for ourselves and others. We recognize our interdependence with other people and with the world in which we live.

Code: **Student Knowledge of the Learning Process**

Respectful Communication

Consistently shows respect by listening to others, valuing and accepting points of view and different opinions. Listens to the need of others and acts upon it. Makes decisions based on fairness and equality. Knows that there are differences in beliefs, points of view, and ideas, and is able to state own opinion without hurting others' feelings.

Promoting open communication based on understanding and respect, the IB encourages students to become active, compassionate lifelong learners.

They 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.

Responsibility to the Group

"Challenging learning environments help students to develop the imagination and motivation they require to meet their own needs and the needs of others. Principled action means making responsible choices, sometimes including decisions not to act. Individuals, organizations, and communities can engage in principled action when they explore the ethical dimensions of personal and global challenges. Action in IB programs may involve service learning, advocacy, and educating one's self and others."

Critical Reflection

Effective teaching and learning in context help students and teachers to inspire critical and creative thinking as students encounter multiple, and sometimes conflicting, value systems and cultural perspectives, including concepts that are open to different interpretations such as citizenship, identity, and globalization.

Accordingly, it is important that all framework units include opportunities for students to collect evidence, construct explanations or arguments (often in groups emulating the scientific community), and share those explanations or arguments in class discussions where they can publicly debate and critique different ideas.

Code: **Task Structure**

Teacher-Prompted Action

To develop ATL skills that facilitate effective and efficient learning, students need models, clear expectations, developmental benchmarks (or targets) and multiple opportunities to practice.

Interdisciplinary Context

In the MYP, learning contexts should be (or should model) authentic world settings, events and circumstances.

Conceptual Knowledge Built on Inquiry

Teachers should choose strategies that provide for learning through disciplined inquiry and research, involve communication of ideas and personal reflection, and give students the opportunity to practice and apply their new understandings and skills. The inquiry process in MYP projects involves students in a wide range of activities to extend their knowledge and understanding and to develop their skills and attitudes. These student-planned learning activities include: • deciding what they want to learn about, identifying what they already know, and discovering what they will need to know to complete the project • creating proposals or criteria for their project, planning their time and materials, and recording developments of the project • making decisions, developing understandings and solving problems, communicating with their supervisor and others, and creating a product or developing an outcome • evaluating the product/outcome and reflecting on their project and their learning

Code: **Problem solving**

Shift of Responsibility for Learning to Student Accepting responsibility, assuming a variety of group roles, taking on leadership roles, time management, deciding what they want to learn about, along with what they know and what they need to do to complete the project
Learning to Conduct Analyses Analyzes and evaluates ideas and arguments, valuing a variety of perspectives, its implications, limitations and epistemological underpinnings, dialectical thought, reflection and revision, and collecting evidence.
Social and Emotional Learning Consistently shows respect by listening to others, valuing and accepting points of view and different opinions. Listens to the needs of others and acts upon it. Makes decisions based on fairness and equality. Knows that there are differences in beliefs, points of view and ideas, and is able to state own opinion without hurting others' feelings. Commitment to service, practicing empathy, considering human needs.
Group Dynamics Cooperation, group decision making, classroom and group as a model community, building consensus, negotiating effectively, delegate and share responsibility, give and receive meaningful feedback, globalization considerations, and communication skills.
Promoting Flexible Thinking Transfers what was learned in a variety of ways and uses different methods and knowledge of specific disciplines in different contexts, connects disciplinary learning to be interdisciplinary,

considers broader context in situating problem to solve, application of subject matter, creativity, knowing when to work independently and cooperatively.

Code: **Explaining Ideas to Others**

Respectful and Inclusive Communication Consistently shows respect by listening to others, valuing and accepting points of view and different opinions. Listens to the need of others and acts upon it. Makes decisions based on fairness and equality. Knows that there are differences in belief, points of view and ideas, and is able to state own opinion without hurting others' feelings.
Critical Consideration and Reflection We critically appreciate our own cultures and personal histories, as well as the values and traditions of others. We seek and evaluate a range of points of view, and we are willing to grow from the experience.

Code: **Emotional Engagement**

Social-Emotional Learning Values the importance of teamwork and leadership as crucial aspects in the development of social relationships that are respectful, fair, responsible, and productive.
Respect Consistently shows respect by listening to others, valuing and accepting points of view and different opinions. Listens to the need of others and acts upon it. Makes decisions based on fairness and equality. Knows that there are differences in belief, points of view and ideas, and is able to state own opinion without hurting others' feelings. For example, while developing respect for others our students are becoming "caring" as well as "communicators" as they are learning to listen effectively and respect their peers.
Reflection on Impact on Others We are more conscious of how others may feel, acting in a more reflective way proposing and discussing the different options and choosing the best solution for ourselves, our group and the environment.
Community Context An MYP classroom is itself a model of a community—it is a lively place, characterized by collaborative and purposeful activity. Within this community, students are empowered to do their best, for themselves, and to contribute to the learning and well-being of others. They are supportive of each other and will come to establish their personal set of beliefs and values. The community encourages reflection, and values thoughtful consideration of issues, problems and success.

An IB education fosters international mindedness by helping students reflect on their own perspective, culture and identities, and then on those of others. By learning to appreciate different beliefs, values and experiences, and to think and collaborate across cultures and disciplines, IB learners gain the understanding necessary to make progress toward a more peaceful and sustainable world.

Code: **Cognitive Engagement**

Communication During Problem Solving

We work independently and cooperatively to explore new ideas and innovative strategies.

Application of Knowledge Across Contexts

Transfers what was learned in a variety of ways and uses different methods and knowledge of specific disciplines in different contexts, situations and realities.

“In the MYP, global contexts are at the heart of inquiry and active learning and can encourage students to take responsible action in a variety of situations encountered through the framework. For teachers and students, global contexts provide a means to inquire into subject content by questioning, explaining, discovering, and doing.

Student-Developed Questions

Inquiry questions should engage students and show that inquiry itself is worthy of time and interest. They should allow students to explore the intersection of disciplinary domains by engaging with the statement of inquiry. Some questions might also be needed for developing the disciplinary grounding necessary for effective interdisciplinary learning. Inquiry questions can be classified as factual, conceptual, and debatable.

Code: **Scaffolding Student Work**

Student Context

The most effective way to develop ATL is through ongoing, process-focused disciplinary and interdisciplinary teaching and learning. Teachers can use a wide range of content, developed through MYP key and related concepts and global contexts, as a vehicle for teaching effective learning strategies. Likewise, ATL skills can be powerful tools for exploring significant content. This dual focus (content and process, knowledge and skills) promotes student engagement, deep understanding, transfer of skills and academic success.

Teachers Contriving Task Framework

In developing MYP units, attention should be given to ensure that lessons unfold in a coherent and deliberate order—one that focuses on significant concepts or ideas and develops the understanding with increasing levels of complexity. In turn, individual lessons must focus on assignments designed to ensure that students are introduced to, and given opportunities to practice, the core ideas and their components.

Inquiry Guides Knowledge Building The lessons often require students to make their initial and prior ideas public to teachers (or they recall important experiences or ideas from a previous lesson)—therefore, "key questions" are often posed at the beginning of each lesson to elicit these ideas from students. The MYP expectation is that instruction will be a process of genuine inquiry that may begin with activities that lead to authentic student questions.

Code: **Group Structure**

Individual Responsibility to the Group We take responsibility for our actions and their consequences.
Peer Relationships IB programs promote the development of schools that: create educational opportunities for students that promote healthy relationships, individual and shared responsibility, including interpersonal competencies that support effective teamwork and collaboration.
Teacher Monitoring Counselors play an important role in supporting students through the personal project and community project. MYP projects represent significant milestones, as well as daunting tasks for many students. Counselors can be effective in raising awareness of students' academic and/or emotional needs, and how they might interplay with the challenges of the MYP projects. Counselors might strategically place students of concern with carefully chosen supervisors. Supervisors will then benefit from better understanding the students' needs and challenges, and how to address them throughout the completion of the project.

Code: **Expectations for Group Process**

Respectful Communication Consistently shows respect by listening to others, valuing and accepting the points of view of others and different opinions. Listens to the needs of others and acts upon it. Makes decisions based on fairness and equality. Knows that there are differences in beliefs, points of view, and ideas, and is able to state own opinion without hurting others' feelings.
Planning Preparation involves the student planning the service experience with clarification of roles, responsibilities, actions to be taken, resources required and timelines, while acquiring any skills needed to successfully carry the plan to completion.

Code: **Expectations for Group Product**

Planning and Responsibility
Preparation involves the student planning the service experience with clarification of roles, responsibilities, actions to be taken, resources required and timelines, while acquiring any skills needed to successfully carry the plan to completion.
Respect
Consistently shows respect by listening to others, valuing and accepting points of view and different opinions. Listens to the need of others and acts upon it. Makes decisions based on fairness and equality. Knows that there are differences in belief, points of view and ideas, and is able to state own opinion without hurting others' feelings.
Teacher Evaluation and Feedback
Attend to the purposeful development of and feedback on "soft skills" (competencies in areas such as making decisions, showing commitment, being flexible, leading and following, working as a team, accepting responsibility, dealing with stress, learning from mistakes, and winning and losing gracefully).

Code: **School Culture**

Teacher Collaboration
Teaching in IB programs is collaborative—promoting effective teamwork and purposeful/productive collaboration. Collaborative planning and reflection address vertical and horizontal articulation.
Student Skill Development
By coordinating ATL effectively, schools provide students with purposeful opportunities to use, reinforce, extend and improve new and existing skills in increasingly complex familiar and unfamiliar situations.

Code: **Grouping Rationale**

Student Needs
MYP classrooms are dynamic learning environments, with students moving from group work to individual work in response to their needs and the needs of their inquiries.

Code: **Modeling Collaboration Behavior**

Clear Examples and Direction

To develop ATL skills that facilitate effective and efficient learning, students need models, clear expectations, developmental benchmarks (or targets) and multiple opportunities to practice.
Interdisciplinary Learning Environments Interdisciplinary teaching and learning models the importance of collaboration and teamwork across disciplines (an important life skill).

Code: **Algorithms for Technology Use**

Community Technology Use
School communities can come together around a framework, as it is a way of thinking and doing that creates shared terminology and understanding.

Code: **Group Size**

Small Flexible Groups
Teachers can differentiate teaching and learning by providing examples (work samples or task-specific clarifications of assessment criteria); structuring support (advance organizers, flexible grouping, peer relationships); establishing interim and flexible deadlines; and adjusting the pace of learning experiences.

Code: **School Climate**

Community-Provided Learning Environments
Ideally, in an IB school community there would be an ethos that provided opportunities for discussions and critical reflection about appropriate language use for various contexts.