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## Journal of Teacher Action Research

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Determining the Effects of Cooperative Problem-Solving in a High School Physics Setting on the Students' Confidence, Achievement, and Participation Sarah M. Gagermeier	4
Improving High School Students' Understanding of Quadrilaterals by Using Pre-Constructed Diagrams of Geogebra Kelly A. Steffen Matthew S. Winsor	20
Social Imagination Project: Fostering Empathy in Pre-Service Teachers by Reading Children's Books Featuring Characters Who Have Disabilities Shelly Furuness Kellie J. Esteves	40
Engaging With Play-Based Learning Rebecca Anderson Herbert Thomas	56
Revisiting School Science Curriculum Through School Gardening Participatory Action Research Project in Nepal Kamal Prasad Acharya Chitra Bahadur Budhathoki	69
Using PREP, a Primary Reading Engagement Program, to Motivate Primary Struggling Readers Jeannie Votypka	90
Teaching Mathematics with Music to Young Children and Connecting Families Smita Guha	114



## About the Journal

Founded in 2013, the Journal of Teacher Action Research (ISSN: 2332-2233) is a peer-reviewed online journal indexed with EBSCO that seeks practical research that can be implemented in Pre-Kindergarten through Post-Secondary classrooms. The primary function of this journal is to provide classroom teachers and researchers a means for sharing classroom practices.

The journal accepts articles for peer-review that describe classroom practice which positively impacts student learning. We define teacher action research as teachers (at all levels) studying their practice and/or their students' learning in a methodical way in order to inform classroom practice. Articles submitted to the journal should demonstrate an action research focus with intent to improve the author's practice.

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# DETERMINING THE EFFECTS OF COOPERATIVE PROBLEM-SOLVING IN A HIGH SCHOOL PHYSICS SETTING ON THE STUDENTS' CONFIDENCE, ACHIEVEMENT, AND PARTICIPATION

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**Abstract** The aim of this study was to establish if the Cooperative Learning method of problem-solving had any effect on high school physics students' achievement, participation in class, or confidence levels. A quasi-experimental research design that utilized both quantitative and qualitative methods of data collection was developed and applied to Honors and grade-level Physics classes comprised of upperclassmen in a high school on the eastern shore of the United States. Research data was collected using pre and posttests, surveys, student worksheets, and observations. During this study, both intervention groups received instruction on, and completed, multiple iterations of, the Cooperative Learning problem-solving activity during the two-dimensional force's unit. Control groups for both ability levels received conventional instruction and were given the same pre and posttests as the intervention groups. The honors intervention group was found to have an increased average post test score when compared to their control group; however, the grade-level group showed a slight decrease in achievement that was likely a result of minimal scaffolding. Both honors and grade-level students demonstrated improvements in participation and confidence as a result of the intervention. According to the data, the cooperative problem-solving activity was beneficial and superior to conventional teaching tactics for Honors students in terms of achievement, confidence, and participation. However, this activity would require further scaffolding and a higher degree of modeling for grade-level classes to be as successful for those students.

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**Keywords:** teacher action research, cooperative learning, physics, secondary education, problem solving, critical thinking

## Introduction

The Cooperative Learning Method (CLM) encourages student communication, is inquiry based, and allows students to practice giving and receiving criticism in the classroom. Being heavily grounded in mathematical application, physics requires strong critical thinking skills in order to properly plan and execute a solution to free response questions. Students new to the subject consistently struggle to build up confidence in their problem-solving abilities and their work is often lacking the required steps and logic needed to show mastery of the content. This paper

will investigate if the application of the CLM, when utilized to instruct secondary physics students at both the honors and grade levels, will affect student achievement, confidence in problem-solving, and participation levels. Further, it will address the possible effects on student perseverance during solving. More specifically, this action research will seek to answer the question: how does implementing a Cooperative Learning technique to teach problem-solving affect high school students' confidence, participation and achievement on free response word problems in physics?

In order to investigate this research question, a CLM intervention was developed and applied to honors and grade-level physics classes comprised of upperclassmen in a high school on the eastern shore of the United States as an action research project. The intervention lasted approximately one month, and had multiple purposes. The first was to make a concerted attempt at a solution to the lack of engagement with and respect for the problem-solving procedures required in a physics setting. Year after year, nearly every student lacked the understanding of *why* the process was so important and did not feel they should have to show their work. In addition, students would constantly be complaining that they “don’t know how to start” yet would refuse to see the value in the structured process that answered that question for them before having to ask their teacher for every single question listed on a practice sheet. This was a clear indication that their confidence levels were not where they needed to be. Complaints like this are common in nearly every physics unit, however, the worst of it occurs in the two-dimensional forces section, in which students need to use systems of equations and Newton’s Second Law in two dimensions. Getting students motivated to solve these challenging problems and convincing them that problem-solving was essential was becoming an uphill battle that made teaching less enjoyable each semester. Another motivator for implementing this intervention in the classroom was to combat the negative outcomes on assessments students were experiencing as a result of not showing their work. Students who were regularly not practicing good solving techniques in class struggled to recall how to solve when given a similar problem on an assessment. As a result, final scores for the first several unit tests were not where they should be after all the practicing and modeling that had occurred in class. In addition to that, managing makeup tests and remedial work to continue student growth after the unit commenced was becoming a second job for an already busy high school teacher. The third purpose, as action research, was to allow for self-reflection and continued growth as an educator. This intervention lasted approximately one month, and provided an opportunity to determine if the application of cooperative learning methods in a secondary physics classroom, a proposed solution to the struggles being faced, was a superior approach to the more current method of high-volume solving being used, in which students solve several problems with similar goals and structures.

## Literature Review

Understanding and valuing the problem-solving process is essential to success in physics. Physics is the language of engineering; it includes a myriad of variables, symbols, and challenging real-world applications. Even simple phenomena that we experience in everyday life is much more complicated in physics than it appears to the naked eye. For example, a car

turning on an exit ramp is something many of us experience while commuting each day, yet the physics for this requires solving multiple equations and factoring in several variables such as friction, air resistance, and angle of incline. Utilizing a structured planning process helps students organize information in order to find the most efficient solution to any problem they encounter.

According to Gok and Sitlay (2010), experienced solvers store information in terms of overarching topics; working a problem involves planning and drawing on their conceptual database in order to determine the most direct pathway to the solution. Novices are prone to memorizing concepts in terms of units covered in class and are more concerned with the final answer than the solving process, which is referred to as a means-end approach (Doktor et al. 2015). At face value, this may seem like two different approaches to solving a problem with no real detriment to the novice, as the goal *is* to find the answer when problem-solving. However, this surface level cognition of concepts causes students to “engage in a host of undesirable behaviors” in regards to their problem-solving techniques when faced with real-world questions (Gok & Sitlay 2010, p.11). Many students will not know where to begin and give up at that point, claiming the question is impossible. This is particularly difficult and frustrating to manage as a teacher when the same students claiming the problem-solving techniques being taught are useless and annoying are quickly giving up the second their own tactics fail them during solving sessions. CLM can be used to increase their confidence and familiarity with the process of solving, and well as encourage students to learn from their mistakes. This results in improved communication skills, provides positive experiences with constructive criticism, and offers opportunities for students to embrace more structured methods of solving, all of which benefit a student’s confidence and achievement in class.

Confidence and participation in sciences are significant concerns as, over the last three decades, students’ perceptions of science have become increasingly negative during middle and high school (Gok & Sitlay. 2010). CLM can help combat this by encouraging students to build stronger relationships with peers. In an action research study with chemistry students, researchers found that these methods helped the students foster a feeling of comradery in the classroom which lead to improvements in achievement and student communication (Kreke & Towns, 1998). Another study conducted with over 400 college students in a biochemistry course found that students who participated in the cooperative learning group scored higher on assessments than their peers in the group that received traditional problem-solving instruction (Anderson, 2005). CLM activities promote all of the skills needed to become a critical thinker, good communicator, and a detail-oriented solver in the twenty-first century world of STEM.

## Methodology

The research followed a quasi-experimental, mixed methods design that utilized both quantitative and qualitative data points. Using both methods of data collection allowed for flexible analysis and a comprehensive study of the students. This multifaceted design facilitated clear triangulation of data.

*Samples and Settings.* The setting of the research was an eastern shore high school in the United States, with approximately 1,200 students. A detailed breakdown of student demographics can be found in *Table 1*. Both honors and grade-level physics students participated in this study. The expectations of work for each level varies; at the honors level, students are pushed to move at an accelerated pace, are provided with additional challenge problems, and are expected to use more complicated mathematical applications. In a grade-level course, the students still cover the same content as the honors course but are provided more leading questions to help them problem solve. Where an honors student would be expected to be given a single problem statement and be able to recognize the need to use something like a quadratic equation or systems of equations to solve, the grade-level student would be given a problem with steps broken down as question parts and would have a flow chart to help them through the steps of a systems of equations problem. The control groups and intervention groups were determined by who signed up for the courses during a particular semester. The control group members were enrolled in the course in the semester prior to the intervention group. As this study was conducted in a public-school system, there was no way to create a true random assignment of participants, which is why the experiment type is identified as quasi-experimental.

*Table 1: Demographics of Control and Intervention Groups*

GROUP	HONORS CONTROL	HONORS INTERVENTION	GRADE LEVEL CONTROL	GRADE LEVEL INTERVENTION
TOTAL NUMBER OF STUDENTS	28	26	17	13
MALE STUDENTS	16	18	11	8
FEMALE STUDENTS	12	8	6	5
GIFTED STUDENTS	16	16	4	0
FREE AND REDUCED MEALS	2	2	2	3
AFRICAN AMERICAN STUDENTS	1	1	0	0
LATINX STUDENTS	1	2	0	0



<b>CAUCASIAN STUDENTS</b>	26	23	17	13
<b>IEP/504 PLANS</b>	0	0	5	2

The content knowledge for this unit, which was two dimensional forces, was taught in the same manner for both the control and intervention groups. However, in the control groups, students were given the practice problems to complete on their own as homework. Though they had the option to work with their peers, many of them choose to work alone and often completed the work outside of the classroom. In the intervention group, the problem-solving practice utilized CLM to create a structured, group solving environment in which students were encouraged to talk about their ideas and process of solving with their peers. The main difference between the control and intervention groups was the method in which they practiced their problem-solving and worked with their peers. Students were placed in groups of three to four people where they were given one of the following roles:

1. **Planner** - this student is responsible for reading the problem, creating a list of given quantities, identifying unknowns, and setting up a labeled diagram.
2. **Math Master** - This student is responsible for picking an equation based on the Planner's setup and creating an expression for the unknown variable in terms of known quantities.
3. **Solver** - This student is responsible for plugging in all numbers and units into the equation and a final answer with units, as well as a justification for that answer.
4. **Project Manager & Scribe** - This student is responsible for reviewing all work and will write everything down on the group whiteboard.

These roles were formulated based on key problem-solving steps required to setup and execute a free response problem. The role of the Scribe was intentionally added to this list in order to encourage communication with peers. Groups of three had the Math Master and Solver roles combined as these two roles are similar and therefore easy to merge if needed. Each group was assigned a different problem, was given time to complete the problem on the group board, then asked to present it to their peers after completion. After the presentation, other groups were permitted to asked clarifying question of their peers if needed. Groups were rotated each week; this procedure was suggested by Gok and Sitlay (2010) to ensure students would gain experience and build relationships with a larger percentage of their classmates. The teacher's role was to remain as much of an observer as possible.

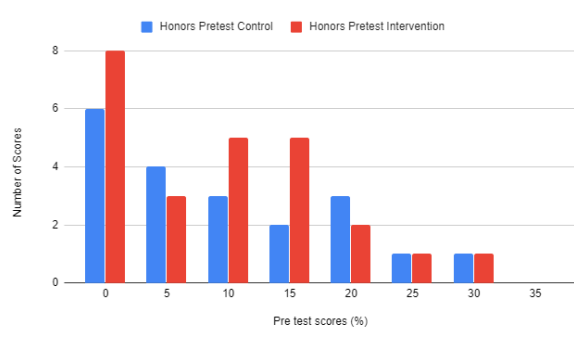
This type of intervention activity occurred two to three times per week over the course of a month, which is the time it takes to cover the two-dimensional forces unit. In the control group, these days were provided to students as individual problem-solving time to get their practice completed. When the intervention was not being completed, students were either participating in lectures, labs, or other class activities just as the control group did. The only difference in teach strategy from the control group to the intervention group was the application of the CLM intervention activity in place of individual solving time.



**Data Collection and Analysis.** To collect data, students were given a pre-survey and pre-test before the initiation of the intervention. They completed this survey and test again at the conclusion of the intervention in order to evaluate if there were any significant changes. Both the survey and the problem-solving assessment were given under testing conditions in the classroom. The survey asked students to reflect on their current attitudes towards physics and problem-solving, how they felt about group work versus individual work, and if they thought this process was helpful or hurtful to their understanding. This data was instrumental in understanding the students' point of view of the intervention as it showcased their perceptions of personal classroom achievement, confidence levels, and participation levels. The pre- and post-tests were structured as a classical unit assessment with multiple choice questions, free response questions, and essay questions related to the content covered during the unit. During CLM intervention sessions, groups were observed for a few minutes at a time while working and significant behaviors such as participation level, asking higher order thinking questions of their group members, being too controlling/passive, or even responses to criticism were noted. Students were not aware that they were being watched or listened to intently in order to keep the conversations and interactions more natural. In addition, student work samples were collected by taking pictures of the group whiteboard after each round. Average posttest scores were compared to pretest score to determine growth, and to the control groups posttest average to determine achievement. T-tests were completed to verify the results of the quantitative data. For student surveys and observations, the transcripts, responses and notes were reviewed multiple times in order to identify patterns and key phrases. This qualitative data was essential to the investigation into any changes in participation and confidence.

## Results

**Pretests and Posttests.** In order to determine if the control groups for both levels were at a comparable starting point as the intervention groups, histograms of the pretest scores were made, as can be seen in *Figures 1 and 2*.



*Figure 1: Honors Pretest Control vs. Intervention Scores*

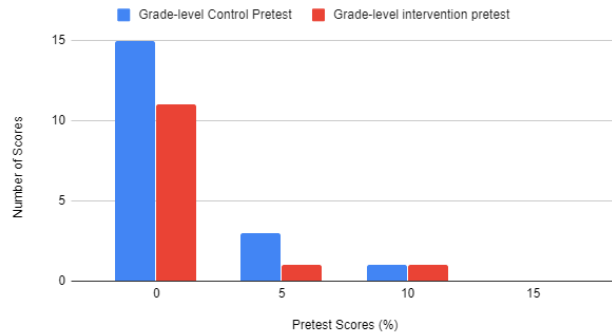


Figure 2: Grade-Level Pretest Control vs. Intervention Scores

Additionally, the 26 participants in the honors intervention group ( $M = 11.13\%$ ,  $SD = 3.52$ ) when compared to the 28 participants in the honors control group ( $M = 11.80\%$ ,  $SD = 4.4$ ) demonstrated no significant difference,  $t(52) = 0.24$ ,  $p = .406$ . Similarly, the 13 participants in the grade-level intervention ( $M = 2.96\%$ ,  $SD = 0.48$ ) when compared to the 18 participants in the control group for grade-level physics ( $M = 3.38\%$ ,  $SD = 0.71$ ) demonstrated no significant difference,  $t(28) = 0.45$ ,  $p = .326$ .

Figures 3 and 4 show histograms that were made in order to compare both levels intervention and control groups posttest scores.

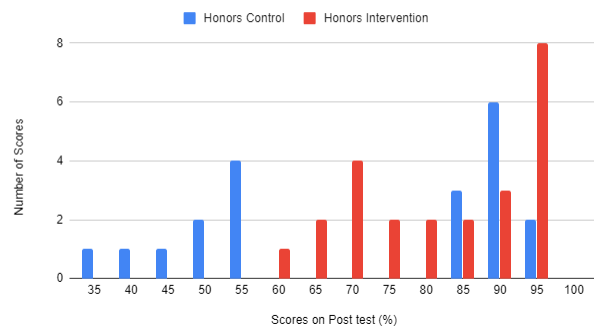
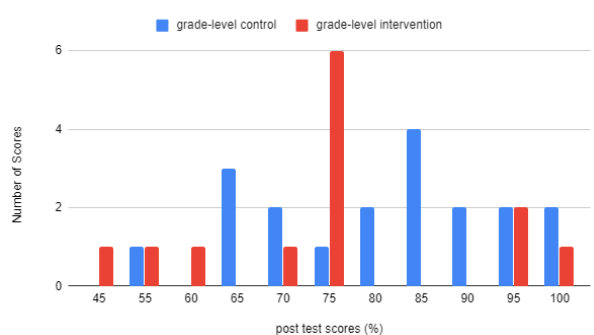


Figure 3: Honors Posttest Score Control vs. Intervention



*Figure 4: Grade-Level Posttest Scores Control vs. Intervention*

The 26 participants in the honors intervention ( $M = 83.67\%$   $SD = 2.166$ ) when compared to the 28 participants in the honors control group ( $M = 73.25\%$   $SD = 4.195$ ) demonstrated a significant increase in achievement on the assessment,  $t(52) = -2.05$ ,  $p = .046$ . However, the 13 participants in the grade-level intervention ( $M = 76.42\%$   $SD = 4.182$ ) when compared to the 18 participants in the control group for grade-level physics ( $M = 66.42\%$   $SD = 2.898$ ) demonstrated a slight so significant difference on the post test scores,  $t(28) = 1.33$ ,  $p = .193$ . Though the results for the honors class were significant and likely caused by the intervention, the results for the grade-level class were minor and cannot conclusively be determined to be the result of the intervention. To ensure that both classes demonstrated growth as well, the pre and posttest scores were compared. Based on the average scores for the assessments, there was clear growth in both courses from pre to post test. In terms of achievement, it can be determined that higher ability level students benefit greatly from the application of CLM during problem-solving. However, grade-level students may need more scaffolding or modeling in order for the activity to be as successful in improving their achievement.

*Surveys.* All students in both intervention groups completed pre- and post-surveys. The questions were designed on a Likert Scale with one being “strongly disagree” and five being “strongly agree”. These questions can be found in Appendix A. The differences between responses for each question from the pre to the post survey for both honors and grade-level physics were calculated and graphed in *Figures 5* and *6*. Additionally, the responses from the last question on the post survey, which was an open-ended question asking students to reflect on their experience, was coded and results were entered into *Table 2*.

According to *Figure 5*, the students in the Honors class showed a decrease after the post survey for question one, which asked about their work ethic or how committed they remain to solving a question when they got “stuck”. They demonstrated no change for question three, which asked if they felt problem-solving in a group was the most effective way to learn about solving. Honors students increased for questions two, four, five, six, and seven which were related to the importance of problem-solving skills to success in physics, feeling rewarded when they get a question correct, ease of connections to concepts, their confidence levels, and participation levels, respectively. The most notable increase for the Honors class was in question seven in relation to class participation.

According to *Figure 6*, the grade-level class exhibited a decrease in questions one and three, which asked about work ethic and if group problem solving was the best way to learn about problem solving practices, and showed increases in all other inquiries. The largest magnitude of change occurred with question two, in relation to how important students felt problem solving ability was to success in physics.

## Discussion

Looking at all of the data collectively, it is apparent that the honors class significantly benefitted from the CLM intervention in multiple areas. A comparison of average posttest scores between

the intervention and control groups shows an increase of over 10%, which can be further verified in the positive shift of the distribution of scores in *Figure 3*. Comparing the pretest to posttest score average for the honors intervention group shows a 72% increase, which clearly demonstrates significant growth in their understanding and application of two-dimensional forces. A main concern for this action research project was that students achieved a higher level of comprehension in a section that was becoming cumbersome and tedious to manage. Based on the findings and data, it is obvious that the action research successfully improved the achievement level of the honors intervention group.

In stark contrast to this is the data for the grade-level course. These students consistently struggled throughout the month-long intervention and, while they may have shown improvements in other areas, the data does not show significant changes to student achievement and comprehension. This result is apparent when comparing their scores on the posttest to those of the control group. Additionally, the distributions in *Figure 4* did not change from the control to the intervention group, which further confirms that this intervention did not significantly impact their achievement. Because the p-value was above the accepted 0.05 guideline, the numerical data alone cannot confirm the intervention itself is the cause of the slight decline in average score. However, the qualitative result from teacher observations and student reflections allowed for a clearer understanding of why their achievement was not significantly affected. The following is a quote from one student in the grade-level class.

“I felt like it was easy to do and [the cooperative problem solving] made it so that you did not have to do as much work alone, but I depended too much on my other group members to fix my mistakes without really learning from them and sometimes let them do my work for me because I did not know what to do. I wish I had put more time into it because then I think the test would have gone better for me.”

This exemplifies the point that, while some students were aware their actions were harmful to their performance on the test, at the time of the intervention they did not utilize the process to their benefit. Towards the end of the intervention there were some students in the grade-level class refusing to participate, leaning too much on group members to do the majority of the work, or simply refusing to follow the guidelines of the activity regardless of punishment, loss of points, or teacher intervention.

This may also indicate that grade-level students need more modeling and scaffolding when it comes to CLM problem-solving activities in class. Another solution could be to provide more time to complete this unit on two-dimensional forces and to provide greater diversity in problem-solving techniques. While consistently repeating a similar activity may bring comfort to honors students, it seemed to bore and frustrate grade-level students. Further research into how CLM can be adapted or adjusted to meet the needs of grade-level students should be conducted in the future.

With regard to confidence levels, the CLM increased and supported confidence levels in most students for both groups. Question six on the surveys asked the students to rank their confidence levels on a scale of one to five, with one being very low confidence and five being very high. According to *Figure 5*, honors students showed a 0.5 increase in this area while

Figure 6 shows grade-level students had a 0.8 increase here. Though these increases were not as high as one would expect, the qualitative data in *Table 2* provides deeper insight into the situation. Students in both classes claimed they felt supported by their classmates when they obtained the same answer as a peer. Because they were in a group with multiple sources of inputs, when their answers matched their classmates, they received instant confirmation and gratification, and likely felt more self-assured in the next session.

During the observations, it was noted that more students were stepping up to speak, had more direct speaking tones, and were engaging in on-topic discussion with peers. Students were asking for assistance from each other prior to asking for assistance from me, which was a main issue I had hoped to address at the start of this process. Although this did not guarantee that the students always had the correct answers, it did demonstrate that they were more likely to take risks in the classroom and felt confident enough in themselves and their abilities to answer questions.

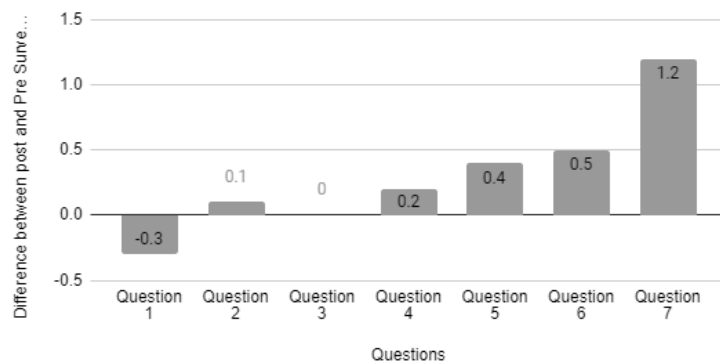


Figure 5: Difference Between Honors Pre and Post Survey Responses

The increased confidence levels of both classes are directly linked to participation. Students who were feeling more confident seemed more likely to participate in class at an increased rate without having to be cold called. Further, the students were more inclined to start discussions after a student volunteered and answer with little teacher intervention or encouragement. According to *Figure 5*, students in the Honors class increased on question seven, in relation to their participation levels, by 1.2 points. This is the largest increase for this class outside of their achievement and was further reflected in teacher observations of classroom behavior. During the last week of the intervention the following quote was written in the teacher observation notes:

“I have not needed to pull names out of the popsicle stick cup over the last two weeks for this class which is notable as I had to depend on that method of student participation for nearly every question I have asked them since the start of the semester.”

This intervention gave the students an increased exposure to their classmates and made them feel more comfortable speaking out as they had gained experience with nearly every person in

the room. Some students claimed that, if their confidence levels were low enough to start with, it was difficult to argue your point or know if you should argue at all, as seen in *Table 2*. Although they may have had low confidence, this did not mean that they also had the lowest ability level. Often students with high ability level were still unsure of themselves. Repeated practice and thorough review of the problem-solving utilized in the CLM activity helped students identify mistakes, build on their critical thinking skills, and develop a logical sense of progression for solving any type of problem in physics with confidence that the process will work.

*Table 2: Open-ended Post Survey Responses for honors and grade level physics*

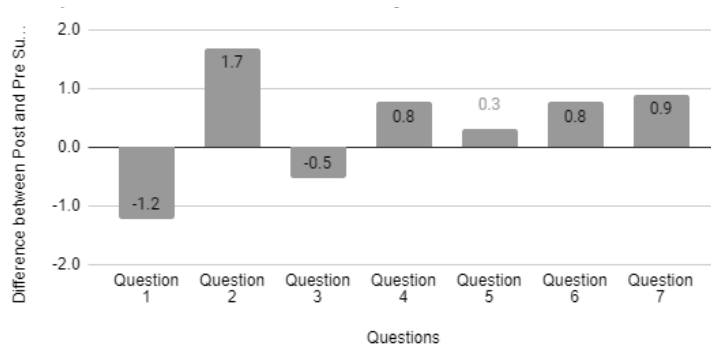
TOPIC/IDEA EXPLICITLY MENTIONED IN RESPONSE	% OF RESPONSES WITH THIS TOPIC—NUMBER OF STUDENTS	EXAMPLE OF STUDENT RESPONSES
IMPROVEMENT IN PROBLEM-SOLVING ABILITIES	88% honors – 22 students 76% grade level – 10 students	“I thought I was understanding what I was doing at the beginning but I was not used to the process. Now that we have done it so much it feels like second nature to me.” – <i>Grade Level Physics</i>  “Everything has increased for me. When I went into the AP class at the start of the year I had no clue what I was doing so I dropped down to grade level physics. When I got into the class I learned the problem-solving procedure and then I could do what I thought impossible.” – <i>On Level Student</i>
INCREASE IN CONFIDENCE	56% honors – 14 students 69% grade level – 9 students	“I believe my confidence and participation have increased since working collaboratively because having the same answer as group members felt rewarding.” – <i>Honors Student</i> .

**LOW CONFIDENCE IN  
COMMUNICATION/GROUP  
DYNAMICS**16% honors – 4  
students15% grade level – 2  
students

“I thought this activity was difficult because I had low confidence to begin with. So when someone came up with an answer that was different than mine I did not know if I should argue for or against them.” - *Honors Student*

“I did not like having the whole group graded as one, even though it was a very low number of points, because if someone in your group made a mistake and you were not able to convince others to change it, then it became frustrating.” - *Honors Student*.

From a teaching perspective, the choice to rotate groups was very beneficial, as it served the educational purpose of increasing student discussion with others and likely had a direct effect on their confidence and participation. Further, I found students often looked forward to finding out who they would work with next. However, from a research standpoint, this decision may have decreased the validity of the study as one grouping could have been preferable to another. Although it is unclear the true effect it had on validity, this decision brought to light a plethora of questions about grouping benefits for future action research.



*Figure 6: Difference Between Pre and Post Survey Responses for Grade-Level Physics*

According to Figure 6, the grade-level class increased their participation by 0.9. Observations also confirmed that some students were improving, however, the following comment made in the teacher log explains the disparity between participation levels in the room.

“Students are either heavily participating and supremely engaged or they are outright refusing to participate. There seems to be no middle ground in the grade-level class. Clearly this intervention is a major success for some but two students are consistently not being reached by this activity.”



Because the class was so small, two students made up 15% of the class. These students were clearly honest in their survey answers, both accurately stating that their participation level was a one out of five, which leads me to feel that their results on the post survey are valid and a good representation of their true efforts in class. More support and time to establish clear expectations may alleviate this in future applications of the activity.

## **Limitations**

Any good study or action research project still has its limitations and challenges and this study is no different. For example, since the courses are populated by the students who signed up to take it there was no way to get a true randomization of subjects. This also meant that I was unable to decide how many students would be in each group, which caused some issues in the smaller class sizes where only a few students can make up a significant percentage of the class. Further, the inconsistent number of students per class meant that the ideal grouping of three students was not always able to meet. In larger classes, some groups needed four students to avoid having groups of less than three, where it was likely that one would become more dominant and take over.

In regards to the surveys, though they proved to be essential in further analyzing quantitative data, they were also limited in some aspects. For example, students were asked if they felt their confidence had changed, and they were able to respond with either a positive or negative change, as well as remaining neutral. What they were unable to communicate, unless they made a point to do so in their open-ended reflection, was in what area they felt more confident in. Some students may have felt that their confidence in class discussions went up, but may not have felt a change in their individual abilities, or vice versa. More time to implement an intervention of this size, with four different groups and large data sets, would have also been beneficial.

## **Conclusion**

The question I sought to answer with this action research project was: how does implementing a Cooperative Learning technique to teach problem solving affect high school students' confidence, participation and achievement on Free Response word problems in Physics? Based on the findings and discussion sections, I feel that this project successfully answered that question for honors physics students, however, there is still much work to be done in regards to meeting the needs of the grade-level students. This information can prove to be useful for others when considering activities to implement in their classroom in order to diversify how students engage with problem-solving in physics, or any other math intensive course. Additionally, this research can provide a good starting point for others who are seeking to investigate student learning problems in regards to achievement, confidence, participation, or even class grouping.

In the future, I would like to investigate how grouping can affect grade-level students, and what other possible interventions may prove beneficial to them in regards to achievement,

confidence, and participation in class. Further, I hope to study how this could potentially affect males and females in the classroom differently, as gender imbalances in physics have always been a personal interest of mine since I experienced it myself in college. I hope to continue to learn and grow through action research as an educator in order to provide the best possible learning environment for my students. Though this process may be difficult and a lot to take on at times, in the end it is worth it to feel like you can make actionable change in your classroom.

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### About the Author

**Sarah Gagermeier** teaches Physics and AP Physics Mechanics C at a rural high school in Maryland. She received her undergraduate degree in Secondary Education Physics from The Pennsylvania State University and is set to finish her Master's Degree in teaching Science, Technology, Engineering, and Mathematics from the University of Maryland at Baltimore County within the next year. In the future she hopes to continue her studies with an additional Masters in Physics and Mathematics. She has committed much of her time and research to the advancement of women and girls in the field of physics and engineering. Her hope is to inspire many more young women to enter a physics career path. Email: [smg72795@gmail.com](mailto:smg72795@gmail.com)

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### **Appendix A: Questions from Student Survey**

When faced with a challenging problem I work at it until I have the correct answer.

(1) Strongly Agree, (2) Agree, (3) Neutral, (4) Disagree, (5) Strongly Disagree

I think problem-solving is an important strategy for physics class.

(1) Strongly Agree, (2) Agree, (3) Neutral, (4) Disagree, (5) Strongly Disagree

I think solving problems collaboratively (in a small group where everyone has an individual role/responsibility) more often is the best way to learn and practice.

(1) Strongly Agree, (2) Agree, (3) Neutral, (4) Disagree, (5) Strongly Disagree

It feels rewarding to get an answer correct while problem solving.

(1) Strongly Agree, (2) Agree, (3) Neutral, (4) Disagree, (5) Strongly Disagree

I have difficulty connecting the content to the problem solving.

(1) Strongly Agree, (2) Agree, (3) Neutral, (4) Disagree, (5) Strongly Disagree

My confidence in my work and answers in this class is

(1) Very Good (2) Good (3) Neutral (4) Poor (5) Very Poor

I regularly participate in class discussions and activities, speaking out in class at least once or twice per day.

(1) Strongly Agree, (2) Agree, (3) Neutral, (4) Disagree, (5) Strongly Disagree