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The Impact of Identifying Problem-Solving Strategies within Collaborative Work in 5th and 6th Grade Classrooms

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Abstract

The purpose of this study was to determine the effect of naming and modeling problem-solving strategies on the students' identification and implementation of problem-solving skills within collaborative settings. The research took place over a seven-week timeframe, beginning in September of 2019 and ending in November 2019. The population for this action research study included fifth-grade students enrolled in a public elementary school, and sixth-grade students enrolled in a parochial school both in suburbs of Saint Paul, Minnesota. The 25 fifth grade students participated from their contained classroom, and the eighteen sixth graders participated from their science classroom. Data collection included student assessments, discussion groups, situational responses, and experiment reflections. In addition, teachers collected classroom observations in order to triangulate students' overall growth within problem-solving strategies, involving both student perception and teacher observation.

This inquiry-based study showed that over the course of seven weeks, students increased the number of problem-solving strategies they used within collaborative groups, and more students identified collaboration as a tool to solve problems. From the beginning of intervention to the end, students identified problem-solving skills to have more importance in their work inside and outside of school. From this research we concluded that inquiry-based collaborative group work needs to be present in classrooms for developmentally appropriate problem-solving skill development.

Keywords: Problem-solving, collaborative work, student perception, strategies

The ability to cope with the unfamiliar, process the uncomfortable and solve the unknown is a trait not inherited, but learned through trial and error, failure and success, as well as experimentation. The need to access and use the skills of problem-solving surrounds people of all ages and professions every day. These necessary skills, when implemented, allow for critical thinking, an important component when developing the ability to work flexibly, efficiently, and accurately, when learning how to persevere and how to communicate ideas clearly.

Problem-solving is having a repertoire of strategies and skills in order to face a problem, pulling skills from past experiences, and creating a solution to the situation at hand (Laine, Näveri, Ahtee, & Pehkonen, 2014). The development of these skills in adolescence is vital for the independent implementation of critical thinking into adulthood. The absence of these developed skills results in a lack of confidence, independence and the ability to communicate when faced with a problem with an unknown solution.

Problem-solving proves to be a vital component in learning across curriculums and contexts within a school setting. Students face opportunities for problem-solving daily in the classroom, and the development of problem-solving strategies and skills need to be included in the curriculum. Currently, there is little curriculum that includes the development of effective methods of problem-solving within classrooms. Without curriculum or methodology that supports representing problems, approaching solutions, determining necessary data as evidence, solving or not solving a problem, and explaining their solutions to peers, students are unable to develop these skills required for future everyday interactions. The methodology of modeling and naming current student strategies within classroom curriculums allows for students to represent problems, approach solutions, determine data, solve or not solve a problem and communicate their process to others, all while developing the independence needed to apply problem-solving skills in daily life.

Every day, people encounter new problems requiring them to identify and apply strategies leading them to overcome or solve an initially unfamiliar situation. The development of problem-solving skills should be present in schools and learning within the classroom in order to foster critical thinking. Curriculum guiding this development is lacking in current classrooms and what is available does not foster an environment that provides experiences for students to use their problem-solving skills. Due to this lack of research, we decided to investigate problem-solving skills within fifth and sixth-grade classrooms, both in suburbs of Saint Paul, Minnesota. Our study will be researching the following questions:

1. To what extent will 5th and 6th graders recognize and utilize modeled problem-solving strategies in collaborative group settings?
2. What effect does modeling problem-solving strategies have on the implementation of problem-solving skills within collaborative group settings?
3. What effect does modeling problem-solving strategies in the classroom have on students' perception of the importance regarding said skills?

Theoretical Framework

21st Century Learning refers to the opportunity for development and application of the skills required in the modern everyday workforce (Jerald, 2009; Rich, 2010; Trilling, & Fadel, 2009). The 21st Century Learning theory includes the ability to learn and apply new knowledge quickly, as well as utilizing the skills of problem-solving, communication, teamwork, technology use, and innovation (Trilling & Fadel, 2009). As Rich (2010) stated, "The term '21st-century skills' is generally used to refer to certain core competencies such as collaboration, digital literacy, critical thinking, and problem-solving that advocates believe schools need to teach to help students thrive in today's world," (para. 1).

This research will focus on critical thinking, one particular aspect of 21st Century Learning. Critical thinking, a component of problem-solving, is ranked by employers as the number one necessary skill for employees to hold (Jerald, 2009). Employers believe that critical thinking will become more important over the next five years, due to the tasks within workplaces requiring this skill (Jerald, 2009). In order to prepare students for successful adulthood in the workplace, problem-solving strategies must be developed in adolescents to apply critical thinking in real-life situations. Students' problem-solving ability is enhanced when provided opportunities to solve problems themselves and witness others solving problems (Karatas & Baki, 2013). Critical thinking skills are essential because they allow students to deal with problems effectively in social, scientific, and practical situations (Snyder & Snyder, 2008). Developing and implementing opportunities for problem-solving skills within classrooms allows students to practice their communication and collaboration necessary for effective problem-solving.

As educators, we see a lack of curriculum for the development of critical thinking skills. That deficiency is what motivated us to research the development of problem-solving strategies. Problem-solving encompasses critical thinking, communication, collaboration, and teamwork, all components of 21st century skills. During the research process we found that understanding students' development of problem-solving strategies is the foundation in determining how the skills need to be introduced, taught and practiced with students. By allowing students to practice problem-solving skills in non-routine and unfamiliar situations within the classroom, students can develop and implement strategies in new, but similar situations in their everyday lives (Pedersen and Liu, 2003). Instruction in the classroom that promotes the teaching of specific problem-solving strategies allows students to develop, practice, and refine necessary 21st century skills for their futures.

Review of Literature

Definition and Importance of Problem-Solving

Modern problem-solving was introduced in the 1950s by George Polya who determined the four steps to problem-solving: 1) Understanding the problem, 2) Devising a plan, 3) Carrying out the plan and 4) Looking back (Laine et al., 2014). Some traits and aspects to problem-solving that may be present are: accuracy, communication, consistency, relevance, depth, evidence, fairness and perseverance in the solving of the problem at hand (Carlson, 2013). Problem-solving includes the effort of one's skills and thought processes to achieve a goal without an immediate solution while utilizing problem-solving skills in an educational or real-world environment (Carlson, 2013; Schunk, 2012).

The more students practice problem-solving, first collaboratively, then independently, the better learners they become (Ollerton, 2007). Students become self-reliant and gain the ability to make rational decisions while building independence (Ollerton, 2007). Students' problem-solving ability is enhanced when provided opportunities to solve problems themselves and witness others solve problems (Karatas & Baki, 2013). Teachers have an essential role in the students' development of problem-solving skills and must choose problems that engage students to utilize critical thinking (Karatas & Baki, 2013).

The development of problem-solving skills leads to metacognition in students, or an individuals' knowledge of cognitive processes and their regulation of these processes (Jin & Kim, 2018). Jin and Kim (2018) argued that metacognitive practice in their learning is essential in students' decision making and problem-solving. Students' varying ideas and questioning that occurs in collaborative problem-solving have potential to ignite metacognition due to the need of reflection on thinking and action in these situations (Jin & Kim, 2018). Jin and Kim (2018) found that elementary students' group work allowed students to monitor and adjust their own and peers' thinking processes through collaborative interactions and discussions.

Development of Problem-Solving Skills

Responding to the importance of critical thinking skills, Brookfield (2013) stated,

> That's really what the purpose of education is to learn to think more critically. I think that's true whether you are a student of mathematics, botany, theology, sociology, accounting, law, or anything. The ability to think critically is a foundational skill needed in so many areas of life. I'd say that whether working with adults and college students or even kindergarten, elementary, junior high, and high school students, thinking critically is the foundation undergirding all education (p. 26-27).

In order to foster the development of critical thinking and the use of problem-solving strategies, there are specific tasks educators can adapt for their classroom to allow students to practice their skills.

Routine tasks refer to situations that are familiar or similar to a previous problem a student has encountered (Laine et al., 2014; Zsoldos-Marchis, 2014). If the development of problem-solving skills has occurred, the student should recognize what skills and strategies will help solve the problem (Laine et al., 2014). Non-standard tasks are unlike problems a student has seen before and may be different, surprising, and demand new types of thinking by solvers

(Laine et al., 2014; Zsoldos-Marchis, 2014). Highly developed problem-solving and critical thinking skills are needed to solve non-standard problems (Laine et al., 2014). Higher level critical thinking skills require higher-order thought processes to allow for students to analyze their thinking and the necessary steps to solve non-routine problems (Snyder & Snyder, 2008). Additionally, students can use stages to solve non-routine problems that include understanding the problem, devising a plan, carrying out the plan and looking back (Laine et al., 2014; Schunk, 2012; Zsoldos-Marchis, 2014).

Analogical reasoning aids in the conscious development of problem-solving skills. Schunk (2012) defined analogical reasoning; where one makes a connection with a familiar situation and the problem situation. In order for analogical reasoning to occur, the problem must be structured similarly to familiarize the problem with a past situation (Schunk, 2012). The goal of this strategy is to help students connect familiar situations or steps and transfer them to solving a problem (Schunk, 2012). Relating problems to familiar situations allows for connections that help solve problems.

Problem-Solving Strategies and Techniques

Methodologies and techniques can be used to develop problem-solving skills in students. When students are active learners in their education, opportunities arise to practice problem-solving and discuss their strategies with peers (Carlson, 2013; Schunk, 2014). Applying critical thinking and problem-solving within teaching and learning new content increases students' motivation and improves overall learning outcomes (Trilling & Fadel, 2009). Collaborative learning encompasses many techniques that are essential in the development of problem-solving skills, including peer discussion techniques and peer-assisted learning (Kaya &

Altun, 2014; Lansiquot, Blake, Liou-Mark, & Dreyfuss, 2011; Zsoldos-Marchis, 2014). Teacher questioning is an essential tool to help students process their thoughts and refine their ideas when thinking critically about their responses as well as others' (Carlson, 2013; Rashid & Qaisar, 2016; Snyder & Snyder, 2008; Todade et al., 2013).

Active Learning and Modeling

Active learning is a technique that can be used to encourage students' problem-solving by seeking new skills and adapting throughout their education rather than being passive consumers of knowledge (Carlson, 2013; Schunk, 2014). A study done by Carlson (2013) found that when using lectures and videos as the instructional method, students had a negative perception of the critical thinking skills implemented in their learning regarding that course. When using discussions, brainstorms, projects, and presentations, students had an overall higher perception of critical thinking skills and employed problem-solving strategies in their work. Students use instructional strategies, including problem-solving and inquiry-based learning, to develop their knowledge to identify and solve a problem (Newman, Dantzler, & Coleman, 2015; Schunk, 2012). Inquiry environments are also useful in promoting problem-solving. Inquiry environments where teachers encourage elaboration of answers, allow for students to justify their answers and support their claims (Kim & Hand, 2015; Oliveira, 2010; Smart & Marshall, 2012; Snyder & Snyder, 2008).

Modeling is a technique that can be used to enhance student problem-solving skills while utilizing active learning methodology. Snyder and Snyder (2008) mentioned how students are not born with the ability to think critically and modeling allows for students to be taught how to think critically. Pedersen and Liu (2003) suggested that evidence shows students can replicate and apply problem-solving strategies to similar situations when the strategies were teacher modeled. Modeling helps students understand what questions to ask in order to gain relevant information, avoid questions not useful to their understanding, and walks students through the process of thinking critically (Pedersen & Liu, 2003; Snyder & Snyder, 2008). Johanson (2010) stated that when teachers model their thinking, critical thinking is present for students. Challenging assumptions and viewing the situation from multiple perspectives opens up conversations with students (Johanson, 2010; Carlson, 2013; Hilton, 2013; Rashid & Qaisar, 2016; Tofade, Toyin, Elsner & Haines, 2013). In addition to better understanding how to question to gain relevant information, students are also able to write rationales and reflections of their work in a more organized and detailed fashion (Pedersen & Liu, 2003). Modeling allows students to gain a better understanding of thinking critically, questions to ask, as well as the evidence that supports claims both through dialogue and written applications (Johanson, 2010; Pedersen & Liu, 2003; Snyder & Snyder, 2008). Through active learning in combination with modeling, problem-solving skills may be developed through a multitude of learning methods (Carlson, 2013; Schunk, 2014; Snyder & Snyder, 2008). Collaborative learning, peer-assisted learning, and peer discussion allow opportunity to employ problem-solving techniques, specifically when using scaffolded, open-ended questions allowing for critical dialogue.

Collaborative learning

Collaborative problem-solving requires two or more people to engage in the problem-solving process effectively in order to solve a problem (Zsoldos-Marchis, 2014). This process allows students to pool their knowledge, skills, and efforts to come to a solution (Jin & Kim, 2018; Zsoldos-Marchis, 2014). For this research, collaborative learning and cooperative learning are considered as the same technique in which students are working together on solving a problem. Collaborative learning allows for students to become metacognitively aware of their own thinking and their peers' thinking (Jin & Kim, 2018). Zsoldos-Marchis (2014) found that cooperative problem-solving helped students when encountered with thought barriers due to receiving explanations from their teammates and using these ideas in solving their individual problems. Students reported that when they discussed the problems together, they understood the problem better (Kaya & Altun, 2014; Zsoldos-Marchis, 2014).

Peer-assisted learning

Another form of collaborative learning is peer-assisted learning. Peer-assisted learning is a form of instruction where students actively learn in a small group, facilitated by a peer leader (Lansiquot et al., 2011). The learning goal of peer-assisted learning is to build a community where students feel safe to question and challenge concepts, integrate problem-solving strategies, and to communicate ideas while working collaboratively (Lansiquot et al., 2011). The peer leaders are responsible for guiding the group, ensuring a focus on the topic at hand and encouraging each group member to question and think deeper than their individual responses would allow (Lansiquot et al., 2011). Lansiquot et al. (2011) stated how peer-assisted learning is "designed to increase critical thinking skills, enhance problem-solving abilities and strengthen computational proficiency" (p. 21). Peer-assisted learning incorporates peer-discussion in a small group setting to allow for collaboration to encourage problem-solving (Lansiquot et al., 2011).

Peer discussion

Peer-discussion can be beneficial for students when working towards a solution to a problem (Kaya & Altun, 2014). Kaya and Altun (2014) noticed that students found peer-discussion in collaborative learning environments beneficial for learning by providing them opportunities to discover their weaknesses and then provide them time to fix errors. Peer-discussion also allows for metacognitive regulation through the different ideas, and uncertainty of problems that arise when problem-solving (Jin & Kim, 2018). Peer-discussion can be incorporated within the classroom to encourage collaborative problem-solving. Teachers can implement techniques including, think-pair-share, thinking-aloud pair problem-solving, and jigsaw to incorporate peer-discussion (Zsoldos-Marchis, 2014).

Zsoldos-Marchis (2014) explained think-pair-share as a technique where students first think independently on an idea or problem. They then pair up with a peer and share their answers and responses. If the answers differ, they need to discuss what is contradicting and work to find a unanimous answer. Another technique includes thinking-aloud pair problem-solving, where students work in pairs (Zsoldos-Marchis, 2014). One partner is the explainer, and the other is the questioner. The explainer discusses the problem and its solution. The questioner prompts for more detail through the use of questions, which allows for different ways to solve the problem and encourages deeper level thinking. Students then reverse roles to complete the next problem (Zsoldos-Marchis, 2014). Similarly, is the jigsaw technique, where there are two groups of students as opposed to just a pair of students. Zsoldos-Marchis (2014) explained the jigsaw technique to include two groups, a home group, and an expert group. Each student is part of a home group and a separate expert group. Every student has a problem to solve, and students with the same problem will discuss their solutions together becoming experts within their expert group. Then they return to their original home group to explain, justify, and demonstrate their problem and their expertise. Think-pair-share, thinking-aloud pair problem-solving, and jigsaw are techniques that incorporate peer-discussion to allow for deeper problem-solving within students (Zsoldos-Marchis, 2014).

Questioning Techniques

Questioning techniques can also be used to enhance problem-solving in students. Effective teacher questioning facilitates a classroom climate where students often share their ideas allowing for indirect student learning on how to question (Smart & Marshall, 2012). Open-ended questions allow for a variety of responses to encourage discussion (Oliveira, 2012; Tofade et al., 2013). Critical dialogue also encourages discussion due to the posing of questions to spark ideas (Hilton, 2013). Questioning can also be used to help scaffold student ideas and understanding of concepts (Rashid & Qaisar, 2016; Schalk et al., 2018).

Open-ended questions. The use of open-ended questions allows for a variety of responses that require further elaboration of thoughts and ideas, which encourages discussion (Oliveira, 2012; Tofade et al., 2013). Kim and Hand (2015) stated that asking open-ended questions that elicit reasoning and critical thinking, as opposed to yes or no answers, allows for students to challenge others' ideas and encourages the development of new or elaborated ideas of their own. Questions that require students to evaluate their thinking, as well as provide clarity and accuracy of their thinking, allow for additional depth (Snyder & Snyder, 2008). Additionally, the Socratic method uses inquiry to promote open-ended discussions where viewpoints can be compared (Carlson, 2013; Rashid & Qaisar, 2016; Tofade et al., 2013). In order to develop problem-solving skills, students need to be able to elaborate on their thoughts and ideas, which can be promoted through the use of open-ended questions (Oliveira, 2012; Tofade et al., 2013).

It is important for students to be able to justify their answers as they continue their development of problem-solving skills (Smart & Marshall, 2012). However, it is important for teachers to wait for student responses, instead of re-wording questions (Snyder & Snyder, 2008). Follow up questioning strategies can be used to scaffold student ideas to support the construction of their thoughts, an important aspect of problem-solving (Smart & Marshall, 2012). Situations answered with wrong answers are not the only moments to use additional questioning. Researchers have found that students' cognitive levels increase when teachers follow up correct answers with additional productive questioning to allow for justification of students' responses (Kim & Hand, 2015; Oliveira, 2010; Smart & Marshall, 2012).

Scaffolding of questions. Scaffolding of student ideas is vital to help develop problem-solving within students. Self-explanation is a scaffold often combined with work examples in which students monitor their learning processes, make connections to prior knowledge, and form a solution (Schalk et al., 2018). The curriculum should emphasize how students explain their solutions to their peers (Karatas & Baki, 2013).

Self-explanation prompts were necessary for scaffolding learners' processing of concepts (Rashid & Qaisar, 2016; Schalk et al., 2018). When students fail to find the right solution, they can use the failure to prepare for their explanation (Schalk et al., 2018; Schunk, 2012). A technique that encourages explanation is the use of small group problem-solving. In small group problem-solving, students are presented with a problem and must dialogue to reach an agreed-upon solution, which fosters effective classroom communication (Kaya & Altun, 2014). Self-explanation can be used to help scaffold student ideas when solving problems (Karatas & Baki, 2013; Rashid & Qaisar, 2016; Schalk et al., 2018).

Critical dialogue. Critical dialogue is a discussion technique that encourages participation from everyone by posing questions that ignite conversation for an equitable understanding of situations, ultimately understanding multiple perspectives of the topic at hand (Hilton, 2013). Problem-solving settings that use classroom discussions provide students opportunities to analyze their thoughts, share and compare their thoughts to that of their peers and allow for discussion of different ideas (Karatas & Baki, 2013; Kim & Hand, 2015; Oliveira, 2010; Smart & Marshall, 2012). Rashid and Qaisar (2016) summarized their research findings by stating, “It is observed that probing questions of the teacher motivated the students to participate in lively classroom discussion, and students not only answer the questions openly but they contradict the answers of each other" (pg. 166). Laine et al. (2014) found that it is essential to create a classroom community where students feel safe and comfortable asking questions to think deeper about their problems, and allow them inquiry-based opportunities to expand their knowledge of multiple perspectives.

Challenges Problem-Solving Development Faces in the Classroom

Throughout this literature review, we have discussed fostering the development of problem-solving skills and critical thinking. However, there is a difference between development and transfer in order for critical thinking to occur. Problem-solving allows for the development of students’ responsibility, which directs them to search for answers and increases motivation (Karatas & Baki, 2013). Problem-solving experiences help expand students’ thinking, encourage persistence through difficulties, and empower students to create their own learning (Karatas & Baki, 2013). Expert problem-solvers classify problems at a deeper-level as opposed to novice problem-solvers who look at the surface level; they spend more time planning and analyzing

(Schunk, 2012). How do students not only obtain these skills but implement them into their thinking to become critical thinkers?

It is widely agreed upon that problem-solving skill development should be present in schools (Brookfield, 2013; Rashid & Qaisar, 2016). There is debate on whether these skills and critical thinking should be embedded within all subject curricula or specific subject matter (Rashid & Qaisar, 2016). Students benefit most developmentally when they witness a teacher thinking critically before their eyes and modeling problem-solving skills (Brookfield, 2013; Pedersen & Liu, 2003; Snyder & Snyder, 2008). Brookfield (2013) goes on to discuss that this modeling can be done in any subject and any situation. This way students are seeing the versatility of problem-solving skills. Problem-solving has yet to be formalized within curricula (Brookfield 2013).

Discussion

Problem-solving is a necessary skill for students. However, these skills and techniques are not often directly taught (Brookfield, 2013). With a flexible skill set of problem-solving strategies, students are more likely to be self-regulated learners and perseverant in their work (Zsoldos-Marchis, 2014). Through the curriculum, students should be taught how to solve problems that are non-routine and unfamiliar, staying flexible, creative, and thinking divergently toward solutions (Laine et al., 2014; Schunk, 2012; Zsoldos-Marchis, 2014). As educators, there are methods and techniques within the classroom that allow problem-solving skills to develop within students. Problem-based learning provides learners with experiences that can be reflected in real-world situations in order to develop problem-solving skills (Newman et al., 2015; Schunk, 2012). Cooperative learning provides students with opportunities to develop problem-solving strategies and techniques (Kaya & Altun, 2014; Lansiquot et al., 2011; Zsoldos-Marchis, 2014). Experiences through self-explanation and critical dialogue include components that incorporate questioning strategies when faced with a problem (Hilton, 2013; Karatas & Baki, 2013; Kaya & Altun, 2014; Rashid & Qaisar, 2016). Finally, there is a need and benefit of creativity and divergent thinking within problem-solving that encompass the development of problem-solving skills rather than just the transfer of knowledge (Karatas & Baki, 2013; Schunk, 2012).

Research exists about the benefits and techniques that enable problem-solving skill development with students. These benefits and techniques appear to be where the research ends in substantial amounts, and implementation and perceived successful components are less reviewed.

Students encounter problems every day, and educators have the opportunity to guide them in their development to persevere. By learning techniques, teaching methods, and successful studies, teachers are encouraged to try on a new approach to active, collaborative, and problem-solving centered learning in the classroom. Although there are challenges that face problem-solving development within the classroom, it is clear that problem-solving techniques help students gain the necessary skills to enter the real world.

Research Methodology

Design

This study used inquiry-based and reflection designs over seven weeks starting in September 2019. Student assessments, discussion groups, situational responses, and experiment reflections were collected. In addition, classroom observations made by the teacher were collected in order to triangulate students' overall growth within problem-solving strategies, involving both student perception and teacher observation.

Setting and Subjects

The population for this action research study was fifth and sixth-grade students. The fifth-grade students were enrolled in a public elementary school, the sixth-grade students were enrolled in a parochial school both in suburbs of Saint Paul, Minnesota. The 25 fifth grade students participated from their contained classroom, and the eighteen sixth graders participated from their science classroom, both within the first trimester of the 2019-2020 school year. Of the total 43 participants, 22 were female and 21 were male, further defined in Table 1.

Table 1

Study Demographics

	5th Graders	**6th Graders**
Total Participants	25	18
Male	12	9
Female	13	9

Tools to Collect Data

Pre- and post-assessments (See Appendix A) were used that featured Likert scale and open-ended questions. These questions were designed to gather information on students' perceptions of their own problem-solving abilities. Pre- and post-discussion groups were conducted in person and voice recorded by classroom teachers featuring semi-structured interviews (See Appendix B) which allowed students to elaborate on their views of the development and importance of problem-solving skills. Problem-solving situational responses (See Appendix C) were administered through FlipGrid, an online video response website, to allow students to share problem-solving skills and strategies they would use in hypothetical and predetermined situations. After each experiment students completed a written reflection (See Appendix D) that asked questions regarding which strategies and techniques were implemented within the collaborative process and experiment. The reflection also allowed students to share how confident they were with the task and their problem-solving strategies and implementation. Teachers completed observations (See Appendix E) during each collaborative process and experiment, identifying how student groups implemented problem-solving strategies as well as which specific students used each skill. This data allowed for comparison to the student reflections, to determine if implementation and confidence coincided.

Procedure

Prior to any problem-solving instruction, pre-assessment and discussion groups were held. The online pre-assessment was taken by students after a STEM collaborative paper chain activity within their classroom. The pre-discussion groups were held with selected groups of students who volunteered to be interviewed at a classroom community table. The discussions were led by question prompts from the teacher and allowed each student to verbally respond and provide their input. At the beginning of the seven-week intervention, the classroom teachers discussed the strategies with their students, giving examples of each strategy. Four different hypothetical problem-solving situations were completed biweekly using FlipGrid. Students individually completed responses within a small area of the classroom. Students completed weekly teacher-directed inquiry-based experiments or activities requiring collaboration in pairs or a small group. During these weekly investigations, problem-solving strategies were pointed out to students, discussed and practiced. After each experiment or activity, students reflected on their processes through a paper assessment, including what problem-solving strategies they used, and their confidence in the completion of their task. Student observations made by the teacher were completed throughout the process of each experiment or activity. These observations were recorded on a chart using shorthand for the strategies witnessed in the classroom. The observations recorded individual students' use of problem-solving strategies, as well as the strategies witnessed within their collaborative groups. This was a working document throughout the study. After seven weeks, an online post-assessment mirroring the pre-assessment was given to students after they completed another STEM, collaborative activity in the classroom. Post-discussion groups were held in small groups within a community table asking the same questions as the pre-discussion.

Results

The collection of all data occurred through various Google Forms and video responses on the online video platform called FlipGrid. The student assessment was a Google form (See Appendix A) given to students before specific teaching and post-interventions. The questions prompted students to place their responses on a Likert scale of agreement as well as in short answer responses. The FlipGrid scenarios (See Appendix C) were given on a bi-weekly basis and asked students to respond to different hypothetical problem-solving situations. The students completed a written reflection (See Appendix D) individually after every problem-solving experiment or activity in the classroom. Students completed responses on paper copies, and teachers inputted them into a Google Form, due to a lack of technology in the classrooms at the time of the survey. The questions in this reflection prompted students with checkboxes for which strategies they used, as well as placing themselves on a Likert scale for specific responses.

Our raw data from the student assessment was in the form of numerical responses based on questions providing students with a range of their agreement with prompts, as well as short answer responses from questions asking students about specific strategies related to problem-solving. The numerical responses were analyzed by the two researchers to find how many students had personal ratings that increased, decreased, or remained the same from pre to post-assessment. Criteria categorized the short answer responses based on the commonalities of a random sampling of responses. These criteria remained the same throughout each short response sorting. Researchers compared responses from pre to post-assessment.

Our raw data from the student responses on FlipGrid was in the form of video responses by individual students. The specific researcher involved with those students transcribed their responses. Researchers sorted these transcribed responses into categories of similar responses, which were the same criteria as the short answer responses. The FlipGrid responses were analyzed from situation 1 to situation 4, looking for growth within specific categories, as well as the number of categories mentioned in responses overall.

Our raw data from the student reflection questions were in the form of responses where students checked boxes for all the problem-solving strategies they used. These numbers were then compiled for each student, for each week one through seven. The researchers looked at the number of strategies used in each problem-solving situation from week to week, as well as the average number of strategies used. The personal reflection questions on the student reflection were numerically based on a range of agreeance with prompts. These numbers were sorted by each student, week after week, noticing totals for each response, as well as the average response.

Data was divided into two groups, based on the grade level of the student, and researchers analyzed data for overall totals and averages. Researchers then compiled the data to find the overall percentages of participants that made growth, declined, or remained stagnant throughout the research in all the various components of data collection. Both researchers compiled their data into one common Google Sheet to sort through formulas and coding, allowing researchers to transfer and compare other data collection numbers.

The purpose of this research was to determine the impact of identifying and modeling problem-solving strategies within 5th and 6th grade classrooms. This was done in two separate schools, one a public school, and the other a parochial school both in the suburbs of Saint Paul, Minnesota. This research was completed through pre and post student assessments, student reflections after each problem-solving experiment or activity, as well as student video responses to hypothetical situations. Throughout all of this work, teacher observations were made to support the responses of students and make connections between observed skills and the students' perceived understanding of problem-solving strategies and skills.

Recognition and Utilization of Problem-Solving Skills

The first research question dealt with whether 5th and 6th grade students would recognize and utilize problem-solving strategies in collaborative work settings. To answer this question students completed an assessment prior to the learning period and post the seven-week intervention. Students also responded to hypothetical situations with how they would solve a problem. These responses were collected through an App or a website-based response tool called

FlipGrid. Additionally, students completed a reflection after each problem-solving experiment or activity on a weekly basis, naming which problem-solving strategies they utilized for that situation.

Overall students perceived they used more problem-solving strategies, they demonstrated more problem-solving strategies, and more strategies were observed throughout the research process.

Table 2

Average Number of Problem-Solving Strategies Used

	5th Grade Average Number of Strategies Used to Complete Task	6th Grade Average Number of Strategies Used to Complete Task	Total Participants Average Number of Strategies Used to Complete Task
Week 1	4.33	3.94	4.14
Week 2	3.87	5.00	4.44
Week 3	5.81	5.47	5.64
Week 4	6.04	5.29	5.67
Week 5	6.06	4.76	5.41
Week 6	5.30	4.78	5.04
Week 7	6.21	4.11	5.16

Table 2 shows the average number of strategies used by 5th and 6th graders each week. Students self-selected strategies including understanding the problem, devising a plan, carrying out the plan, revising the plan, looking back at previous work, asking a classmate, asking the teacher, comparing work to a classmates', making connections to other work or knowledge outside of the activity, and collaborating with others. The reflection also had an ‘other’ option where students could write in the other specific strategies they utilized. 5th grade students showed a constant increase in the number of strategies used, in exception to Week 6 where there was a slight decrease in the number of strategies used. 6th graders increased the number of strategies being used faster than 5th grade participants, however this increase became stagnant around Week 3, and declined starting in Week 5.

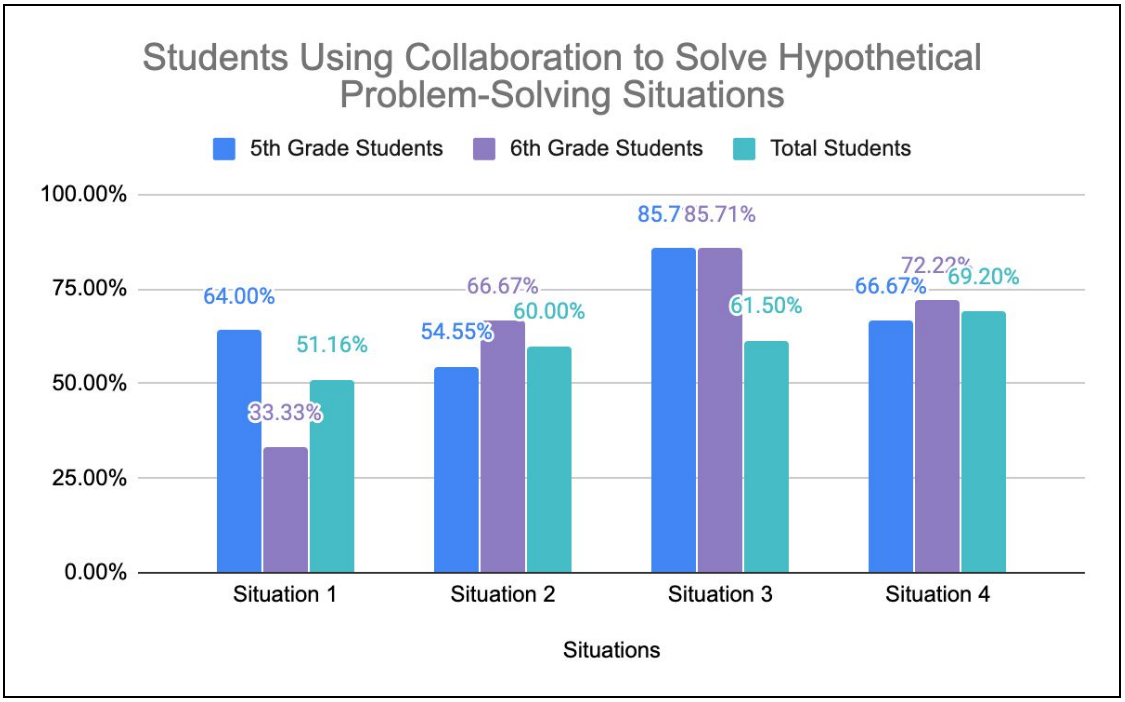

Figure 1

Students Using Collaboration to Solve Hypothetical Problem-Solving Situations

Some students began to use more problem-solving strategies in the responses to the hypothetical situations on FlipGrid. Both 5th and 6th grade students developed the ability to make a plan throughout the process. In Situation 1 only 24% of 5th graders and 66.67% of 6th graders made plans. By Situation 4, 95.24% of 5th graders and 94.44% of 6th graders developed plans, meaning 94.87% of participants overall developed a plan. These plans included the specific problem-solving strategies students would use to navigate the situation. In addition to this increase, the number of students who mentioned collaboration, and working together to problem-solve also increased. This data is shown in Figure 1.

The data from throughout the study showed students utilizing problem-solving strategies within collaborative settings, as well as relying on collaboration to solve problems. The pre and post assessment showed students learned more specific problem-solving strategies to use in these situations. The assessment gave students the prompt, "When faced with a problem, some strategies I use are:" and allowed students to respond with a short written response. In the pre assessment, only 21.43% of participants listed specific skills they would use. In the post assessment, 59.52% of students listed specific problem-solving strategies, and both 5th and 6th grade students showed growth in this regard.

Implementation of Problem-Solving Skills

The second research question addressed the implemented problem-solving skills of 5th and 6th grade students within collaborative group settings. To answer this question, students completed an assessment prior to the learning period and post the seven-week intervention. Students also completed a reflection after each problem-solving experiment or activity on a weekly basis, rating if classmates helped them. Additionally, the two teachers made observations during each experiment and activity, observing group strategies including, asking questions of one another and asking for help from the teacher.

Table 3

Student ranking of importance of problem-solving within a group

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
5th Grade Pre	0	2	6	8	8
6th Grade Pre	0	1	4	5	8
Total Pre	**0**	**3**	**10**	**13**	**16**
5th Grade Post	0	0	6	9	9
6th Grade Post	0	2	1	5	10
Total Post	**0**	**2**	**7**	**14**	**19**

The pre and post assessments asked students about the importance of being able to problem-solve within a group. Students responded on a Likert scale regarding their agreement with the above prompt. Table 3 shows student responses in the pre and post assessment. After the intervention, 33.33% of 5th graders and 16.67% of 6th graders increased their agreeance of the importance of problem-solving within a group with a total of 26.19% of students increasing their agreeance. 54.76% of students kept their agreeance the same from pre to post-assessment.

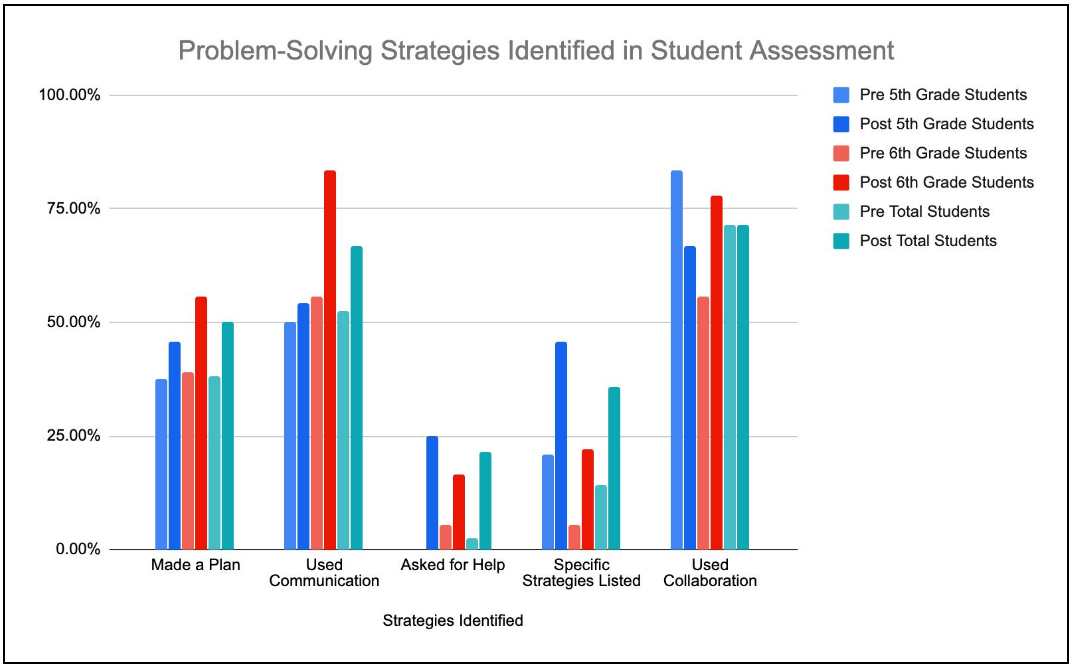

Figure 2

Problem-Solving Strategies Identified in Student Assessment

The assessment asked students, "What are some problem-solving skills and strategies you use when working with groups?" As seen in Figure 2, there was an increase in responses that mentioned making a plan for both 5th and 6th grade students between the pre and post assessment. In the pre-assessment, 38.1% of students mentioned making a plan, and 50% of students in the post-assessment mentioned making a plan. There was a greater increase in 6th-grade students (27.77%) from the pre and post-assessment in regards to communication. Overall, 66.67% of students mentioned communicating in the post-assessment, which showed a 14.29% increase from the pre assessment. Zero percent of 5th graders mentioned asking for help in the pre-assessment, while 25% of 5th-graders mentioned it in the post-assessment, compared to an 11.11% increase in 6th graders from pre to post-assessment. Overall, 21.43% of students mentioned asking for help in the post-assessment, which was a 19.05% increase from the pre-assessment. When listing specific strategies, there was an overall increase by 21.42% from the pre to post assessment. Fifth graders had a greater increase of 25% compared to 6th graders with 16.66% between the pre to post assessment.

When completing reflection questions after each activity or experiment, students were asked if their classmates helped them. Students responded using an agreeance scale. Throughout the seven weeks, both 5th and 6th grade students consistently agreed that classmates helped them during the experiment or activity.

Throughout each experiment and activity, both researchers observed groups within their classrooms. They specifically looked for whether group members were asking questions of one another and if groups asked for help from the teacher. From Week 1 to Week 7, there was an increase in the number of groups who asked questions of one another, with 100% of groups asking questions of one another in Week 7. Only half of the 5th and 6th grade groups over the seven weeks asked for help from the teacher.

Perceived Importance of Problem-Solving Skills

The third research question unpacked 5th and 6th grade students' perception of the importance of problem-solving skills and strategies. In order to answer this question, students completed an assessment prior to the learning period and post the seven-week intervention. Students also completed a reflection after each problem-solving experiment of activity on a weekly basis, rating if they wanted to give up during the activity.

Students ranked their confidence prior to intervention and post seven-week intervention. 62% of 5th graders and 22% of 6th graders reported an increase in confidence, from pre to post assessment. When rating the importance of problem-solving individually, 37% of 5th graders had more of an increase in their perception compared to 33% of 6th graders.

Table 4

Student Responses to Importance of Problem-Solving

	Real-life situations	Mention of importance to learning & success	Not need others	Not having to give up
Pre-Assessment				
5th Graders	37.50%	54.17%	4.17%	37.50%
6th Graders	50.00%	22.22%	27.78%	11.11%
Total	42.86%	40.48%	14.29%	26.19%
Post-Assessment				
5th Graders	45.83%	29.17%	8.33%	50.00%
6th Graders	66.67%	50.00%	11.11%	22.22%
Total	45.83%	38.10%	9.52%	38.10%

Students responded to the question, "Why is it important to problem-solve?" prior to intervention and post-intervention. Table 4 shows student responses. There was an increase in both 5th and 6th grade students who saw the importance of problem-solving for real-life situations. However, less than half of the students mentioned the importance of using problem-solving in real-life situations. Overall, 14.29% of students in the pre-assessment mentioned not needing others to problem-solve versus 9.52% of students in the post-assessment. There was a decrease in both 5th and 6th grade students who mentioned not needing others in order to successfully problem-solve. There was an increase by 11.91% of students who mentioned not giving up from pre to post assessment.

When completing reflection questions after each activity or experiment, students were asked if they wanted to give up. Students responded using an agreeance scale. Students disagreed that they wanted to give up during the experiments throughout the seven weeks. 6th graders strongly disagreed and 5th graders disagreed throughout the seven weeks.

Conclusion

Throughout a seven-week problem-solving intervention, students developed specific problem-solving strategies to use within collaborative settings. Prior to the intervention, students completed an assessment on their personal views and perceptions of problem-solving. Discussion groups were held for students to expand on their responses from the survey. Once research began, each week students completed an experiment or activity where they were required to implement problem-solving skills in a collaborative setting. Students then completed reflection questions where they were to select which skills they used from a teacher-created provided list. Teachers also made observations throughout each experiment or activity to compare to students' perceptions. Additionally, students responded bi-weekly to four hypothetical situations using an online video recording platform FlipGrid, where students were asked how they would solve the problem. At the end of the intervention, students completed the same assessment on their perception of problem-solving and discussion groups occurred.

Throughout the seven-week intervention, we witnessed growth in many aspects of students' learning and problem-solving. Students entered the process hesitant to name and use problem-solving strategies, communicate with peers, or collaborate in their thinking. Throughout the seven weeks, we watched as students implemented strategies they now could identify and became more open to teamwork. Students also had a shift in mindset toward collaborative problem-solving settings and in how they viewed themselves as critical thinkers.

In the classroom, we drew attention to naming specific problem-solving strategies for students to use and allowed for practice in the experiment or activity. From week to week during these collaborative practice sessions, students showed an increase in the number of strategies used. These strategies were not only observed by the teachers, but students identified themselves using them in post-activity reflections. Therefore, we concluded by naming and practicing problem-solving strategies in the classroom students were more able to identify and utilize the strategies within collaborative group settings.

As the seven weeks progressed, we noticed giving students the opportunity to practice and identify problem-solving skills improved their implementation and opinion of importance regarding collaborative settings. From week one to week seven, students increased the number of questions they asked of one another. Students became more collaborative when faced with problems and looked to their partner or peers for assistance. From the pre-assessment to the post-assessment, students identified the benefit of working together and asking questions of others. Additionally, from pre-assessment to post-assessment students increased their ranking on the importance of problem-solving in a group. At the conclusion of the seven weeks, teachers observed more communication and collaboration between classmates. Students also were able to name specific strategies they used to complete their experiment, activity, or hypothetical situation. Overall, allowing students to implement problem-solving skills within collaborative settings increased students' use of skills and developed a more positive outlook on problem-solving with peers.

Throughout the intervention, students' reflections showed an increase in their level of comfort using their own strategies and the skill of utilizing their peers' ideas, and the need for teacher guidance diminished. Fewer students reported the feeling of wanting to give up through the experiment or activity each week. The number of students that identified using 'ask the teacher for help' as a strategy lowered from week one to week seven. The number of students identifying 'compare to a classmate', and 'asked a classmate' strategies increased. From pre-assessment to post-assessment students showed an increase in confidence regarding their problem-solving abilities and the strategies they understand how to utilize. In the post-assessment there was a higher number of students who related the importance of problem-solving to real-world, outside of school situations. From these findings, we conclude that providing collaborative problem-solving opportunities allows students to grow in independence, and confidence in their problem-solving strategies. Due to this work students also developed opinions about problem-solving that allow for positive implementation to their everyday lives.

From our findings, we found that classrooms with collaborative learning improve the development of problem-solving strategies. Knowing this, we have determined what needs to be considered next when preparing learners with 21st Century Skills. Educators will require professional development in order to successfully implement and promote problem-solving skills in their classrooms. The type of professional development needs to be determined in order to best meet the needs of students and their level of development. In determining how to promote problem-solving skills and strategies within classrooms, techniques and curriculum need to be considered for what may be most developmentally appropriate. We have yet to determine the learning curve that follows problem-solving and its development. This investigation may help best determine what curriculum or techniques are best used to foster the development of problem-solving strategies.

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Appendix A
Sample of "Pre and Post Student Assessment"

Student Assessment

Completion of this survey is voluntary. By completing this survey, you are giving your consent to participate in this study. Completing this survey is completely voluntary and you may quit at any time. Answer each question, and provide as much information as you can on the open-ended questions. It is important to be honest in your answers because I will use the information you provide to help me plan for future lessons. Thank you for helping me with this important project.
* Required

1. Name: (First and Last) *

____

2. School: *

Mark only one oval.

◯ School 1
◯ School 2

3. My confidence in finding solutions to problems I face is: *

Mark only one oval.

	1	2	3	4	5	
Not confident at all	◯	◯	◯	◯	◯	Extremely confident

4. Why is it important to know how to problem-solve? (Think about in school and outside of school) *

____
____
____
____
____

5. How often am I challenged to find solutions to new problems at school: *

Mark only one oval.

	1	2	3	4	5	
I am never faced with finding a solution	◯	◯	◯	◯	◯	I have to problem solve everyday

6. How often am I challenged to find new solutions to new problems outside of school: *

Mark only one oval.

	1	2	3	4	5	
I am never faced with finding a solution	◯	◯	◯	◯	◯	I have to problem solve everyday

7. When faced with a problem, some strategies I use are: *

____

8. It is important to problem solve by myself *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly Agree

9. It is important to problem solve in a group

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

10. How well do I work with others when in a group? *

Mark only one oval.

	1	2	3	4	5	
I do not work well with groups	◯	◯	◯	◯	◯	I work exceptionally well with groups

11. What are some problem-solving skills and strategies you use when working with groups? *

Appendix B

Sample of "Pre- and Post-Discussion Questions"

Students in Discussion Group: ___________________________ Date: _______________

Pre	Post

Do you prefer learning on your own, listening to class lectures or working in a collaborative group?

When faced with a problem, what steps would you take to find a solution?

What problem-solving strategies have you learned about or practiced in school?

In what ways is learning in a collaborative group different than learning in other ways?

How does working in collaborative groups affect your ability to problem-solve?

What do your teachers do (or not do) to help you practice using problem-solving strategies?

How could I, as the teacher, improve your ability to problem-solve while working in a collaborative group?

What helps you learn how to use problem-solving strategies best? (If clarification is needed: modeling, lectures, hands-on activities, etc.)

Appendix C
Sample of "Problem-solving Situational Responses"

FlipGrid Hypothetical Problem-Solving Situations

- Students will be provided a hypothetical situation and respond on how they would solve it using video recording on FlipGrid.

Situation 1: You are working on a group project in class. Your grade is based on your contribution to the group. There is one person in your group that wants to control everything. They are very difficult to work with. How could you solve this problem? What steps would you take?

Situation 2: Your class is working on answering the question to a science investigation. Your group is responsible for figuring out a plan to guide your experiment to find the solution. Your group members cannot agree on how to conduct the experiment. What could you do to help your group conduct a successful experiment? What steps would you take?

Situation 3: You are working on a group project in class. One of your team members enjoys hearing themselves talk. They dominant the discussion and expect everyone to listen to them. This person is not the assigned leader of the problem-solving team. How could you solve this problem? What steps would you take?

Situation 4: Your class has been chosen to design the new school garden. Each student is responsible for part of the design, and the class will vote on their favorite parts to include in the garden. What steps will you take to create your garden design? How will your planning and process show your classmates the quality of your design?

Appendix D
Sample of "Student Written Reflection Questions"

I used the following strategies when solving this problem: (Check all that apply)

__ Understood the Problem
__ Devised a plan
__ Carried out plan
__ Revised plan
__ Looked back
__ Asked a classmate
__ Asked the teacher
__ Compared to a classmate
__ Made a connection to something I already knew
__ Worked with a partner
__ Worked with a group
__ Other: Explain-____

____

This task was challenging: (Circle)

Strongly Disagree Disagree Neutral Agree Strongly Agree

At one point, I wanted to give up: (Circle)

Strongly Disagree Disagree Neutral Agree Strongly Agree

I felt that my classmates helped me during this activity to solve the problem: (Circle)

Strongly Disagree Disagree Neutral Agree Strongly Agree

Appendix E
Sample of "Observational Data Collection Checklists"

Individual Student Skill Identifier

Student Name	**Date/Behavior**	**Date/Behavior**	**Date/Behavior**	**Date/Behavior**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
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21				

23				
24				
25				

Problem Solving Strategy Abbreviations			
OEQ: open-ended questions	MS: multiple strategies	CAW: Comparing Answers/ work	AH: Asking for help

Collaborative Work Checklist

Activity: ____Date: ________________________

Behavior	Group 1	Group 2	Group 3	Group 4
All members actively participate.				
Group members ask questions of one another.				
Members elaborate on their ideas when other members ask questions.				
Students compare strategies, work and/ or answers with each other.				
Students ask the teacher for help when needed. (Note when during the process help was asked for- Beginning, Middle, End).				