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Using Cooperative Groups to Enhance Student Learning in a High School Math Class

Caitlin McCain

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by

Caitlin McCain

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Primary Advisor: Laura Halldin
Content Reviewer: Mike Weber
Peer Reviewer: Claire Madden, Choua Yang, Kayla Kraska

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE

Introduction

Growing up, I always liked math because I was good at it, I was especially good at memorizing facts and formulas. In middle school, my Minnesota Comprehensive Assessment (MCA) score in math caused me to be placed in Algebra the following year, and this began my advanced track in math. In a typical class period we would sit in rows and watch our teacher work through problems as we took notes. The first part of class was spent watching the teacher work through examples that we were expected to write down. We would then have time to work on our assignment, which was a number of problems, usually odd so we could check our answers, where the point was to mimic the process we had just learned. This structure worked for me. Nobody asked me why things worked or to discuss my thoughts with others. I knew what to do, and if I didn't, I knew my teacher was there with all the answers.

College Math

When I got to college, the structure that I had grown accustomed to changed drastically. In my college courses, I was expected to work with others around me, sometimes with almost no direction at all to solve a problem. I once took a course where the entire class period was spent working with a partner at the whiteboard on a difficult problem. As neat as this was, I struggled with the lack of direction on how to attack the problem. I had never been asked to do something like that before, the teachers I had in the past had mostly stuck with the "I do, You do" structure.

Professional Position

The traditional structure worked well for me and I enjoyed math so much that I decided I wanted to teach it. I wanted to be the kind of teacher I had in school. I was going to stand up at the front, teach them the lesson and then they would practice whatever the skill was for the last part of class and I would walk around helping students at the first sign of trouble. It was going to be great.

Fast forward to my first few years of teaching, and this is exactly what I did. I found out very quickly that while this way worked for myself and some others, there was a large population of students that needed more. When I got a new job teaching at a new school that was in the pilot years of a new student centered and problem-based curriculum, I was not sure how I would do in this role. I wondered what I would do if I were not the holder of all math information.

Discovery

What I ended up finding was incredible when it worked. The sharing of ideas and the discussions that can happen when students are encouraged is amazing. However, just as some students don't enjoy lecture based teaching, others do not feel it necessary or important to discuss math with others. Currently, my desks are arranged in groups, and they work through problems in their teams while sitting and at other times they are standing at whiteboards. Sometimes this works great, but occasionally it's hard to get students to talk to each other at all, or they may talk but not about the task at hand. Trying to meet the needs of all students to ensure they reach their maximum potential is difficult, but incredibly important.

My experiences in the classroom have led me to this question: *How can I use cooperative groups to enhance student learning in a high school math class?*

Personal Background

I grew up and went to school in a suburb north of the Twin Cities, Minnesota. My high school was a large school, with about 600 in my graduating class. I always enjoyed school, mainly because I did well. I was put in advanced math in seventh grade, and from then on, I loved math. Looking back, I only enjoyed it because I was good at it, and it made me feel good to be good at something. I can also look back and see that my understanding of math when I was a student was very surface level. I could do the steps and processes that I was taught, but I was not making the important connections that tie it all together. I don't think I made some of those important connections until college, maybe even during my first few years of teaching.

College Math Experience

When I started college, I had an idea that I might want to be a math teacher, but I was open to the possibility of doing other things. I ended up doing some math tutoring after I had taken a few higher level courses, and I really enjoyed helping people. Around that time I needed to make a decision on my major, so I went with math education. During my college courses, I did some group work in the classroom, but we often formed study teams and met outside of class to help each other and work through problems together. When we did work in groups in class, we were not instructed on how to work together. I had very knowledgeable professors who taught us the content and encouraged us to work with each other, but nothing really sticks out as memorable from my time as a student.

Student Teaching

Perhaps the most memorable part of my experience in the education program was actually the lack of time I spent in a math classroom before my student teaching. Due to the school being required to find us a placement and other various scheduling conflicts, I only got about a quarter of the time spent observing a classroom that I was supposed to. I really felt the significance of this when I began my student teaching. Going from watching a few teachers in their classrooms to being up at the front expected to teach was quite the shock. Both of my cooperating teachers primarily used direct instruction, so at the end of my student teaching I felt very confident in my abilities to do direct instruction. I could feel how boring it was when I taught, but it was what I knew. I had ideas for how to make things more fun, but I was always scared off by the sheer amount of material I knew I needed to cover. I was also afraid of having chaos in my classroom if I tried something new. Fast forward three years, I made the switch to where I am now and I am loving it.

Teaching

My first year at the new school was a whirlwind. One of the courses I was teaching was piloting a new curriculum that abandoned the traditional style of teaching in favor of a problem-based student-centered style of teaching. The students are to work in groups, with each person having a role on the team. The roles are listed on a placemat that sits in the center of the group with a list of sentence starters to help with discussion. The four roles are facilitator, task manager, resource manager, and recorder/reporter. When I first started teaching this way, I used the roles very rigidly. The facilitator was always the one to read the problem to their group, the resource manager always gathered

the materials, the recorder/reporter would share out and the task manager's job was to keep everyone on task and be a timekeeper. The students worked in their teams to solve the core problems each day while I circulated, checking in and helping as necessary.

My Role As Facilitator

Merriam-Webster defines a facilitator as someone who helps to bring about an outcome by providing indirect or unobtrusive assistance (2023). This is what I strive for as a teacher using this curriculum. I'm able to walk around and check different group's answers and processes, that way I don't have to debrief every problem as a class at the end. There are different strategies included in the curriculum and teacher notes for each day that help to give students more opportunities to talk about math with each other. The effectiveness varies from class to class, and even from group to group. One thing that I have done more lately is switch up the roles within my groups. I typically still have the resource manager gather the materials, but I try to mix up everything else. Instead of always asking facilitators to read, I will ask them to either pick someone to read or to ask their team who will read. I've also started to use the team roles as a way to get the students talking to each other. If I notice that the groups are having a hard time starting the discussion, I may pose a question and say, "Task managers, please start the discussion by answering this question first. If you don't know the answer you can ask your team if someone can help." This has helped to get discussions going, but often it's still surface level discussion where they all say what they think the answer is and then stop talking.

A new strategy I have implemented in class is having the students work in groups at vertical whiteboards. Usually it's wonderful, because it gets everyone up and moving, and it forces them to talk a little more when one person is writing for the whole group. I have noticed that I need to be very intentional with the structures and problems I am

using, and how often I use the vertical whiteboards. If I use them too much, students get burnt out. I can tell this happens when I send them to the whiteboards and some students will immediately sit in the closest desk to their whiteboard instead of standing. Sometimes it is hard to get the students to collaborate which tells me it might have been the wrong problem to choose for the whiteboards or I need to incorporate a team builder into my vertical whiteboard practice.

All of these strategies I've tried can be great if all the conditions of the class are just right. I continue to try new activities and new strategies to increase student learning and collaboration. Other than the fact that my students are in groups, I haven't done any real digging into how I can make the groups more effective.

Rationale

Currently with the curriculum we have in place, the engaging problems and study strategies are there. However, I feel like I am falling short with the implementation and it does not feel like my lessons are as effective as they could be. While I am circulating around the room observing and helping teams, I know that I spend too much time with some teams and answer their questions too quickly before they've had a chance to grapple with it and really think about the problem. I really wanted to learn more about the structure of groups and what makes them effective, as well as how the structure can be used or altered during class time. I have always made groups of four, but I am not sure that is the best number. It is possible that four has been used in the past because of rectangular shaped desks or tables.

When I first started teaching, I would change groups only a few times per semester, and only when it started to become a problem in class. This was mostly due to

the fact that I would spend hours assigning student groups, and I didn't make time to do it as often as I should have. I have since started doing groups randomly, only specifically placing students who have accommodations that require them to be in a certain place within the classroom. Since I now group randomly, it frees up a lot of time so I have been switching the groups biweekly. I have included this in my research as well. I wanted to know if random or assigned is better, and what frequency for changing groups is most effective. After I reviewed the literature relevant to my question: *How can I use cooperative groups to enhance student learning in a high school math class?,* I created supplemental materials to use alongside the curriculum. This includes a master list of cooperative statements to give my students, one formal unit plan consisting of several lessons to teach and model the behaviors I expect to see while they work in teams. These lesson plans include discussions on the "why" behind teamwork, since not all students will always see the benefit of teamwork. Also included in the lesson plans is metacognitive training in the form of Polya's (1973) problem-solving process. There is a visual located on the second page of the cooperative statement sheet that will serve as a prompt for students since they will be expected to use this process. Lastly, there are two unit plans for a high school geometry class. Each lesson plan highlights the cooperative/teambuilding strategies that will be used during that day. There are some considerations for how I will structure my groups and use team roles during this time. I would like this to be a reference for colleagues who like to use the activities in our curriculum but who may struggle with the organization of their classroom as I have.

By completing this project, I hope to contribute to the professional conversation around moving from direct instruction to student centered and problem-based learning.

Summary and Preview

In this chapter, I discussed my own learning background from high school and college and how that led me to teaching. I mentioned some of my experiences in college and how my lack of time spent in a classroom left me feeling less prepared than I would have liked to begin teaching in my own classroom. I went on to talk about my first three years in my own classroom where I taught exactly how I was taught in school, and how I realized that something more was needed if I was going to become the highly effective teacher I wanted to be. I discussed in detail just how different my teaching experience was after I switched schools and how this ultimately led me to my research question. I briefly discussed my project and what I would like it to accomplish.

In Chapter Two, I reviewed the available literature as it is relevant to the question: *How can I use cooperative groups to enhance student learning in a high school math class?* This has allowed me to give some background on the research behind working in groups, as well as what the best practices are surrounding students working in groups.

CHAPTER TWO

Literature Review

Introduction

This chapter explores the literature that inspired the capstone project that responds to the question: *How can I use cooperative groups to enhance student learning in a high school math class?* This research provides further rationale for my capstone project. I have created supplemental materials to be used in a classroom setting that uses cooperative learning. Included is a master list of cooperative learning statements to aid students in their discussions. Also included are lesson plans to teach and model the behaviors that students will be expected to demonstrate while working in teams. These lesson plans also address metacognitive training in the form of Polya's (1973) problem-solving process. There is a visual included to prompt students to do the different parts of the process. Lastly, there are two unit plans for a high school geometry class that highlight the cooperative learning strategies used.

The first section as a whole will discuss how students work together. We will first define cooperative learning, which will be followed by an outline of the four major theoretical perspectives on cooperative learning as indicated by Slavin (2011). Next will be a look at the essential components of cooperative learning that create student learning. The second section will discuss collaborative groups and review current best practices around grouping students. This will include group size, group composition in terms of ability, and other conditions. The third section will explore the obstacles to effectively using cooperative groups, and what can be done by teachers to overcome these obstacles.

Theoretical Perspectives on Cooperative Learning

Cooperative learning refers to instructional methods where students are organized into small groups where they help each other learn academic content. (Slavin, 2011). Others use the term "collaborative learning" in their research, with a definition similar to cooperative learning. For the purpose of this paper, we will use the term "cooperative learning" and define it as any instructional method where students are working together to learn.

Slavin (1995 as cited by Slavin, 2011) identified four major theoretical perspectives on the achievement effects of cooperative learning. Each of these perspectives begins with different assumptions about student learning, and ends by explaining the achievement effect in different terms. As mentioned later on, according to Slavin (1995) these perspectives do not exist on their own, instead they work together to enhance student achievement.

The four perspectives are the motivationalist perspective, social cohesion, cognitive-developmental, and cognitive-elaboration. Each perspective has a different rationale for why cooperative learning is effective. The motivationalist perspective asserts that the most impactful part of the learning process is task motivation (Slavin, 1995). Under the motivationalist perspective, in order for a student to meet their own personal goals, they must help their group meet their goals while also encouraging them to work their hardest (Slavin, 1996). The social cohesion perspective states that the success of the group is based on their cohesiveness as a group (Slavin, 1995). This means that the students help each other because they care about each other and want their classmates to succeed (Slavin, 1996). The cognitive perspectives focus on interactions among students,

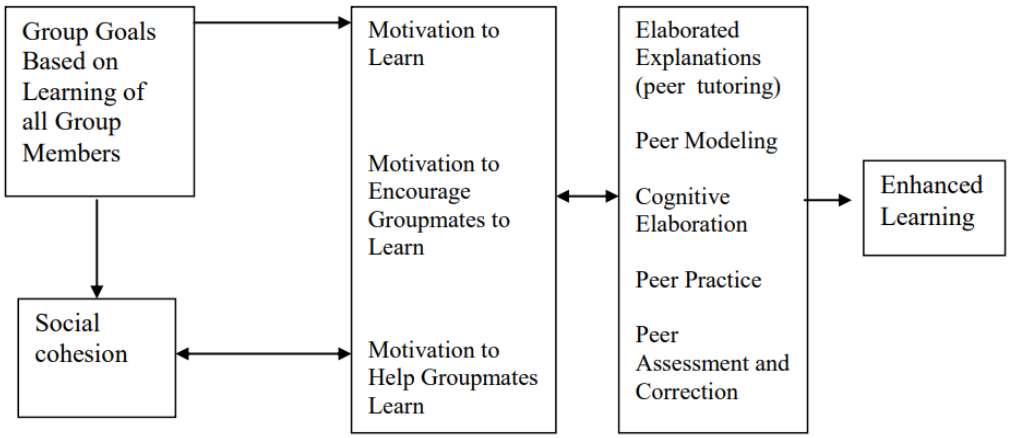
and the idea is that those interactions lead to better student achievement. There are two different cognitive perspectives. The first is cognitive-developmental while the second is cognitive-elaboration. The key assumption of the developmental perspective is that when children interact with the content using appropriate tasks, that increases their level of mastery (Slavin, 1996). The elaboration perspective holds that if students are to retain something in their memory that is related to what they already know, they must engage in some sort of elaboration with it first (Wittrock, 1986 as cited by Slavin, 1996). One of the most effective ways to engage in this sort of elaboration is to explain the content to someone else (Slavin, 1996). Slavin (1995) offers a theoretical model that includes ideas from all four perspectives, showing how they are all complementary to each other, not contradictory. Motivation and social cohesion as a group can affect the cognitive processes that enhance student learning and achievement. A group that has social cohesion and cares about one another may also be motivated to work together to complete the tasks to help their group, which in turn helps them. This social cohesion and motivation will likely produce better interactions among the students around the content, which in turn may elicit the elaborations that are necessary for students to retain the information. This is illustrated in Figure 1.

Metacognition

Metacognition has been described as the ability to think about one's thinking (Price-Mitchell, 2015). Kramarski and Mevarech (2003) studied the effect that metacognitive training can have on students' learning. Part of their findings were that students should be exposed to metacognitive training in order to be skilled in discourse (p. 22). In this study, there were 12 classrooms from four different schools, each school

was assigned to one of these four groups: cooperative learning with metacognitive training, cooperative learning without training, individual learning with metacognitive training and individual learning without training. In the program used in this study, students work in small groups and are trained to come up with and answer questions of

Figure 1:
Integration of Theoretical Perspectives on Cooperative Learning Effects on Learning



Slavin, 2011 adapted from Slavin, 1995

themselves that focus on the nature of the problem, finding connections between new and previous learning, and finding what strategies would work to solve the problem (Kramarski & Mevarech, 2003).

The metacognitive training used three sets of questions: comprehension questions, strategic questions, and connection questions. The comprehension questions were designed for reflection before students solved a problem. The strategic questions were meant to get students thinking about what strategies they could use and why. The connection questions were to get students to compare and contrast the immediate problem with previous problems they had done (Kramarski & Mevarech, 2003). The structure they

used was based on Polya's (1973) method for problem-solving. Polya's (1973) method includes four steps. The first step is to be able to understand the problem, the second step is to make a plan, the third step is to carry out the plan, and the last step is to evaluate your solution and go back to any of the first three steps as needed. It's important to note that this model is not always a completely linear process. You should do steps one through four in order, however, you may get to the end of the fourth step and realize that you made some calculation errors, which would bring you back to step three. It's also possible that you find out after completing the problem that you misunderstood the problem, in which case you would go all the way back to step one. The comprehension questions used in Kramarski and Mevarech's (2003) study apply to the "Understand" step of Polya's (1973) model. The strategic questions used in the study apply to the "Make a plan" and "Carry out the plan" steps of Polya's (1973) model. Finally, the connection questions apply to the "Understand" step as well as the "Evaluate" step of the model. Kramarski and Mevarech (2003) found that the students who were exposed to this type of training significantly outperformed those who were not. In many of the categories, students from both the cooperative learning and individual groups who had metacognitive training outperformed those who had not had any training. It is important to note that in many of those categories, the difference between the cooperative learning groups and individual learning groups without metacognitive training was insignificant (Kramarski & Mevarech, 2003). This illustrates that metacognitive training is an important addition to the classroom regardless of the structure you use.

Agency

Another important aspect of cooperative learning is agency. Agency is defined by Gresalfi et al. (2009) as the way in which they act, or refrain from acting, and the way in which their action contributes to the joint action of the group in which they are participating (p. 53). Students' exercised agency is their participation in constructing math arguments, or their lack thereof. Agency will vary within different interactions (Gresalfi, 2009). The three types of agency discussed will be shared, primary, and secondary. Shared agency is the co-construction of arguments where all members of the group are contributing. The individual agency of a student can be broken into primary and secondary. When one student makes the final argument by making sense of a peers idea, that student is exercising primary agency. A student who contributes input that influences the original argument is exercising secondary agency (Mueller et al., 2012).

In the study conducted by Hansen (2022) pairs of students were studied and two main types of interactions emerged: bi-directional and one-directional. Bi-directional interactions featured students who engaged with similar roles as their partner. They both tried to understand the others ideas, and they were each making suggestions and therefore driving the process. Both students in this partnership were helping to build a shared understanding, suggesting ideas, accepting the others ideas, and repairing misunderstandings; these students exercised shared agency. One-directional interactions showed students engaging with different roles. The conversation was mostly led by one person who is doing the reasoning and making suggestions in order to solve the problem, while the other person attempted to follow along and occasionally commented. These types of interactions can lead to primary and secondary agency. The student who suggests

and makes arguments that were anchored in mathematical properties is exercising primary agency. The student who builds shared understanding by accepting the other student's ideas, repeating and observing is exercising secondary agency (Hansen, 2022).

If both students suggest ideas that are rooted in mathematical properties, that is considered shared agency. Shared agency suggests co-construction which, under the theoretical perspective of cognitive elaboration, suggests that learners must engage in some manner of elaboration of new materials to learn them (Slavin, 2011).

If a teacher notices that interactions are one-directional, the teacher may choose to step in and offer that group more support to facilitate both students' sharing in the thinking (Hansen, 2022).

Student Interactions

There are multiple reasons that these interactions may differ from group to group. Student personalities, past success in math, and perceptions about their role or the role of others in their group may contribute to one-directional interactions (Mueller et al., 2012). If students believe they are the "smart" one in their group, this may contribute to them doing most of the thinking or the work. Likewise, if a student believes that they are not the "smart" one in their group, they may be ready to listen and observe their teammate figure everything out from the moment you say go. This is one of the reasons Liljedahl et al. suggest using random groups. It helps to avoid the roles that can unintentionally form when students work together (2021).

Another reason for differing interactions between group members could be the task at hand. Hansen (2022) suggests making it a more meaningful task for students to engage in to promote better interactions.

Additionally, classroom norms or teacher involvement can have an impact on the interactions between students. If a teacher observes one-directional interactions, they could step in and facilitate a change of roles to try to generate bi-directional interactions and get the students to engage with similar roles (Hansen, 2022).

We have now discussed some of the important components of cooperative learning including metacognition, agency, and the different interactions that can come from students working together. Next, we will look at the specifics of cooperative groups, and what the best practices are for grouping students.

Benefits

According to Saleh et al. (2005) cooperative learning has been found to have advantages over individual learning methods. Cooperative learning, specifically grouped instruction, has been found by many to be superior to whole-class or non-grouped instruction (Kulik, 1992; Lou et. al, 1996; Slavin, 1987 as cited by Murphy et. al, 2017).

Lou et. al (1996) found that within-class grouping positively affected learning in all contents, with learning in math and science being affected even more than other content areas. With so many different ways to group students, some encouraging results are that all students in this study were shown to have benefitted from being in small groups regardless of their ability level (Lou et. al, 1996). Even more encouraging, that study was done roughly 27 years ago.

Although the exact conditions of cooperative learning may vary, many researchers agree that increased student achievement is one important benefit of using cooperative learning in the classroom (Saleh et al., 2005; Murphy et al., 2017; Whicker et al., 1997; Liljedahl, 2021). Saleh et al. (2005) also noted important benefits that are related to

student achievement, and those are peer elaboration, and co-construction (or collaborative elaboration). Peer elaboration is when one student in a group is helping another student and through their explanation the other is able to understand it, this benefits both group members. Co-construction is where the group comes to a shared understanding of the idea through their conversations with each other (Saleh, 2005).

While many researchers agree on the benefits of cooperative learning, some possible disadvantages have come out of the same discussions. A few of the disadvantages include lower achieving students being passive in group arrangements, the amount of time it may take some groups to form a bond, and adapting curriculum and materials to fit (Whicker et al., 1997). Possible ways to remedy these issues include smaller group numbers, assigning roles to team members to motivate them to be more engaged, teaching explicit lessons on productive discourse and teamwork, and more team building activities (Liljedahl et al., 2021; Saleh et al., 2005; Murphy et al., 2017). A study done by Whicker et al. (1997) also found a small percentage of students being frustrated with uncooperative group members, while others felt left behind when the rest of the group understood a concept that they didn't. Again, some of these issues could also be addressed using the aforementioned remedies. Overall, in all studies reviewed, the consensus was still that grouped instruction is better than non-grouped instruction and has many benefits.

Group Composition

One of the most important benefits of students working in collaborative groups is student achievement. Although having students work in groups was found to enhance student achievement, there are different conditions that were found to be ideal for

different ability levels. One such condition is the composition of the group. Many researchers have studied the difference between heterogeneous groups and homogeneous groups. Lou et al. (2000, as cited by Saleh et al., 2005 and Murphy et al., 2017) found that students of low ability performed better in heterogeneous groups, students of average ability performed better in homogeneous groups, and students of high ability performed well regardless of the grouping they were placed into. While this shows that there may not be a one-size-fits-all approach for grouping students, there were also some differences found in the types of social interactions taking place in the different groups. In heterogeneous groups, more individual elaborations were produced and in homogeneous groups there were more collaborative elaborations (Saleh et al., 2005). Van Boxtel (2000) tied both perspectives together by saying that elaboration can be either individual or collaborative, and both can exist together in cooperative groups and are associated with increased student achievement.

In contrast to Saleh's findings, Liljedahl et al. have a different take on what the composition of groups should look like. Liljedahl et al. (2021) found random groups to be the most effective. Part of his reasoning was that a group needs to have a good blend of redundancy and diversity. Redundancy is defined as things the students have in common, and diversity is considered the different perspectives and ideas each student brings to the group that they do not have in common. If students are able to self select groups, they will likely have too much redundancy and not enough diversity. There is also the issue of student goals vs. teacher goals (Kotsopoulos, 2007 as cited by Liljedahl et al., 2021). Student goals for grouping are likely to be related to social reasons while teachers goals for grouping students will likely be more related to academics. No matter how strategic a

teacher may be in choosing groups, if there is a mismatch like that, some students will be unhappy and disengage (Liljedahl et al., 2021). With random groups, you are not taking away the possibility of students working with people they want to work with. This is especially true if the groups are being randomized frequently, which Liljedahl et al. state is an important part of using random groups. They should be randomized approximately every hour (Liljedahl et al., 2021). When randomizing your groups, it's likely the students will at some point get to work with those they want to. He also mentions the importance of understanding the difference between students who *really shouldn't* be together and students who you would *prefer* not be together in groups, so you should be very selective about moving students once they have been grouped randomly and only do it if absolutely necessary (Liljedahl et al., 2021).

Lastly, group size has been found to make a difference in the effectiveness of groups. Lou et al. (2000) found that three to four members produced better results than five to seven members. Liljedahl et al. (2021) concluded that three members was the optimal size. Groups of two seemed to struggle, and groups of four would end up being two groups of two, or a group of three plus one.

Strategies to use in groups

One way to use collaborative groups is to have the students work in groups on learning activities that are specifically designed to enhance learning. Saleh et al. suggests that this may encourage average-ability students to play a more active role in group work, (2005) which may in turn enhance the group interactions and elicit more elaborations which are essential for students to learn new material (Slavin, 2011). This type of

collaboration was studied by Saleh et al. (2005), but it's important to note that it was researched using homogeneous groups only.

Another idea that has shown to help student achievement is to have teachers include specific tasks or lessons on productive discourse in their instruction (Lou et al., 1996 as cited by Murphy et al., 2017). As discussed in the previous section, exposing students to metacognitive training can also lead to higher math achievement, and better explanations among students working both in groups and individual settings (Kramarski & Mevarech, 2003).

Assigning team roles is a third strategy that can be used. Taken from CPM's website in a section on study teams, students work in teams of two or four which creates an environment for student discussion, sharing of ideas, and articulation of thinking, and it provides security to allow students to take risks to refine their ideas. (2023) Part of the CPM curriculum is that students work in teams where each person has a designated role. This idea is supported by Gillies (2004) whose study concluded that structured groups demonstrated less off-task behaviors than their classmates who were in unstructured groups. In contrast, Liljedahl et al. (2021) found that in the classrooms he observed where there were specific roles for each student, the engagement was not very authentic. Some students focused more on what their role was which meant they weren't thinking about the task or problem at hand, they were using the role as a way to escape doing any thinking. CPM's (Dietiker et al., 2014) website says that the textbook was written for teachers to be able to choose if they want to use the roles or not. If a teacher does choose to use the roles, there are several questions listed for each role that many teachers put on a placemat in the middle of the group so that students can see what their role could look

like in action. The questions listed for the resource manager are: “Does anyone have an idea?”, “Who can answer that question? Should I call the teacher?”, “What supplies do we need for this activity?” The questions listed for the facilitator include: “Who wants to read?”, “Does anyone know how to get started?”, “What does the first question mean?”, “I’m not sure. What are we supposed to do?”, “Do we all agree?”, “I’m not sure I get it yet—can someone explain?” The questions included for the recorder/reporter are: “Does everyone understand what to write down?”, “How should we show our answer on this poster?”, “Can we show this in a different way?”, “What does each person want to explain in the presentation?” Finally, the suggested questions/statements for the task manager are: “Ok, let’s get back to work!”, “Let’s keep working.”, “What does the next question say?”, “Explain how you know that.”, “Can you prove that?”, “Tell me why!” Although the roles are still meant to keep all students responsible for the work, the questions and statements they list as ideas are geared toward getting the students to work effectively as a team. (2023) Although the questions and ideas would serve to help students start and continue the conversation, this could potentially produce the less authentic interactions Liljedahl et al. mentioned. (2021) For example, if the task manager sees that part of their role is keeping everyone on task, they may be satisfied to say “Let’s get back to work” every few minutes and feel that they have accomplished their job, while still not doing any thinking for the actual task at hand. A modified version of this structure could be used with metacognitive questions to accomplish what Kramarski and Mevarech laid out as metacognitive training to enhance collaborative groups.

An additional strategy that can help engagement when using visibly random groups is to give the groups somewhere to meet after assigning them. For example,

putting numbers on the spaces the students will use and assigning each random group a number allows them to find each other quickly, especially if they don't know the names of their classmates yet.

We have now seen some of the best practices for grouping students according to Murphy et al. (2017), Saleh et al. (2005), Lou et al. (2000), and Liljedahl et al. (2021). Next is a look at some obstacles to using cooperative learning as described by teachers who have implemented cooperative learning.

Obstacles to Cooperative Learning

Collaborative learning has been shown to have many benefits when it is implemented correctly and when the right conditions are met. As Oakley et al. said,

> "Cooperative learning has been repeatedly shown to have strong positive effects on almost every conceivable learning outcome. Simply putting students in groups to work on assignments is not a sufficient condition for achieving these benefits, however. Unless the instructor takes steps to assure that the groups develop the attributes associated with high-performance teams, the group learning experience is likely to be ineffective and may be disastrous." (Oakley et al., 2004, p. 21 as cited by Baker and Clark, 2010)

This section outlines some of the obstacles to implementing collaborative learning effectively, and some possible antecedents to those as found by several studies. Next will be a look at more potential barriers found by teachers who implemented collaborative learning. Following that will be a look at eight evidence-based classroom management practices and how collaborative learning fits in with those.

In a study by Le et al. (2017) in Vietnam, 19 teachers and 23 students were interviewed about obstacles to effective student collaboration. Obstacles identified by both teachers and students were a lack of collaborative learning skills, free-riding, competence status and friendship. The collaborative skills that students mentioned they felt they were lacking in their groups include accepting opposing viewpoints, giving elaborate explanations, negotiation, helping others and getting help. Only seven out of 23 students mentioned this as an obstacle, while almost all the teachers noticed this.

The next obstacle identified was free-riding, and two-thirds of both the students and teachers recognized this. The students were able to verbalize their specific frustrations because they were in the group, but the teachers had a different viewpoint. They could see that there was unequal participation, but couldn't always rate individual contributions of students.

Ten of the students and 10 of the teachers identified competence status as an obstacle. High status students or students perceived as "smarter" or "more able" would dominate the group conversation, and their ideas were almost always accepted, even if they weren't correct. Low-status students or students perceived to be "less able" felt inferior because of this, and often wouldn't even offer ideas. Teachers would notice this when students would share ideas with them that they hadn't shared with their peers for fear of being wrong.

The fourth obstacle identified was friendship. Six out of 23 students talked about this, while only two teachers mentioned it. The students who did believe this was an obstacle said they felt a lack of self-discipline when working with friends, and were more likely to engage in off-task or unproductive behaviors.

Three main antecedents to these obstacles were identified by students and teachers as goals, instruction and assessment. Although all the teachers said that their goals for collaborative learning were for the students to develop cognitive and collaborative skills, only five of the teachers actually mentioned the collaborative skills as a goal in their course objectives. The teachers who did not mention collaborative skills as a goal, gave three reasons for this. The first was that they were using collaborative learning as a means for them to learn the subject, the second was that they were unsure of how to measure their collaborative skills, and the third was that students were already overwhelmed with academic subjects, so they wanted to use collaborative learning as a strategy to enhance learning and not make it another formal goal for the students.

The second antecedent was instruction. None of the teachers reported teaching the collaborative skills students would need in a formal way. 11 out of 19 talked about behaviors that were essential for collaboration, only when they noticed that students were not working well together. 14 of the 19 focused on cognitive skills, but again left out the collaborative skills. The reasons they gave for this include feeling that they have limited knowledge and experience with collaborative learning, and also a heavy amount of knowledge needed by the students in some courses. Similarly, many of the students felt unprepared to work with their groups, and since it hadn't been explicitly taught or talked about, they felt it was more important to focus on the academics. There were 10 students who said they had been given strategies for teamwork during a group activity, and three of those 10 reported being formally instructed on those collaborative skills mentioned above. Those three focused on those skills, but kept it to themselves since they didn't feel that it was being emphasized.

Finally, the third antecedent was assessment. Less than half of the teachers reported assessing the collaborative process, and those that did mentioned some challenges. The methods they used included assessing the final product, and using peer and self-assessment. Teachers did not feel that they could always trust the peer and self-assessments, and likewise, students said they were more lenient on friends. Assessing the final product left the group process out, so that was another challenge mentioned by them. Time constraints and class sizes were also mentioned. (Le et al., 2017)

A common theme with these obstacles is that teachers did not feel they had enough experience or preparation to effectively teach collaborative learning. They knew the benefits and wanted to use it but with lack of training and resources, it was not reaching maximum potential. Due to these limitations, they "tried to establish an inspiring CL environment whereby students feel excited to learn together." (Le et al., 2017, p. 114)

Culturally Diverse Groups

In a study conducted by Baker and Clark (2010) in New Zealand, they found some obstacles that were similar to Le et al., but also found additional issues. An important difference about this study is that it specifically looked at collaborative learning in culturally diverse groups. Part of the study included a survey conducted in 2006, and about 45% of teachers included in this survey had received training on collaborative learning methods. Of the students that participated, about half of them reported being taught specific group strategies and procedures. Even with the training, many of the students mentioned frustrations with group members who didn't contribute

equally, or were perceived as being ‘lazy’. These students felt that they needed more training on how to deal with these issues

Those that did not receive training reported groups functioning in a more traditional way. The students would divvy up the work and exchange only necessary information. This also happened in groups where there were cultural and language differences. Students recognized that some cultures value individualism over teamwork and felt that was a barrier to having effective groups. Similar to Le et al.’s findings, teachers in this study found it difficult to assess the group process, and also cited lack of time as a barrier to preparing students to work in groups. (Baker and Clark, 2010)

Implementation Barriers and Strategies to Overcome

A third study explored in this section was done by Gillies and Boyle (2010) and looked at issues of implementing collaborative learning. There were 10 teachers in this study who taught students between the ages of 11 and 14 in Brisbane, Australia. All teachers in the study agreed that they had positive experiences with collaborative learning. They found that students were more willing to take risks and weren’t so worried about making mistakes. They also mentioned that in general, they felt the quality of work was high. The same teachers who made these comments also found challenges similar to those identified in previous studies. A few mentioned were time management, organization, and students socializing more than working in their collaborative groups. Another challenge that was brought up was the additional time and effort required to find appropriate tasks for the groups to work on.

Tasks and Social Interactions

The importance of choosing the right task cannot be understated. Cohen et al. (1994, as cited by Gillies and Boyle, 2010) found that when students work on tasks where basic recall is needed, there will be minimal student interactions because they are only checking answers, asking for help, or exchanging information. With open-ended tasks or discovery-based tasks, students actually have to share ideas if they are going to solve the problem. Wegerif et al. (1999, as cited by Gillies and Boyle, 2010) advocates that

> "social interaction and reasoning is enhanced when:
>
> 1. all relevant information is shared;
> 2. the group seeks to reach agreement;
> 3. the group takes responsibility for its decisions;
> 4. reasons are expected;
> 5. challenges are expected;
> 6. alternatives are discussed before decisions are made; and,
> 7. group members are encouraged to speak.
>
> (pp. 936-937)

Cohen et al. found that it is the frequency of these task-specific interactions that is tied to achievement gains. (Cohen et al., 1999 as cited by Gillies and Boyle, 2010) Concurring with the other researchers in this section, all teachers in the study conducted by Gillies and Boyle agreed that students needed to be taught to work collaboratively. Some things that those teachers did in their classrooms to teach collaborative skills include identifying characteristics of successful groups (how they look and sound), specifically teaching

them not to talk over each other and how to take turns, conflict resolution, and constant reflection of how they worked together as a group (Gillies and Boyle, 2010).

While there are many ideas that have been identified as helpful for implementing collaborative learning, the extra time and effort associated with creating tasks, teaching collaborative skills, organizing the groups etc. is likely intimidating to teachers. A reasonable conclusion to draw from this information is that adequate resources and training are needed if a teacher is to implement collaborative learning effectively. This coincides with the results of a survey conducted by Lopata et al. which found that teachers were more likely to use collaborative learning when they had participated in staff development designed to help them with implementation. (Lopata et al., 2003, as cited by Gillies and Boyle, 2010)

This also fits in very well with Guskey's logic model of teacher change as seen in Figure 2. If teachers are provided with adequate professional development on collaborative learning, they could implement it in their classroom, and when they see improvements in student achievement, that will likely be motivation enough to continue with the practice. Conversely, if teachers try to implement without a solid foundation, they may not see the change or improvement in student learning outcomes, therefore not moving on to the change in beliefs.

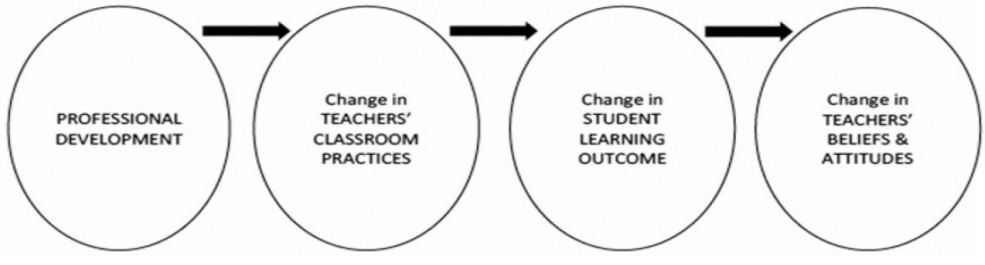


Figure 2. Guskey's logic model of teacher change (Guskey, 2002).

Evidence-based Classroom Management Practices

Finally, in this section is a discussion of classroom management practices and how some of the same strategies used for effective cooperative learning can also help with classroom management, since it is possible that classroom management is a reason teachers would not consider trying cooperative learning. Figure 2 outlines eight evidence-based strategies.

Figure 3. Evidence Based Classroom Management Strategies (Mitchell et al., 2017)

Strategy	Description
1. Physical layout	Arrangement facilitates typical instructional activities, orderly, arranged for safe teacher and student movement.
2. Expectations	Teacher broadly describes and explicitly teaches how students should behave.
3. Routines	Teacher outlines and teaches steps for completing needed classroom procedures.
4. Behavior specific praise	Teacher delivered verbal statement that explicitly identifies and affirms a student behavior.
5. Active supervision	Teacher monitors classroom by moving, scanning, and interacting frequently with students.
6. Opportunities to respond	Teacher solicits student response with high frequency and using a variety of strategies (individual, group, written, or verbal, etc.)
7. Reminders about behavior	Before a behavior is expected, teacher makes a statement reminding students what to do.
8. Consistent responding	Teacher adheres to classroom expectations and routines and provides consistent error correction and additional instruction/ re-teaching when problem behavior does occur.

Similar to how researchers have found that directly teaching collaborative skills is necessary to effective collaborative learning (Gillies and Boyle, 2010; Baker and Clark, 2010; Le et al., 2017), setting and teaching expectations and routines are important strategies to effective classroom management (Mitchell et al. 2017). In a survey conducted by Hepburn et al. (2021) on secondary school teachers in Queensland, Australia, it was found that although a preventative approach has been found to be more

effective than a reactive approach (Oliver et al., 2011 as cited by Hepburn et al., 2021) more teachers tend to use reactive practices instead of proactive practices (Roache and Lewis, 2011; Sullivan et al., 2014 as cited by Hepburn et al., 2021). Researchers also found that the current classroom management training package available to the Queensland teachers, called *The Essential Skills for Classroom Management* (Hepburn et al., 2021) has more reactive practices than preventative practices. It also does not specifically incorporate practices meant to increase student engagement which Mitchell et al. (2017) asserts is an important part of a preventative approach (Hepburn et al., 2021). So while some may be intimidated by collaborative learning because of the potential of classroom management difficulties, this research illustrates that collaborative learning, if implemented effectively, could actually be a solution to classroom management.

Conclusion

This chapter explored the research related to the question: *How can I use cooperative groups to enhance student learning in a high school math class?* First we looked at cooperative learning and its essential components. This was followed by an outline of best practices for grouping students while using cooperative learning. Lastly, we discussed some obstacles to cooperative learning as identified by those who had implemented it in their classrooms. Student achievement is perhaps the most important benefit of cooperative learning. Two other benefits that are related to student achievement are co-construction and peer elaboration. Co-construction is what happens when students work together to develop ideas, while peer elaboration is the idea of students helping each other by explaining concepts in different ways. Both are very impactful on student learning. To ensure that cooperative groups demonstrate these ideas, it’s important to first

set up the classroom for success. This includes carefully considering the composition of groups, and the tasks they will be completing. It also means teaching the students the cooperative skills they will need before expecting them to be able to use them in a group.

The research in this chapter provides a foundation for this capstone project. The project will consist of supplemental materials to use alongside a cooperative learning curriculum. This will include lesson plans for cooperative learning as well as other tools and activities to show students the types of productive behaviors expected. This will be described in more detail in Chapter 3.

CHAPTER THREE

Project Description

Introduction

In my research, I looked into different conditions that can make cooperative learning more effective, as well as some of the benefits to using a cooperative structure. This chapter provides a description of the intended project, which is supplemental materials teachers can use alongside their curriculum. This includes a master list of collaborative statements, as well as lesson plans to integrate into the regular curriculum to help teach students the collaborative skills they will need to be successful in groups. This project is intended for in-person instruction. This project, along with the literature discussed in chapter 2 is meant to help answer the question: *How can I use cooperative groups to enhance student learning in a high school math class?*

Some key takeaways from the research were the benefits of using cooperative learning, but also how it's important that students are taught how to work cooperatively in order for groups to be most effective. Also discussed were different ways to structure groups, and what the most effective ways are, according to each researcher.

This chapter will first give an overview of the project itself. The rationale behind this project and how it connects to the research will follow. The next section will discuss the audience and setting this project was designed for. Last will be some ideas on assessment for how to measure the effectiveness of this project.

Project Overview

The project includes supplemental materials that teachers can use to teach students the cooperative behaviors they need to work together. This includes a master list

of collaborative statements. This list will, among other things, help students to disagree without devaluing, serve as sentence starters when groups are having difficulties getting the conversation going, and help them to be reflective as they work with each other. Also included are four lesson plans to teach and model the behaviors that will be expected of the students during teamwork as well as some background and practice with metacognitive training. These could be done in four consecutive days or broken up into parts over several days. Just as teachers often spend time at the beginning of a year or term teaching behavior expectations and classroom routines, students need to be taught the expectations and routines of working in a team. Additionally, I have created two unit plans for a high school geometry class. Each lesson plan includes a teambuilding activity, team warm up, and additional cooperative strategies that are highlighted in the cooperative/teambuilding strategies section. There is also a piece at the end of each lesson to tie it all together, some of which are meant to be done as a team, and some are intended to be done individually.

Rationale

The literature and my own personal experiences indicate a need to specifically teach the cooperative practices to my students that I expect them to use. I created this project with my research in mind, and I also used Tomlinson and McTighe's (2006) framework, Understanding by Design (UbD).

Framework

Tomlinson and McTighe (2006) outline a three stage process to use when planning using UbD. The first stage is to identify desired results. Tomlinson and McTighe (2006) suggest that during this stage, you should consider what you would like your

students to know, understand, and be able to do. (p. 27) The long-term end goal for this project would be for students to learn the content. The short-term goal that is more applicable to this project would be students having the ability to work in cooperative groups effectively. This goal will eventually lead to the other. I also consider the standards for mathematical practice to be a goal.

The second stage involves determining acceptable evidence. Tomlinson and McTighe (2006) suggest teachers ask themselves how they will know whether students have achieved the desired results, and what do they consider acceptable evidence? (p. 28) The way I will know if my students have achieved those results is through a combination of my documented observations, formative assessments, and survey results. I hope that the survey results and my observations align and show good attitudes toward math and cooperative learning, as well as the competence of students working in groups.

The third stage is where the planning of instruction and classroom activities takes place. It is suggested to consider the knowledge and skills that students will need to perform effectively and to find appropriate activities and resources that will help meet the goal. (Tomlinson and McTighe, 2006, pg. 28) My project includes some direct instruction about cooperative learning practices and productive group behaviors, and also some activities that will hopefully help students to understand and participate in cooperative learning better.

My project will address the Common Core's Standards for Mathematical Practice (SMPs). Specifically, my project aims to develop the following:

- SMP #1: Make sense of problems and persevere in solving them.
- SMP #3: Construct viable arguments and critique the reasoning of others.

- SMP #6: Attend to precision.

The questions/statements that I provide to my students will hopefully help them to have more meaningful discussions in their teams where they will work together to understand and solve the problems. They will also reason with each other to construct arguments. In working with each other, the students should be verbalizing much of what they do which allows for many opportunities to find and fix errors which will help them be more precise.

Setting

I considered my own students in planning this project. I teach in a large high school located in a north suburb of the Twin Cities in Minnesota. We have recently implemented a new curriculum called College Preparatory Mathematics (CPM) which already has many instructional strategies and engaging problems embedded in it. CPM also has its own team structure in place with specific roles teachers can choose to use. My project is meant to be supplemental to this curriculum and has been created for my geometry class, which includes mainly tenth grade students. It could be adapted for any of the CPM courses at our school which include algebra and algebra 2 in addition to geometry.

Audience

The intended audience for this project is math teachers within my department at school. I will ask for their feedback as I implement this project. If it proves to be effective and receives encouraging feedback from other math teachers, I'd be happy to share it with others in the community who are using cooperative learning in their high school math classrooms.

Assessment

To see how effective this project is at answering the question: *How can I use cooperative groups to enhance student learning in a high school math class?,* I have a few ideas. It will be easier to measure individual student achievement by using final products such as tests or other formative assessments. To assess the other parts like the group process and the sharing of ideas, a survey will be used to gather some information.

I have created a survey with open-ended questions as well as Likert scale questions about the group process, how they work together as a group, and reflection questions help me to see what is and is not working for the students, so I can adjust if needed. Since data that isn't on individual outcomes can be difficult to measure, and not always accurate, some concrete assessment criteria for the teacher to use while students are working in groups could be helpful also. One way this was done in the project is during a participation quiz, the teacher will be circulating and marking things down that are heard while teams are working. The categories are questions (Q), ideas (I), miscellaneous math talk (M), or off-topic talk (T). These should be communicated to students before the participation quiz. A different way that isn't specific to a participation quiz is for the teacher to circulate and listen for the conversations that directly pertain to Polya's (1973) problem-solving method. These could be written on the board while students work so they know exactly what the teacher is looking for.

Summary

This chapter provided an overview of the project that aims to answer the question: *How can I use cooperative groups to enhance student learning in a high school math class?* The overall project is to see how cooperative learning can enhance learning,

specifically when students are instructed on how to work in cooperative groups. This will be implemented for roughly twelve weeks in a high school geometry class. The next and final chapter will conclude the project. This will include my personal reflections on the capstone project process itself, and what the results of this project could mean for the future.

CHAPTER FOUR

Reflection

Introduction

The first time that I taught using a new curriculum that involved cooperative learning, I was skeptical. My first few years of teaching consisted of direct instruction, “I do, We do, You do” and plenty of silent work time to practice. It was how I learned and it had worked well for me, and I was good at it. I felt like I was the holder of information and during class it was my job to pass it to them, and then they repeated the process in their practice after the lesson, and then restarted the whole cycle over the next day during the following lesson. Unfortunately (or now I would say fortunately), I found out quickly that teaching in that way does not work for most students. When I started with the new curriculum and first started having students work in teams, it was incredible to see what could happen when students had the chance to talk to each other and work together to figure problems out. The curriculum itself was great, but still left me wondering what else I could add or adapt to best meet my students' needs and help them get the most out of it. These observations led me to the research question, *How can I use cooperative groups to enhance student learning in a high school math class?* This final chapter will be a way to reflect on the project itself as well as the process of creating the project. First discussed will be some of the important findings that surfaced throughout this process. Next I will revisit my literature review and highlight the parts that had the biggest impact on me and guided the creation of my project. The following section will discuss future implications, as well as limitations of the project. Next will be a section of what the future research could look like as a result of this project. The final sections will take a look at how these

results will be communicated and what value is added to the teaching profession from the creation of this project.

Major Findings

As I journeyed through this capstone process, one of the biggest things I discovered is just how complex it can be to use a cooperative learning structure in your classroom. There are so many ways to arrange your students and furniture as well as the variety of strategies there are to use in the classroom. To begin, there is random grouping, homogeneous grouping, and heterogeneous grouping. Lou et al. (2000, as cited by Saleh et al., 2005 and Murphy et al., 2017) found that low ability students performed better in heterogeneous groups, students of average ability did best in homogeneous groups, and high ability students did well in both settings. As their teacher, I would love to group my students according to what will potentially be the best place for them even if that means having a mixture of heterogeneous groups and homogeneous groups. However, keeping Liljedahl et al.'s (2021) findings in mind about unintentional roles forming in groups and visually randomizing groups each day, it gets slightly more complicated. Liljedahl et al.'s (2021) idea that groups of three is the ideal number also adds another element, being that my classroom furniture (and I'm sure many others) is rectangular. Finding a structure for your classroom that meets the needs of your students, is hopefully research-based, and doesn't take you hours outside of the school day is quite the balancing act. Although I've spent plenty of time in the past figuring out seating arrangements, it wasn't until I began the project that I realized how much goes into it.

Revisiting the Literature Review

Many works guided the creation of this project. The group structure that I decided

on for my lesson plans came from Liljedahl et al. (2021). This includes using groups of three, visibly randomizing the groups each day, and having them work on vertical whiteboard spaces. Groups of two seemed to be stuck more often, and groups of four almost always devolved into two groups of two (Liljedahl et al., 2021). The reason for randomizing over heterogeneous groups is that in a group where students have been placed using test scores or some other measure, they tend to find out their "roles" quickly, if they don't know them already (Liljedahl et al., 2021). For example, if a student believes they've been placed in a group because they struggle with content, they may assume that a "smarter" student in their group will figure things out so they'll be able to get by without doing any actual thinking. On the other hand, if a student believes they've been put into a group because they are "smart" and usually do well on everything, they will likely meet the unwritten expectation and do all the thinking for their group to make sure they continue to do well and understand everything. (Liljedahl et al., 2021) Along with randomized groups, Liljedahl et al. asserts that they must be *visibly* random. If you tell students that they are randomly assigned but they don't actually see the randomness, they may not perceive that they are random and may believe that you intentionally chose their spot. This can again lead to the unintentional creation of "roles". To avoid these roles, another important part of the random groups is that they must be randomized approximately every hour, which works out nicely in my case to be every class period. Lastly, Liljedahl et al. talks about the importance of students working at Vertical Non-Permanent Surfaces, which shows up in team building activities and warm up questions quite often in this project.

In a study carried out by Kramarski and Mevarech (2003), the most significant

difference in achievement was found not between students who were instructed using individual learning and students who were instructed using cooperative learning, instead the biggest difference was found between those were exposed to metacognitive training, and those who were not. I could have taken this statistic to be disheartening, but instead I found it more motivating to take this project on. It goes to show that putting students together in groups and expecting them to do great work and have authentic, thought-provoking conversations is unlikely if you don't provide them with the skills and resources they need to be successful. The metacognitive training they used was based off of Polya's (1973) problem-solving method, so I chose to use his method in this project.

Slavin (1995, 1996, 2011) identifies four major theoretical perspectives that coexist together to explain why cooperative learning is beneficial. The four perspectives are the motivationalist perspective, the social cohesion perspective, the cognitive-developmental perspective, and the cognitive-elaboration perspective. The motivationalist perspective says that there would be some sort of cooperative incentive structure which would cause students to feel that they need to help their group members meet their goals in order to meet their own personal goals (Slavin, 1995, 1996, 2011). Somewhat similar, yet still different is the social cohesion perspective which says that students want to help each other because they care about each other (Slavin, 1995, 1996, 2011). The cognitive-developmental perspective says that students who interact around appropriate content-based tasks will increase their mastery of concepts (Slavin, 1995, 1996, 2011) The cognitive-elaboration perspective says that if students are to retain the information in their memory, they need to engage in some sort of elaboration, such as explaining the concept to someone else (Slavin, 1995, 1996, 2011). I drew from all of

these perspectives during the creation of my project. The daily team-building activity and team warm ups pertain more to the social cohesion perspective and the motivationalist perspective. The teambuilding activities are meant to build a team bond, especially since they will be in random groups each day, and some of the activities and warm ups require that they work together. My hope is that the daily teambuilding and warm ups will pave the way for authentic conversations to take place while working through the lesson, making a safe space for students to help each other out and explain things that need explaining to increase their mastery.

Implications and Limitations

Something that may occur as a result of this project is that at first, the problems the students do each day will likely take them significantly longer while they are learning how to use Polya's (1973) problem-solving process. As they use the process more and more, I believe it will become natural and not take as much additional time. This could be difficult to accommodate for an already packed schedule. It would be very important to keep accurate time for the teambuilding and warm ups. While those are fun and helpful in creating a team bond for the random teams each day, they can take up a lot of time if you let them, and that time will likely be needed to complete the main problems. Additionally, it might be helpful to add more modeling with the problem-solving process at the beginning. Some of the warm ups could be replaced or adapted to instead be teacher-led where the problem-solving process is modeled.

The daily team-building activities could be useful to other teachers, as those are not specific to the curriculum and are purely there to encourage social cohesion. The warm ups are either pertaining to one of the learning objectives from the last few days, or

are there to practice a skill students will need in the future. These could be useful to other teachers as well. The other strategies may not be realistic for another teacher to use who isn't using one of the CPM courses, or some other problem-based curriculum. The problem-solving process that I've chosen to include could be adapted to use with other curricula, but many of the strategies included are meant to be used alongside structured team tasks.

Future Research

Although I believe this project is a great starting point, I know that there is much more work to be done. I plan to add teambuilding activities and more interactive warm ups to every lesson in the units that follow the ones in this project. In addition, I plan to find a way to include Polya's (1973) problem-solving method into each and every day. Thinking about and discussing the questions listed on the problem-solving process sheet that each student will have is a practical way for students to practice metacognition. With the teambuilding activity, warm up, using the problem-solving method for all the main problems and then some type of closure for each day, the schedule is packed. For future research, I would like to investigate other ways to include metacognition in the classroom without adding a considerable amount to the daily schedule.

What the students do each day in class and how they are assessed at the end of a unit is vastly different. They stand up, work together at vertical whiteboards, and then discuss their thoughts and strategies while they work on problems together at their seats. At the end of a unit, they sit down and take an individual unit test on the content. In the future, I would like to create some assessment options that assess their knowledge on a benchmark in a manner that is more similar to what they do in class each day. I don't

know if I would ever fully abandon paper assessments, but it could be in the form of more exit tickets, or possibly making a paper assessment an option for students at the end of a unit. This is something that I think is worth exploring more.

Something that came up often in my research was the idea that students needed to be taught the skills needed for cooperative learning in order to achieve the best results. This sparked the idea for my project. Something else that came up frequently in my research was the need for training for teachers who are going to implement cooperative learning. In a survey conducted by Lopata et al. (2003, as cited by Gillies and Boyle, 2010), it was found that teachers were more likely to use cooperative learning when they had participated in professional development that was designed to help them specifically with implementing cooperative learning. With the curriculum we use, we have had some great professional development to go along with it. In the future, I would like to investigate how it would look to create professional development to aid teachers with implementing cooperative learning. I would like to design something for teachers who do not already have a problem-based curriculum at their fingertips. Although it would be great, it is not reasonable to suggest that all districts can or will invest in a brand new curriculum all in the name of cooperative learning. This professional development would look at how teachers could start out from scratch with no structured team tasks or problem-based curriculum. It must not be something too time-consuming, otherwise it will likely not be used.

Communication and Benefit to the Profession

To start, I plan to share the beginning lesson plans with the teachers I work with who are in my collaborative team (CT). They all teach Geometry as well. They could use

these lesson plans in their entirety, or they could break them up into several days, or even just use bits and pieces.

I believe this project shows one way that the curriculum can be implemented that isn't exactly as the book suggests always, but also doesn't reduce rigor. The students are still completing the core problems suggested by Dietiker et al. (2014), just using different strategies at times. I have done various CPM courses over the last five years, and some of the changes I've made before have reduced the rigor. In the short term, this may feel like a welcome change because you are able to pull everyone along and get through it, but in the long run, reducing the rigor and doing too much direct instruction can allow you to fall into a pattern quickly, and students recognize that. If you can push through and stick with the strategies and allow students to grapple with problems, that teaches them perseverance and will ultimately benefit both student and teacher more in the long run. I hope that with my adaptation of our curriculum, I have achieved that.

Conclusion

Overall, this entire capstone process has been one of the most challenging tasks of my entire academic career. Challenging, yet extremely rewarding. I feel fortunate to have been able to dive into some of the queries that I've had since before I even began this program in 2020. The huge shift that I experienced when I moved from my last school to my current school sparked the research question *How can I use cooperative groups to enhance student learning in a math classroom?* My research ultimately led to the creation of this project. Overall, I hope this project can benefit students and teachers, and serve as a building block for more research and future implementation of cooperative learning.

APPENDIX A

Unit Design Template – Stage 1

Established Goals	
Essential Questions	
Key Knowledge and Skills	
Students will know…	*Students will be able to…*

Stage 2

Performance Tasks
Assessment/Other Evidence

Stage 3

Stage 3 - Learning Plan

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