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## Journal of Teacher Action Research

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## 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

**Sarah M. Gagermeier**

**The University of Maryland at Baltimore County**

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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.

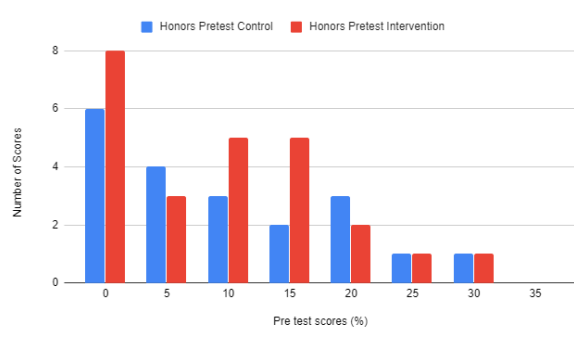
This type of intervention activity occurred two to three times per week over the course of a month, which is the time it takes to cover the two-dimensional forces unit. In the control group, these days were provided to students as individual problem-solving time to get their practice completed. When 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*

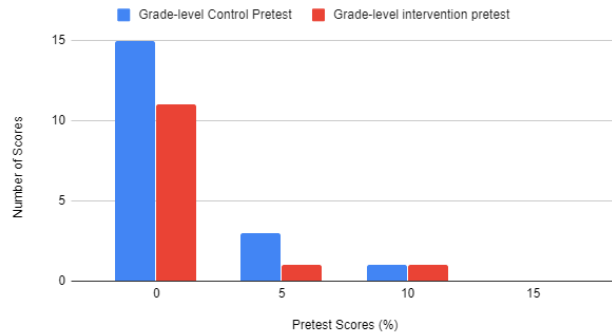


Figure 2: Grade-Level Pretest Control vs. Intervention Scores

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.

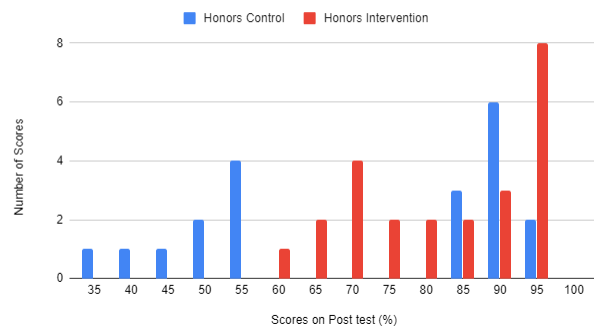
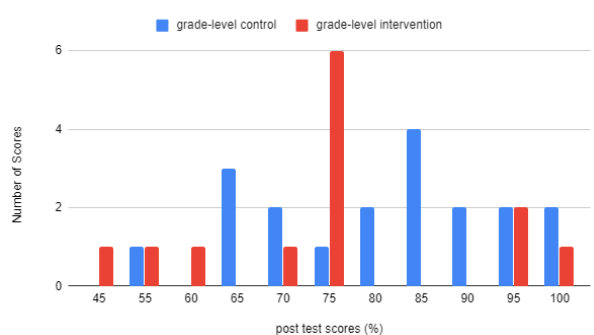


Figure 3: Honors Posttest Score Control vs. Intervention



*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.

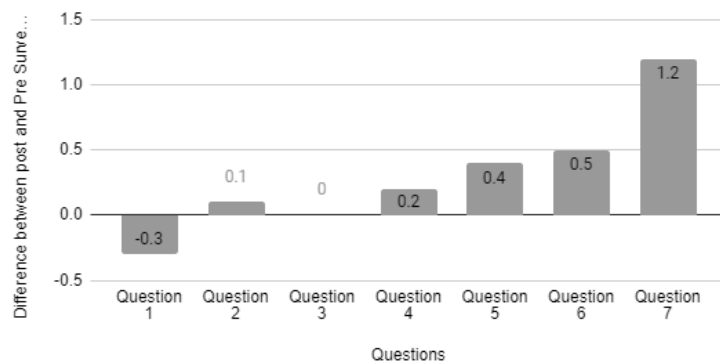


Figure 5: Difference Between Honors Pre and Post Survey Responses

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*

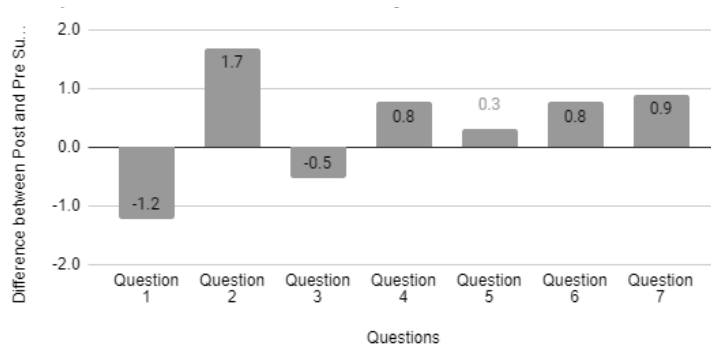
TOPIC/IDEA EXPLICITLY MENTIONED IN RESPONSE	% OF RESPONSES WITH THIS TOPIC—NUMBER OF STUDENTS	EXAMPLE OF STUDENT RESPONSES
IMPROVEMENT IN PROBLEM-SOLVING ABILITIES	88% honors – 22 students 76% grade level – 10 students	“I thought I was understanding what I was doing at the beginning but I was not used 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

# IMPROVING HIGH SCHOOL STUDENTS' UNDERSTANDING OF QUADRILATERALS BY USING PRE-CONSTRUCTED DIAGRAMS ON GEOGEBRA

**Kelly A. Steffen**

**St. Joseph-Ogden High School**

**Matthew S. Winsor**

**Illinois State University**

**Abstract** The purpose of this action research study was to discover a method for helping secondary students understand the properties and relationships of special quadrilaterals. Students are more likely to work from their concept image of a geometric shape rather than a memorized definition when asked to recall the shape's properties in order to solve given problems. Giving students opportunities to experience and explore examples of each shape helps to refine and build students' concept images of each special quadrilateral. In order to give students the opportunity to enhance their understanding of special quadrilaterals via exploration, we created a unit of study which employed pre-constructed diagrams created on Geogebra. We wished to discover what kind of effect working in a dynamic environment with scaffolded activities might have on students' understanding of special quadrilaterals. Comparing pre- and post-assessment data from three separate classes ( $n = 67$  students) showed that students' overall understanding of special quadrilaterals increased as a result of the intervention activities. However, not all students reached the same level of understanding by the end of the unit. The exploration-based structure of the unit allowed individualized instruction. Thus, regardless of students' prior knowledge, the activities from the unit provided each individual with an opportunity to grow in their understanding of special quadrilaterals.

**Keywords:** teacher action research, high school geometry, Geogebra, special quadrilaterals

## Introduction

Students usually rely on specific geometric examples to make sense of geometric theorems and definitions (Cunningham & Roberts, 2010; Fujita & Jones, 2007; Tall & Vinner, 1981). Unfortunately, when studying the properties of and relationships between special quadrilaterals, teachers often present students with definitions of each quadrilateral at the beginning of the unit without letting students explore the quadrilaterals themselves. Teachers then require students to verify the definitions and deduce any additional properties of each quadrilateral not mentioned in the definition (Salinas, Lynch-Davis, Mawhinney, & Crocker,

2014). Unfortunately, students are rarely successful in applying memorized definitions to solve problems involving quadrilaterals (Cunningham & Roberts, 2010). Therefore, it seems that teachers must adjust their approach for helping students gain a conceptual understanding of quadrilaterals.

One reason for teachers to avoid teaching quadrilaterals without student exploration is the students' level of geometric reasoning, commonly referred to as their van Hiele level (Van Hiele, 1959/2004). Van Hiele emphasized that students must progress linearly through the earlier stages of geometric understanding before being able to engage in formal deductive reasoning, which is the highest van Hiele level (Crowley, 1987; Lai & White, 2012). Therefore, in order for students to understand a particular special quadrilateral, they must explore concrete examples of the shape to recognize the properties of the figure (Battista, 2007). Through the process of viewing multiple examples of a particular special quadrilateral, students begin to form a working definition of the given geometric shape.

I experienced this first hand during my first few years of teaching. As a new teacher, I assumed that all of my high school geometry students had a basic understanding of each special quadrilateral. As a class, we wrote down the properties of each shape. I required students to memorize these properties and then immediately moved into trying to teach formal deductive proofs involving the properties of special quadrilaterals. At the conclusion of the unit, I always found myself frustrated. Most students could not see relationships between special quadrilaterals nor complete formal proofs with quadrilaterals on their own. After a few years of observing students' difficulties with quadrilaterals, it seemed that students never truly understood the properties of each special quadrilateral. This challenge motivated me to discover a different way to help students understand quadrilaterals and their properties. Therefore, the aim of this action research study is to employ a research-based teaching method to help students better understand quadrilaterals.

My research question is as follows:

In what ways, if at all, do students show growth in their geometric understanding of special quadrilaterals both during and after completing guided explorations of dynamic quadrilateral constructions?

## **Literature Review**

*van Hiele Levels of Understanding.* In the 1950s, Pierre van Hiele noted that students learn geometry in a linear progression. According to van Hiele, a student must advance through five levels of thinking in order to fully understand a geometric system (Van Hiele, 1959/2004). These five levels are now known as van Hiele Levels of Geometric Thought. The descriptions of each van Hiele level stay relatively consistent throughout most research. Table 1 summarizes the descriptions that have been commonly used amongst researchers (Battista, 2007; Crowley, 1987; Fujita & Jones, 2007; Gutierrez, Jaime, & Fortuny, 1991; Lai & White, 2012).

*Table 1: Descriptions of van Hiele Levels*

<b>VAN HIELE LEVEL</b>	<b>DESCRIPTION</b>
<b>PRE-RECOGNITION (LEVEL 0)</b>	Students are unable to identify many common shapes.
<b>VISUAL (LEVEL 1)</b>	Students are able to identify shapes according to their appearance.
<b>DESCRIPTIVE/ANALYTIC (LEVEL 2)</b>	Students are able to characterize shapes by their properties.
<b>ORDER/RELATIONAL (LEVEL 3)</b>	Students are able to form definitions and establish relationships between shapes.
<b>FORMAL DEDUCTION (LEVEL 4)</b>	Students are able to develop and apply theorems within an axiomatic system.
<b>RIGOR (LEVEL 5)</b>	Students are able to apply geometric concepts to various mathematical systems.

As can be seen in Table 1, student-understanding of a geometric topic starts with informal conceptualization based on previous knowledge and experiences. As students are given opportunities to examine geometric concepts, their understanding ultimately progresses toward a formal property-based system (Battista, 2007). Van Hiele stressed the importance of teachers matching instructional design to meet the van Hiele level(s) of their students (van Hiele, 1959/2004). For example, students at a van Hiele Level 1 are not ready to use a book definition of parallelogram to deduce properties of a parallelogram. Rather, it may be more successful for these students to view multiple examples of parallelograms with the goal of determining what all of the examples have in common (Lai & White, 2012). Teachers must help students construct knowledge that will allow them to progress toward being able to reason deductively (Jones, 2000). Students cannot be expected to prove geometric properties if they cannot first identify the properties.



Teachers must be aware of their students' geometric thinking levels in order to design proper instruction. Traditionally, van Hiele levels have been measured by the number of correct answers on a multiple-choice test (Gutierrez, Jaime, & Fortuny, 1991; Hollebrands, 2007; Kutluca, 2013; Usiskin, 1982; Wang & Kinzel, 2014). However, not all researchers consider van Hiele levels to be discrete (Battista, 2007; Gutierrez, Jaime, & Fortuny, 1991). For example, when a student transitions from one level to the next, she may demonstrate thinking from both van Hiele levels. Because of the fluid nature of van Hiele levels, analyzing students' responses to open-ended questions may be more effective in determining students' van Hiele levels.

The average high school geometry student is at a van Hiele Level 2 (Jones, 2000). At Level 2, students can identify properties of shapes but do so on the basis of visual examples. Therefore, students need multiple representations of geometric objects in order to increase their van Hiele level (Crowley, 1987; Lai & White, 2012). As students become more familiar with the properties of individual shapes, they will begin to notice relationships amongst different shapes. Students who identify connections between objects are at a van Hiele Level 3. For example, a student at Level 3 can deduce that a rectangle can be called a parallelogram due to having all of the properties of a parallelogram (Fujita & Jones, 2007).

*Students' Understanding of Quadrilaterals.* This study is focused on teaching special quadrilaterals to high school geometry students. There exists a hierarchy of related geometric characteristics between certain quadrilaterals that allows students to explore conjectures to identify the hierarchical relationships (Salinas, Lynch-Davis, Mawhinney, & Crocker, 2014). Before entering geometry, many high school students possess prior knowledge of certain quadrilaterals, which comes from visual examples and/or previous encounters with the shape, commonly referred to as a *concept image* (Cunningham & Roberts, 2010; Fujita & Jones, 2007; Tall & Vinner, 1981). The concept image differs from a formal definition (also known as concept definition) of the shape and serves as the foundation for a students' mathematical engagement with the object.

Because students are more likely to work from their concept image of a geometric object, teachers should not ask students to memorize the formal definition of each special quadrilateral in order to derive the properties of each shape. Teachers can facilitate revisions of students' concept images by having students explore examples and non-examples of the object in order to achieve *concept attainment*, the authentic formation of a correct description of the concept being explored (Cunningham & Roberts, 2010; Salinas, Lynch-Davis, Mawhinney, & Crocker, 2014). Students must reach concept attainment for each type of special quadrilateral before they can identify hierarchical relationships (Salinas, Lynch-Davis, Mawhinney, & Crocker, 2014).

In order for students to notice hierarchical relationships, they need to compare and contrast the properties of each specific type of quadrilateral (Salinas, Lynch-Davis, Mawhinney, & Crocker, 2014). It is critical for students to notice the properties that remain consistent throughout most types of quadrilaterals. For example, parallelograms, rhombi, rectangles, and squares all have two pairs of parallel opposite sides. However, differences between

quadrilaterals occur when constraints are made to a set of properties in order to create a new type of quadrilateral (DeVilliers, 1994). For example, in order to create a rhombus, the additional constraint of having four congruent sides must be added to the set of properties for a parallelogram. Hierarchical definitions allow certain types of quadrilaterals to fall into multiple, overlapping subsets (DeVilliers, 1994). Hierarchical definitions prove to be more advantageous for learners once they progress to a van Hiele Level 4 because it reduces the amount of work to prove quadrilateral properties due to certain quadrilaterals being subsets of others.

*Using DGS as an Instructional Tool.* Dynamic geometry software (DGS) allows users to construct geometric objects (e.g. points and lines) as well as manipulate the objects to view geometric relationships between various parts of the construction (Erez & Yerushalmy, 2006; Kutluca, 2013; Poon & Wong, 2017). There are many brands of DGS available to teachers (Kurtz, Middleton, & Yanik, 2005). DGS supports inquiry-based learning by providing students multiple examples of the same constructed figure via dragging vertices of the figure while maintaining the constructed properties of the figure (Hollebrands, 2007; Obara & Jiang, 2009; Poon & Wong, 2017). Geometric exploration helps students at lower van Hiele levels progress toward deductive reasoning (Crowley, 1987).

Students must use their prior knowledge to construct figures with DGS (Battista, 2007). However, students at lower van Hiele levels will not know the essential properties required to accurately construct each type of quadrilateral. One way to address this challenge is to provide students preconstructed diagrams, which allow them to view, measure, and manipulate the components of the preconstructed geometric object (Battista, 2007; Poon & Wong, 2017). Activities involving pre-constructed diagrams ask students to make conjectures about properties of the figure and then to confirm their conjectures (Erez & Yerushalmy, 2006; Hollebrands, 2007). Through this exploration process via DGS, students gain the conceptual knowledge that may not have been accessible via lecture and memorization of definitions (Obara & Jiang, 2009). Activities must guide students to the desired outcome of the exploration (Jones, 2000; Kutluca, 2013). This scaffolding will provide students with an opportunity to develop and/or refine their concept image of the geometric object being studied.

Teachers must also be aware of potential student miscues. As students manipulate a pre-constructed object on DGS, they must realize that a pre-constructed diagram will represent a given geometric shape regardless of how it is manipulated (Battista, 2007; Erez & Yerushalmy, 2006). The geometric properties that remain unchanged via manipulation of the diagram are the critical attributes of the object (Erez & Yerushalmy, 2006; Hollebrands, 2007; Jones, 2000). If students can find the critical attributes of a pre-constructed diagram, they will be able to then advance in their van Hiele level.

Once students have identified critical attributes of quadrilaterals, DGS can guide students towards recognizing that certain quadrilaterals can be given multiple classifications (Erez & Yerushalmy, 2006). In this process, students identify that there are certain attributes that various quadrilaterals share. For example, students can manipulate a rhombus in DGS to look

like a square because both squares and rhombi have four congruent sides. It should be noted that rhombi are not required to have four right angles, which allows students to manipulate a rhombus in DGS to look like a square. DGS acts as a tool for students to make meaningful connections between the various quadrilaterals.

Not all students will be at the same van Hiele level in a class therefore DGS allows for individualized instruction (Fujita & Jones, 2007). Working on DGS with well-structured activities can allow students to work at their own pace and at their own level of geometric thinking. Students who need more support will have the ability to review multiple examples of the quadrilateral, discuss what they are finding with a peer, and receive support from the teacher. Extension problems can be written for students who work at a faster pace.

## Methodology

*Research Design.* This action research study employed a mixed methods approach. In order to determine if dynamic geometry software (DGS) helped students' increase their van Hiele level of quadrilaterals, pre- and post-assessment data was compared. Various studies have measured the impact that DGS had on student-learning by using a similar approach (Johnson-Gentile, Clements, & Battista, 1994; Kutluca, 2013; Pitta-Pantazi & Christou, 2009). In particular, this study measured each student's van Hiele level of understanding quadrilaterals before and after the designed unit centered around student-explorations of pre-constructed diagrams on DGS. In addition to quantitatively comparing students pre and post van Hiele scores as well as pre and post free-write scores, we also examined students' definitions of the various quadrilaterals in order to describe the changes that occurred, if any.

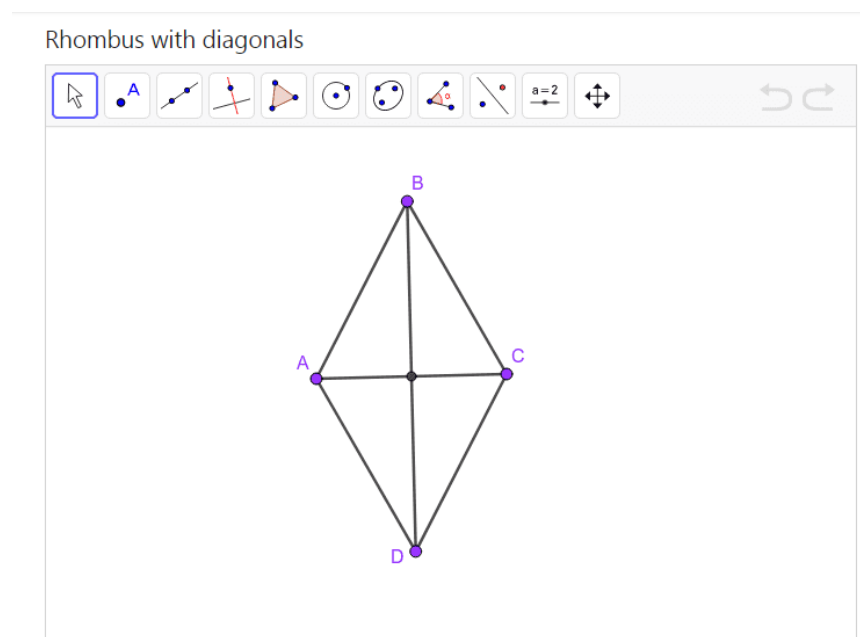
*Study Participants.* This study was conducted at a rural high school in central Illinois. The students in this study were from three different sections of the regular (as opposed to accelerated) geometry course. Each section met every school day for a 50-minute class period. The textbook used for this course was *Core Connections Geometry* by the *CPM Educational Program*. All three sections were taught by the same teacher, who was also the main researcher in this study. A total of 63 students participated in the study: 28 females and 35 males. Of these 63 students, there were twelve 9<sup>th</sup> graders, forty-three 10<sup>th</sup> graders, seven 11<sup>th</sup> graders, and one 12<sup>th</sup> grader. Participants in this study were a diverse group of learners that represented a variety of grades and ability levels.

*Instrumentation.* Two assessments were given both before and at the conclusion of a six-day unit on quadrilaterals. The first assessment was an adapted version of Usiskin's (1982) "van Hiele Level of Geometric Understanding Test". Several studies (Hollebrands, 2007; Kutluca, 2013; Wang & Kinzel, 2014) have used Usiskin's (1982) "van Hiele Level of Geometric Understanding Test" to measure the van Hiele levels of participants. In order to examine students' understanding of special quadrilaterals, we used a subset of Usiskin's (1982) test questions that related to quadrilaterals. The Usiskin (1982) test provides an overall assessment of students' van Hiele levels.

The second assessment was a free-write about each special quadrilateral studied during the unit. Because researchers have found that a student's van Hiele level may differ from topic to topic (Gutierrez, Jaime, & Fortuny, 1991), we asked students to share their concept image for each special quadrilateral in order to detect subtle changes in students' van Hiele levels. Each free-write response was given a van Hiele level rating based on a rubric adapted from Gutierrez, Jaime, and Fortuny (1991). Because students studied seven different shapes, they received seven separate van Hiele level scores on the free-write.

*Procedures.* This study took place during a six-day unit on quadrilaterals (namely trapezoids, parallelograms, rhombi, rectangles, squares, kites, and general quadrilaterals). We decided that six days was sufficient for students to thoroughly examine the different quadrilaterals. Moreover, given the curriculum requirements placed on us by the school district, six days was the largest number of days we could afford to dedicate to the unit on quadrilaterals. Before the unit began, students individually completed the multiple choice and free-write assessments. Students who were classified at the same van Hiele level were then partnered to work together. Placing students in homogenous pairs eliminated some variability when trying to determine the impact that DGS had on students' van Hiele levels. Pairing students also addressed the limited number of computers available for student use.

After receiving instruction about the goals of the unit, students worked in pairs through each guided activity. Each pair of students worked for roughly forty-five minutes each day on the guided activities. Every activity required students to manipulate the pre-constructed diagrams using DGS on the computer (see Figure 1) in order to make observations about the shape with their partner. For example, students moved vertex B to vary the appearance of the rhombus to determine which geometric properties remained constant.



*Figure 1: Sample pre-constructed rhombus on DGS used for the activities*

Each activity had extension questions for students who completed their work early. The extension questions focused on trapezoids and kites, figures which do not receive much attention in textbooks. At the end of Activity 2, students produced a definition for each type of quadrilateral. Students' responses provided a formative assessment that helped the teacher measure progress mid-way through the study.

On the final day(s) of the unit, students shared their definitions of each quadrilateral with the class. The class then worked to synthesize their classmates' definitions in order to establish a class definition of each quadrilateral. Students also proposed hierarchical relationships between quadrilaterals. On the final day of the study, students took the two post-assessments.

### Data Analysis

*van Hiele Level Test.* The multiple choice pre-/post-assessments were scored using the method found in Usiskin (1982) in order to assign each student a van Hiele level (see Figure 2). We then compared the mean scores of the pre and posttest using a one-tailed paired t-test (Cheraq & Shahvarani, 2017; Fields, 2005; Hsu & Lachenbruch, 2005). Our hypotheses are as follows:

$H_0: \mu_d = 0.$

$H_A: \mu_d \neq 0$

We chose to use an  $\alpha$ -level of 0.10 because we were implementing the activities described above for the first time with a relatively small number of students and felt that ( $p < 0.10$ ) would give us a sense of the potential of the activities for improving students van Hiele levels (Schumm, Pratt, Hartenstein, Jenkins, & Johnson, 2013; Taylor, 2020).

#### Scoring the Test (Usiskin, 1982):

- Each group of 5 consecutive questions represents a van Hiele level.
- If a student answers 3 or more questions from the group of 5 correctly, the student is considered to have achieved the corresponding van Hiele level.
- A student cannot "skip" a van Hiele level. Therefore, the first time a student misses 3 or more questions from a group of 5 questions, their van Hiele level has been set.

*Figure 2: Scoring procedures for multiple choice pre-/post-assessments*

*Free-write Assessment.* Each of the seven responses on a student's free-write assessment was assigned a van Hiele level based on the adapted rubric from Gutierrez, Jaime, and Fortuny (1991) (See Figure 3). Scoring was completed separately by two different researchers in order to minimize any bias and assure validity. We analyzed the data in two ways. First, we used a one-tailed paired t-test to compare the pre- and post-scores for each quadrilateral. We set our

alpha at 0.10 and our null hypothesis was that for each quadrilateral, the means for the pre- and post-free-write would be the same.

Next, we used the constant comparative method (Glaser & Strauss, 1967) to identify subtle patterns in the changes between pre- and post-free-write assessments. We hoped to be able to describe patterns of change (or lack of change) for the various quadrilaterals given the complex nature of students' transitions between different van Hiele levels (Battista, 2007; Gutierrez, Jaime, & Fortuny, 1991).

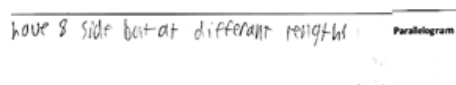
Level 0 (pre-recognition)	-Student leaves description blank -Nothing in the description is correct
Level 1 (recognition)	-Student describes the visual appearance of the shape ("It looks like") -Student only draws an accurate picture of the shape (without geometric markings representing properties) -Student's entire written description includes only irrelevant geometric attributes
Level 2 (Descriptive)	-Student uses correct geometric properties to describe the shape (although some properties may be incorrect or left out) -Student describes the shape in isolation of the other special quadrilaterals
Level 3 (Relational)	-Student uses correct inclusive classification or explains how a given shape is related to the other from the unit -Student mentions all of the necessary properties of the shape (and all additional properties are accurate with no mistakes)

Figure 3: Rubric for scoring the free-write pre-/post-assessments

Figure 4 shows examples of student responses to the term *parallelogram* along with their van Hiele level rating. We transcribed students' answers to the right for the reader to be able to understand students' writing. No details in Student A's response (Level 0) were correct. Student B's response (Level 1) focused on the visual appearance of a stereotypical parallelogram as well as provided a basic diagram of the shape. Although Student C (Level 2) and D's (Level 3) responses look very similar due to each listing several properties of parallelograms, Student D's response also included relationships parallelograms have with other special quadrilaterals.

#### Student A

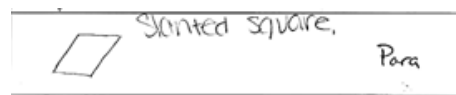
van Hiele Level 0



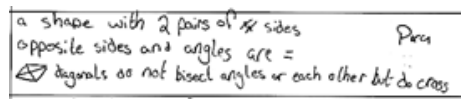
have 8 side but at different lengths

#### Student B

van Hiele Level 1

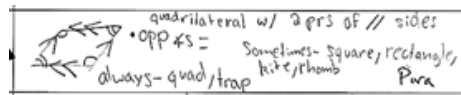


Slanted square

**Student C***van Hiele Level 2*A shape with 2 pairs of  $\parallel$  sides

opposite sides and angles are =

diagonals do not bisect angles or each other but do cross

**Student D***van Hiele Level 3*quadrilateral w/ 2 prs of  $\parallel$  sidesopp  $\angle$ 's =sometimes – square, rectangle,  
kite, rhombus always –  
quad/trap*Figure 4: Sample student-responses for “parallelogram” representing each van Hiele Level***Results**

The students' average overall van Hiele level for quadrilaterals before the unit was ( $M = 1.54$ ,  $SD = 1.01$ ) and after the unit was ( $M = 1.78$ ,  $SD = 1.30$ ). The results of the paired t-test showed  $t(62) = 1.56$ ,  $p = 0.062$ . We therefore rejected the null hypothesis that the pre and posttest means were the same. Therefore, it seems that the intervention given between the pre-test and post-test had an effect in helping students increase their overall van Hiele levels. Given the more general nature of the van Hiele level test, we decided to examine each quadrilateral for changes between the pre- and post-implementations of the free-write assessment.

In order to quantify the changes in van Hiele levels for each quadrilateral, we used a one-tailed paired t-test to see if there was a significant difference between the pre- and post-scores of students' definitions. Our null hypothesis was that there would be no difference between the pre- and post-scores. Table 2 contains the 63 students' average van Hiele levels for each quadrilateral as well as the p-value for the one-tailed paired t-test and the Cohen's D score to determine effect size (Fritz, Morris, & Richler, 2012). Again, we set our alpha level at 0.10.

*Table 2: Comparison of average score on free-write assessment***COMPARISON OF AVERAGE SCORE ON FREE WRITE PRE-TEST AND POST-TEST (N=63)**

SHAPE	Pre-Test	Post-Test	P-value	Cohen's D
SQUARE	1.98	2.41	$p < 0.0000$	$d = 1.38$
RECTANGLE	1.89	2.33	$p < 0.0000$	$d = 1.08$



<b>QUADRILATERAL</b>	1.60	2.37	$p < 0.0000$	$d = 1.02$
<b>PARALLELOGRAM</b>	1.56	2.21	$p < 0.0000$	$d = 1.12$
<b>KITE</b>	1.46	1.81	$p < 0.0000$	$d = 0.62$
<b>TRAPEZOID</b>	1.43	2.17	$p < 0.0000$	$d = 1.00$
<b>RHOMBUS</b>	1.22	2.22	$p < 0.0000$	$d = 1.47$

Given that the p-value for each shape was  $p < 0.0000$ , we can reject the null hypothesis that there was no significant difference in the scores. Further, as can be seen in Table 2, Cohen's effect size value for each shape suggests that there was a significant effect from the activities in the unit when comparing pre- to post-test performances on the free-write assessments. Note that a score equal to one indicates that the difference between the pre- and post-scores is one full standard deviation. This is considered a large effect size (McLeod, 2019).

Each student's pre/post free-write was then compared to determine how many students showed growth. Each student could show an increase in van Hiele levels for up to seven quadrilaterals. As noted in Table 3, 34.92% of the students showed an increase in score for three out of the seven quadrilaterals, which was the most frequent occurrence. Only two students (3.17%) increased their score on all seven shapes. However, 82.54% of the students increased their score for at least three out of the seven shapes after completing the exploration activities.

*Table 3: Frequency of increase in score on free-write exam*

**FREQUENCY OF INCREASE IN SCORE WHEN COMPARING FREE-WRITE PRE-TEST AND POST-TEST (N=63)**

<b>NUMBER OF SHAPES THAT STUDENT INCREASED SCORE ON</b>	<b>Number of students showing this increase</b>	<b>Percentage of the sample studied</b>
7 SHAPES	2	3.17%
6 SHAPES	6	9.52%
5 SHAPES	12	19.05%
4 SHAPES	10	15.87%
3 SHAPES	22	34.92%
2 SHAPES	8	12.70%
1 SHAPE	3	4.76%

0 SHAPES

0

0.00%

Although all students increased in at least one score on the free-write assessment, we were also interested in the cases when students' scores did not increase. In fact, out of the 441 quadrilateral definitions we examined (seven definitions per student times 63 participants), 44.67% of the responses were rated the same van Hiele level (See Table 4). Of the scores that did not change, 87.31% were scored at a van Hiele Level 2.

*Table 4: Frequency of cases when a free-write response score was maintained*

**LEVEL OF UNDERSTANDING WHEN SCORE WAS MAINTAINED FROM PRE-TEST TO POST-TEST (N=197)**

LEVEL OF UNDERSTANDING	Frequency	Percentage
LEVEL 0	3	1.52%
LEVEL 1	15	7.61%
LEVEL 2	172	87.31%
LEVEL 3	7	3.55%

Given the majority of unchanged van Hiele levels were at a Level 2, we were curious to see if there was potential growth within the van Hiele Level 2. Figure 5 below shows the Level 2 rating from our rubric for the free-write (Gutierrez, Jaime, & Fortuny, 1991).

Level 2 (Descriptive)	<ul style="list-style-type: none"> <li>-Student uses correct geometric properties to describe the shape (although some properties may be incorrect or left out)</li> <li>-Student describes the shape in isolation of the other special quadrilaterals</li> </ul>
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*Figure 5: van Hiele level two (adapted from Gutierrez, Jaime, & Fortuny, 1991)*

We used the constant comparative method (Glaser & Strauss, 1967) to classify the 172 cases of students who remained at van Hiele Level 2. We arrived at two categories: *shows growth within Level 2* and *does not show growth within Level 2*. Figure 6 provides how we categorized the 172 student responses. We found that 82 out of the 172 responses showed growth within a Level 2. Note that students who showed growth within a Level 2 added to their knowledge of the particular quadrilateral but were still unable to identify hierarchical relationships between different quadrilaterals, which would classify the response as a van Hiele level 3.

Rubric for Sorting Free-Write Responses that Maintained a Level 2 Score from Pre- to Post-Test

Category 1: Shows growth within Level 2	Category 2: Does not show growth within Level 2
<ul style="list-style-type: none"> <li>-Student listed additional properties of the shape on the post-test</li> <li>-Student eliminated listing irrelevant properties of the shape on the post-tests</li> <li>-Students showed a shift in focus to relationships the shape had with other shapes, however, the explanations were incomplete</li> </ul>	<ul style="list-style-type: none"> <li>-Student's pre- and post-test response were identical</li> <li>-Student may have added additional properties of the shape on the post-test, however, did not include the essential characteristic(s) that sets the shape apart from the other special quadrilaterals</li> </ul>

*Figure 6: Categorical classification for sorting Level 2 free-write responses*

In order to give us a more complete description of student growth, we sought to describe patterns in the type of growth between the pre- and post-free-write assessment. We noticed that there were different types of growth occurring with our students. Each pre/post definition fell into one of four groups described below in Table 5.

*Table 5: Categorization of how free-write definitions changed from pre- to post-assessment*

TYPE OF GROWTH	DESCRIPTION OF GROWTH
<b>HIGH LEVEL 1 TO LOW LEVEL 2</b>	Student's pre definition focuses on the look of the figure (e.g. it looks like a diamond). Student's post definition shifts to listing a few characteristics of the figure (e.g. it has parallel sides).
<b>LOW LEVEL 2 TO HIGH LEVEL 2</b>	Student's pre definition lists a few characteristics of the figure (e.g. it has parallel sides). Student's post definition shifts to an extensive list of characteristics of the figure. The post definition does not mention hierarchical relationships with other quadrilaterals (e.g. a square is a rectangle with equal sides).
<b>HIGH LEVEL 2 TO A LEVEL 3</b>	The student's pre definition has an extensive list of characteristics of the quadrilateral without mentioning hierarchical relationships with other quadrilaterals. Student's post definition shifts to the hierarchical relationships with other quadrilaterals (e.g. a square is a rectangle with equal sides).
<b>NO GROWTH SHOWN</b>	Student's definition did not change.

As can be seen in Table 6, when assigning all 441 responses to a group, responses were somewhat evenly divided at around 25% representation for each group.


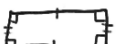
Table 6: Grouping free-write responses based on the growth shown

**GROWTH SHOWN IN COMPARING STUDENT PRE-/POST-TEST FREE WRITE RESPONSES (N=441)**



TYPE OF GROWTH	Frequency	Percentage
HIGH LEVEL 1 TO LOW LEVEL 2	109	24.72%
LOW LEVEL 2 TO HIGH LEVEL 2	82	18.59%
HIGH LEVEL 2 TO LOW LEVEL 3	126	28.57%
NO GROWTH SHOWN	124	28.12%

Figure 6 shows examples representing each type of growth described in the table above. Before the unit, Student E described a rectangle on the basis of the appearance (Level 1) but ended the unit describing a non-exhaustive list of its properties (low Level 2). Student F began the unit where Student E ended (low Level 2) but listed more properties of a rectangle by the end of the unit (high Level 2). Finally, Student G entered the unit understanding most properties of the rectangle (high Level 2) and as a result of the intervention ended the unit recognizing the hierarchical relationships the rectangle had with other special quadrilaterals (entering Level 3).

Student E: High level 1 to low Level 2

 <p>Like square except one longer side. Rect</p>	<p>2 pairs opposite sides equal with 90° angles. Rect</p> 	<p>Student F: Low Level 2</p>
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to High Level 2

 <p>A 4 sided shape with 2 pairs of equal sides. Rect.</p>	 <p>A quad. w/ 2 pairs of parallel sides. Opposite sides equal and parallel. And all 4s are 90°. Rect</p>
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Student G: High Level 2 to Low Level 3

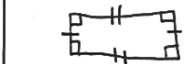

 <ul style="list-style-type: none"> <li>• has 4 right 4s Rect</li> <li>• has 4 sides</li> <li>• has 2 pairs of equal sides</li> <li>• is a polygon</li> <li>• quadrilateral</li> </ul>	 <p>quadrilateral w/ 4 right 4s Rect</p> <p>has 2 pairs of // sides</p> <p>opp sides =</p> <p>always-quad, trap, rhomb</p> <p>sometimes- Rect, Square</p>
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Figure 7: Examples of student pre-/post-test responses falling into each growth group

## Discussion

When reflecting on the findings, three pieces of data support the fact that students' knowledge of quadrilaterals increased due to participating in the guided exploration activities of the pre-constructed dynamic shapes on Geogebra. First, students showed a significant increase in van Hiele level scores on the multiple-choice assessment. Additionally, there was a significant difference between students' pre- and post-definitions for every quadrilateral. Finally, when looking at progress for individual students, all participants increased their knowledge for at least one quadrilateral from the unit: emphasizing that a majority of students increased their van Hiele level for at least three quadrilaterals.

As with any activity implemented for the first time, we found that several questions arose from the results. One trend we observed was students' van Hiele levels were not the same for each quadrilateral. On average, the participants had a stronger understanding of squares and rectangles as compared to all other special quadrilaterals. When the free-write pre-assessment was administered, many of the students skipped immediately to the questions that asked them to share their knowledge of the "square" and "rectangle" before attempting to write about any other shape. In many cases, these two written responses were scored higher than the responses for the five remaining shapes. However, after working through the unit and then taking the post-assessment, the students in the study showed less growth for squares and rectangles as compared to the other special quadrilaterals. We hypothesize that students may have lacked motivation in furthering their understanding of squares and rectangles because they believed their pre-existing concept image of these two shapes was sufficient.

Another trend we noticed was common misconceptions for certain quadrilaterals. The frequency of these misconceptions prompted researchers to wonder about how students experienced the quadrilaterals in previous lessons. First, many students claimed that a trapezoid must be isosceles, in other words, that the two non-parallel sides were congruent. Although the default setting for the pre-constructed dynamic trapezoid used in Geogebra was not isosceles, it seemed that students' pre-existing concept image of a trapezoid was so deeply rooted that students were unable to overcome this misconception.

Although students had difficulty with trapezoids, the intervention did help students correct some misconceptions. In particular, many students entered the unit thinking that rhombi and parallelograms have "slanted" sides whereas rectangles and squares have "horizontal" and "vertical" sides. Given that quadrilaterals are usually presented in textbooks with one side serving as the base, students' erroneous definitions seem reasonable. Students were able to overcome their misconceptions while using the tools on Geogebra because of the ability to orient the quadrilateral in any direction.

One finding that surprised us was that some students achieved a lower post van Hiele level rating. We wondered if the activity caused cognitive conflict within the student. In the pre-test, students may have provided memorized definitions that would receive a higher van Hiele

rating. Participating in student-led exploration that emphasized justifications of student claims may have caused students to question their memorized definition. As a result, the van Hiele level decreased because students were providing their own definition driven by a concept image instead of a memorized definition.

## Conclusion

The motivation behind this research study was realizing that a high school geometry curriculum did not match students' van Hiele levels. Textbook activities attempted to promote formal deductive reasoning without providing foundational knowledge necessary to arrive at formal deductive reasoning. Results from this study seem to show that students can progress towards formal deductive reasoning via exploration and analysis of preconstructed quadrilaterals. This study also adds to the body of literature (Kutluca, 2013; Obara & Jiang, 2009) on the capabilities of DGS to help students transition through the stages of learning geometric content.

The findings also generated more questions as well as observations for how to improve the implementation of the geometry unit discussed in this paper. First, we observed that we need checkpoints in the activities in order to hold students responsible for their work as well as serve as formative feedback for the teacher. We also realized that we had unintentionally created a learning ceiling with the activities. The designed activities were not written to help students move beyond a van Hiele Level 3. Therefore, in the future, we hope to add activities that will allow the students at a van Hiele level 3 to move into a van Hiele Level 4 which focuses on deductive understanding of quadrilaterals.

Although we hoped for greater student growth, we feel that adjusting the activities and implementation of the unit could potentially bring about even greater improvement in high school students' understanding of quadrilaterals. It is our hope that teachers will try out these activities in their high school geometry classrooms and help improve this geometric unit that pairs inquiry-based learning with technology.

### About the Authors

**Kelly A. Steffen** is a mathematics teacher at St. Joseph-Ogden High School in St. Joseph, Illinois. She teaches algebra, geometry, and calculus to 9th-12th grade students. Kelly believes that interactive technology can be an effective tool to promote exploratory learning and assist students in discovering mathematical concepts. Kelly holds a BS in Mathematics for Secondary Education from Indiana State University and a Master's Degree in Mathematics from Illinois State University. Email: [steffenk@sjok12.il.us](mailto:steffenk@sjok12.il.us)

**Matthew S. Winsor** is an associate professor in the mathematics department at Illinois State University. His main foci are preparing preservice teachers to be effective in the mathematics classroom and helping inservice teachers study their own practice in order to learn and grow as a teacher. Having five children of his own serves as inspiration for Matthew's work. Email: [mwinsor@ilstu.edu](mailto:mwinsor@ilstu.edu)

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# SOCIAL IMAGINATION PROJECT: FOSTERING EMPATHY IN PRE-SERVICE TEACHERS BY READING CHILDREN'S BOOKS FEATURING CHARACTERS WHO HAVE DISABILITIES

**Shelly Furuness**  
Butler University

**Kelli J. Esteves**  
Butler University

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**Abstract** This teacher research case study investigated the impact of using children's books featuring school-aged characters with disabilities on the development of social imagination in pre-service teachers. The Social Imagination Project provides evidence for ways empathy is fostered. Themes that emerged include (a) perspective taking, (b) complex view of human development, (c) examination of assumptions leading to the development of professional identity, and (d) advocacy. These findings help teacher educators to support pre-service teachers in examining their own beliefs and biases while also examining educational and social inclusion. The study supports the view that social imagination and empathy building are at the heart of widening people's personal and professional frame of reference.

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**Keywords:** teacher action research, empathy building, inclusive education, disabilities in literature

## Introduction

Skills development and knowledge acquisition are necessary components for the education of competent teachers, but they are not sufficient—not if our goal is to prepare all those who teach for the complex demands of the educational arena. Those in teacher education have known for a long time what Sumara and Luce-Kapler (1996) explained, that “Becoming a teacher involves more than transposing teaching skills onto an already-established personal identity” (p. 65). As instructors in a teacher preparation program situated within a liberal arts university in the Midwest United States that was founded on the principles of diversity, equality, innovation, and access, we are committed to preparing teachers to examine their beliefs about educational and social inclusion.

Peter Johnston (2012) reminded us that “[S]ocial imagination is the foundation of civil society” (p. 72). We continue to regard the development of a strong sense of identity, of social

imagination, and of personal transformation as a means to a larger end—the empowerment of others (Freire, 1971). An important goal in our teacher preparation program is to develop the personal and professional identity and social imagination of teachers beyond what they may have previously imagined themselves or their roles to be, and in doing so we seek to expand how teachers may view their students. We believe, as Johnston (2012) stated, that “[T]eachers whose social imagination is well developed are likely to beget students with well-developed social imaginations” (p. 79). Social imagination and empathy building are at the heart of widening people’s personal frame of reference. We explicitly seek to create a learning community that opens space for personal, individual transformation and empowerment while simultaneously inviting students to develop the capacity to do the same thing with their future students. As participants in such a community we engage in scholarship that supports teaching as inquiry, and we strive to model within our university classroom ways to connect theory with practice.

The Social Imagination Project is an examination of disability and ability primarily through the use of literary fiction. Students read a novel that features a protagonist with an exceptionality. They also read nonfiction accounts written by parents and caregivers who are raising children who have disabilities. The idea for the project came from our own teacher researcher questions and a commitment to a core value of our program for the appreciation of diversity and similarity. We wondered how a course in our teacher education program focused on learning theories and development for both typical and atypical learners, taken by every student in our college of education regardless of their teaching focus, and cotaught by a general education and special education faculty member, might be a place to examine the sociological principles of disabilities. We had noticed how people with disabilities were often held up as models of inspiration by our students. We wondered about the implications of this “good” intention versus the impact of that intention for teaching learners with disabilities. In making this an explicit part of the course, we sought to examine our assumptions together and to build a space where social imagination could be expanded without the fear of judgment. The Social Imagination Project was our vehicle for this exploration and evidence gathering. It helped us to discover whether reading books featuring school-aged characters with disabilities would foster social imagination and empathy and what evidence of that might look like for our pre-service teachers who are first beginning this work. As such, it led us to seek answers to the broad research question: Does reading books featuring school-aged characters with disabilities foster social imagination? And if so, what does evidence of social imagination look like for our pre-service teachers and how can the social imagination project be used to examine the sociological principles of disabilities in a foundational education course?

## Literature Review

*Power of Literacy Fiction.* The idea that stories can have a profound impact on how people understand one another is not new. Decades of research have shown that stories change how we see the world (Chiaet, 2013; Morrison & Rude, 2002; Nikolajeva, 2013), and this is true when attempting to understand aspects of human diversity. In a series of five studies, Kidd and Castano (2013) gave participants excerpts from popular fiction, literary fiction, nonfiction, or

nothing to read and then administered a test to gauge the ability to infer another person's thoughts and emotions. Literary fiction was described as stories that focused on the psychology of characters and their relationships. Results showed that reading literary fiction, more so than not reading or the other genres included in the study, increased the ability to understand another's thoughts and emotions. In fact, "readers form relationships with fictional others through the use of social imagination as a part of the meaning-making process" (Lysaker & Tonge, 2013, p. 634). Lysaker described social imagination, as the term is used here, as the ability to infer the inner life of another person (Purdue News Service, 2016).

*Practicing Empathy.* A similar study showed that reading literary fiction provides training for the practicing of empathy in real-life situations along with the development of theory of mind, the understanding that others have perspectives that differ from one's own (Nikolajeva, 2013). This idea also was supported by Lysaker, who in a 2016 interview with Purdue News Service said that "empathy and social imagination feed into the larger idea that we have a human capacity for understanding each other and we ought to be developing that as a central part of our educational system" (Purdue News Service, para. #7). Nikolajeva pointed out that the development of empathy is gradual and can be intentionally developed by reading literary fiction.

Because empathy is a fundamental skill for educators, honing that skill in teacher education programs is time well spent. Morrison and Rude (2002) contended that reading literary fiction that portrays characters with disabilities is a more effective means of preparing educators to teach individuals with special needs than the use of textbooks alone. They explained that "literary accounts of children with disabilities have provided readers with a more complete view of the world in which a child lives and has allowed readers to experience the world of the child" (Morrison & Rude, 2002, p. 116). When exploring complex topics such as disability and ability, how families respond to those complexities, and the identification of assumptions, students might feel vulnerable. However, as Lysaker pointed out in the 2016 interview, "There's no consequence if you mess up." She went on to explain that "It's a safe place to have a reaction that you might not be proud of having in a real circumstance, and you can catch yourself, take a look at your own feelings and discuss them with others—especially if you have a great teacher and a great classroom" (Purdue News Service, para. 10). Peter Johnston (2012) linked social imagination to moral development and empathy and contended that "Perspective taking—mentally walking in another's mind—is a very effective way of reducing prejudice, because we can see more of ourselves in the other and the other in ourselves" (p. 86).

*Replicating Lived Experience.* Pre-service teachers benefit from understanding a child's life outside the classroom, including the complexities of peer and familial relationships. There is a direct relationship between this understanding and the Council for Exceptional Children's teacher preparation standards, which convey the importance of understanding how exceptionality, or disability, can interact with overall development and learning (Council for Exceptional Children, 2012). The examination of lived experiences such as these is difficult to convey through textbook readings. Reading literary fiction that includes a protagonist who is exceptional in some way, whether through an identified disability or another exceptionality,

affirmatively responds to the widely held belief that educators are more effective when they know their students. A way to know students is to attempt to understand their experiences.

While researchers prefer the term “exceptionality,” we use “disability” throughout the article for the sake of clarity.

*What Is the Social Imagination Project?* In this project, education students are asked to read a novel that features a school-age protagonist with a disability. Students also read nonfiction book chapters written by parents or caregivers that address a child’s family, culture, and other contextual factors. Students are then asked to reflect on their understanding of disability in a variety of ways. The curricular objective tied specifically to this project is for students to describe their understanding of development and individual differences to respond to the needs of individuals with disabilities. Students’ attention is also drawn to the college’s core value: “[Students] are challenged to examine their assumptions about other people, how children from diverse experiences learn, and reflect about the responsibilities of innovative educators.”

To contextualize the Social Imagination Project, we begin by reminding students of the essential questions of the course: (a) How, when, and where do people learn? (b) How can we prepare every learner to thrive in a diverse and interdependent world? (c) What is the role of an educator, and how do history and politics affect the educational landscape(s)? And (d) What does professional behavior look like in a professional learning community? Instructors then explain the content, process, and product related to the Social Imagination Project, which simultaneously models opportunities for differentiation. Excerpts from the assignment description are as follows:

- Content—What materials will you be using for the assignment?
  - As an exercise in both introspection and “social imagination,” you will read fiction and nonfiction surrounding the topic of similarities and differences. Listening to/reading stories of exceptionality from multiple perspectives can help us gain insight into the human condition. As you read, try to “share the space” with the characters as an opportunity to empathize instead of sympathize.
- Process—How will you go about making sense of what you are learning?
  - Reflect on the stories you read, listened to, and viewed in your response journal. Use the guiding questions to frame your response: What did the readings teach you about students with exceptionalities? What did they teach you about the role(s)/perspectives of peers, families, and educators? What connections did you make between the reading and information discussed in class? Use your response journal to document your questions, connections, and thoughts on the reading. The format of your journal is left to your discretion. You will be reviewing your journal entries with your instructors and peers at various points throughout the course, and journal entries should be integrated into your artifact.
- Product—How will you demonstrate what you learned to your professors and peers?

- You will create an artifact that highlights lessons learned from the exercise in social imagination. Options include a collage, video, poem, song, playlist, Prezi presentation, poster, role play—or something else entirely. The project will culminate in a showcase of the artifacts. You will explain your artifact in a written narrative that will be available to your peers and professors during the gallery walk. The final product will be evaluated on both the artifact and written explanation.

The complete assignment description is provided to students in written format and explained in class.

*The Text Set.* The project is launched after the assignment is described with a series of book talks on each of the literary fiction books and the nonfiction chapters. Middle-grade and young-adult books are chosen in favor of books geared for an adult audience because they are high quality but tend to be more condensed, and they might be books students choose to read with their own students in the future. When selecting the books and nonfiction chapters for the text set, the following guiding questions were considered:

- Does the book not only feature a school-age protagonist with an exceptionality, but also examine peer and familial relationships?
- Is the protagonist portrayed realistically and respectfully?
- Did the book foster compassion and empathy in me when I read it?
- Does the story go beyond a clichéd portrayal of the exceptionality?

Instructors also review the websites Disability in Kid Lit: <https://disabilityinkidlit.com/> and Schneider Family Book Awards from the American Library Association (<http://www.ala.org/awardsgrants/schneider-family-book-award>). In this way, we continually take into account books that provide thoughtful portrayal of characters with disabilities. Instructors take turns offering an overview of the plot of the fiction texts, sharing impressions the readings made on us and what others have shared with us about the book. A few examples of texts offered for student consideration include Sharon Draper's *Out of My Mind*, CeCe Bell's *El Deafo*, and R.J. Palacio's *Wonder*. After all fiction titles have been introduced, students are given time to discuss their preferences with classmates prior to checking out the books. Along with the literary fiction text, students are asked to read two chapters from nonfiction books that tell a caregiver's perspective of raising a child with a disability. Not all book chapters address specific disabilities, but students are asked to consider selecting a set of readings that represent diverse perspectives.

Students are given three weeks to read the selected fiction book and nonfiction chapters. During this time period, students are encouraged to check out a different book if their first choice does not resonate with them. Informal questioning before and after class and during breaks leads to casual discussion and also subtle reminders to complete the assignment. *Individual Reflections and Group Discussions of the Readings.* Students are asked to reflect individually and through group discussion. They document their thoughts on the following prompts in written format in their response journals prior to the class discussion:



- What fiction book did you read? What nonfiction chapters did you read? What did the readings teach you about students with exceptionalities?
- What did the books teach you about the role(s)/perspectives of peers, families, and educators?
- What terminology was used for the exceptionality (if any)?
- In what ways did the stories emphasize similarities rather than differences among characters with and without exceptionalities?
- How are aspects of culture portrayed? Consider how financial conditions, social settings, race, religion, sexual orientation, or gender identity may have affected the character.
- Was the plot believable? Explain.

In class, students are intentionally grouped first with students who read the same fiction book and then with students who read different books in order to share the stories with one another and discuss broad themes. The benefit of multiple readings and discussions of those readings is that it reinforces that the perspective of disability is that of the writer; it is grounded in his or her observations and understandings of disability. Small-group discussions are followed up with a whole class discussion that highlights insights that came out of the conversations.

*The Artifact and Gallery Walk.* Students are asked to create an artifact that highlights the lessons they learned from the readings, individual reflections, and class discussions. Examples of products include visual art, poetry, performance art, multimedia projects, or any other form of creative expression. A written explanation accompanies the artifact, as one may find in a museum or gallery. Instructors transform the classroom space into a gallery, and artifacts are showcased. Students walk around the gallery to view their peers' work. They are invited to leave feedback on sticky notes next to the artifacts. In a separate task, toward the end of the semester, students are also asked to reflect on their understanding of the related course objectives.

## Methodology

Teacher research was defined by Cochran-Smith and Lytle (1993) as "systematic, intentional inquiry by teachers, [which] makes accessible some of the expertise of teachers and provides both the university and school communities with unique perspectives on teaching and learning" (p. 1). Historically, teacher research as a methodology (re)positions teachers as both insider and expert. We, the researchers, use this methodology in our cotaught course as an intentional model for pre-service teachers to recognize the broader methodology of teacher research as a powerful tool for generating new knowledge about their practice within their own classroom. This case study, bounded in the study of this singular assignment over time across multiple iterations and sections of our shared cotaught course, was an intensive inquiry into our teaching practices in our natural context from both the etic and emic perspective, because as co-teachers and participants we were examining our own practice as well as each other's. We began with an assumption that the assignment could be a helpful, safe, and intentional scaffold for examining underlying assumptions about difference and shifting perspective from

sympathetic to empathic in regard to the differences examined. Institutional review board approval was obtained for us to study achieved data collected across multiple years of our course. Consistent with the overall framework of our teacher preparation program's beliefs in learning as an inquiry process and a social construction of knowledge, this project reflects an interpretivist view with the purpose of description and explanation (Gall, Gall, & Borg, 2010).

*Data Sources, Collection, and Analysis.* Purposeful sampling was used, as we examined only the work of participants in our cotaught course sections. The primary data collection instrument was the researcher(s) who were also the teachers of the course. Interpretational analysis of case study data was based on principles consistent with teacher research methodology and grounded theory (Glaser & Strauss, 1967), which involve coding into categories and continuing until saturation. Data was collected over five academic years, starting in January 2015 and ending in May 2019. A variety of data points were used to compare and contrast information from a multitude of sources and perspectives (Anderson, Herr, & Nihlen, 2007). Evidence from student work was analyzed from the spring semesters in 2015 and 2016. Course evaluations were reviewed from 2015 and 2016. Reflections were made by the co-teachers throughout the month of May 2019 regarding programs and projects that were related to the research in the time frame of January 2015 to May 2019. Archival records were reviewed, and field note observations were recorded from our coteaching semesters. Researchers also consulted with a former student who had taken a previous version of the course but who had not done the Social Imagination Project. This former student was consulted due to her perspective as a graduate of our program, her rating as a highly effective practitioner, and graduate coursework in the development of social imagination. All data sources were analyzed for emergent themes and patterns within student responses and articulated thought processes. We found themes in the data, developed a set of categories, and then used these categories to construct a theory that we applied to the broad research question: Does this project foster social imagination? Credibility and trustworthiness of these themes were arrived at through the constant comparison of the five years of data in the field, member checking, and triangulation (Creswell, 2003; MacLean & Mohr, 1999; Shagoury-Hubbard & Power, 2003). Applicability of findings provide a thick description of the case to help readers make their own judgments about transferability.

## Results

Analysis of the data began with the review of student work. Specifically, we looked at the Social Imagination Project narratives that were submitted along with the conceptual artifacts. Next, we reviewed responses in students' journals, narrowing our focus to a question related to a theme that began to emerge from the initial review. To build familiarity and make further connections with the data, we reflected on the two semesters of courses together and documented our observations, recalling student behaviors and contextualizing them with the direction those students ended up taking in their educational and career paths. Throughout this process, four themes emerged from the data. We also reviewed course evaluations to see if comments were reflective of the themes that emerged. Based on our coteaching reflections, we identified relevant observations of student behaviors as well as "curricular ripples," which

we defined as projects and programming that arose during the time period of study that related to the Social Imagination Project.

*Identified Themes.* Four themes emerged: (a) Perspective Taking, (b) Complex View of Human Development, (c) Examination of Assumptions Leading to the Development of Professional Identity, and (d) Advocacy. Given that one of these themes related to the examination of assumptions and the development professional identity, we reviewed student responses to the following question in their journals: When you can identify within yourself a bias against a person or a particular group of people, what is your professional responsibility to ensure that all individuals thrive?

Many quotes from student work were cross-coded for Perspective Taking and Complex View of Human Development. Additionally, there was cross-coding between Examination of Assumptions Leading to the Development of Professional Identity and Advocacy.

## Discussion

*Perspective Taking.* The ability to take another's perspective, or as Johnston (2012) puts it, "mentally walking in another's mind . . . see[ing] more of ourselves in the other and the other in ourselves" (p. 86), is a key aspect to the development of one's social imagination. A review of social imagination project narratives showed a solid theme of perspective taking. Students noted how the storytelling format was immersive and enabled them to gain a more nuanced understanding of ability and disability.

The style of writing really did a lot for me as a reader to become one with [the character] and to empathize with her struggles as well as her triumphs. I feel as though I have awakened a new depth of understanding with students on the Autism spectrum. (student reflection, Social Imagination Project)

Not only did this book allow me to see INTO his life, it allowed me to see FROM his life; from his perspective. I got to see the world through [the character's] eyes, and realize that no matter how different people's cultures are, people all have one thing in common: we are all people. Just people, trying to make a life for ourselves and our families and trying to do our best. (student reflection, Social Imagination Project)

If we are to use literary fiction to provide training for the practicing of empathy in real-life situations along with the development of theory of mind (Nikolajeva, 2013), then we need to give pre-service teachers the opportunity to practice empathy.

*Complex View of Human Development.* Pre-service teachers need to develop knowledge about a child's family, culture, and other significant contextual factors and how they interact with that individual's unique strengths and challenges (Council for Exceptional Children, 2012). This complex understanding of development is enhanced by perspective taking. Students documented the storytelling format as an effective means for conveying this complexity.

The novel showed how it feels to have a sibling with a disability and how it impacts their life as they grow up. It also taught me about the role of peers and how great of an impact people's reactions have on a person. (student reflection, Social Imagination Project)

Reading and hearing the perspectives of parents of exceptional students opened my mind to the challenges families face and the joy that they are able to find despite adversity. It has also shown me that educators not only accommodate and support their exceptional students, but serve as a role model to other students in accepting and uplifting special students as well. (student reflection, Social Imagination Project)

The latter student comment reflects a key shift in the pre-service teachers' identity development. The comment reflects not only that new knowledge was gained from the reading of the story, but that knowledge is an impetus for active agency in being a "role model . . . in accepting and uplifting special students." This mirrors the message Peter Johnston expressed in *Opening Minds* (2012), which is a required text for the course. He stated that "As with most other aspects of apprenticeships, modeling productive social behavior is useful, but it is most effective when accompanied by our logic, and it is particularly effective when that logic emphasizes the effects on other people" (p. 87).

We also noted that students saw complexities of disability and ability in themselves. At least one student sought out disability services during the course. Other students commented on how they had not realized that they, or a family member, had a disability.

I have always had the perception that I was different from people with "disabilities" and I never explored the idea that I too had something that disabled me. (student reflection, Social Imagination Project)

This examination of the complexity of human development enabled us to have class conversations about "othering" and the ways in which we use language that separates people into "us and them" categories. We noticed some undertones of "othering" language in some students' written work and class conversations, although not enough to label it as a theme. And while the "othering" language was troubling to see in hindsight, it was also important to remember that this was only an introduction to the process of deeply examining these questions. Bringing deeply held assumptions to the surface and wrestling with the "right" language is an important part of transformative learning, as we saw in the next theme.

*Examination of Assumptions Leading to the Development of Professional Identity.* Students can empathize with characters in the book and understand the complexity of human development as it pertains to disability, but what does that mean for them as educators? Students commented on how this project led them to examine their assumptions and how that has led to further development of their professional identity.

My previous assumptions about the lives and abilities of students with exceptionalities were challenged directly by what I read in these novels. I learned that a disability does not limit the potential of a child, rather the environment and people around them do. (student reflection, Social Imagination Project)

I know of several times where I jumped to conclusions about someone or made a hasty judgment and ended up regretting it as soon as I got to know the person and their story. These accounts have also helped me see the possibility in every situation, and rather than gravitate towards the sweet cuddly kids that anyone can teach, I've enjoyed seeing how I can help the ones with different kinds of exceptionalities and see if we can take on their life as an exciting challenge, rather than an ordeal we have to struggle through. (student reflection, Social Imagination Project)

Before coming to [this university] I didn't really take into account the opinion of others, I would listen but wouldn't really consider where they were coming from. The college of education here at [this university] tries to have students realize this quote "[Students] are challenged to examine their assumptions about other people, how children from diverse experiences learn, and reflect on the responsibilities of innovative educators." After reading these books, I found it really interesting that I was finally seeing things through the eyes of other people. (student reflection, Social Imagination Project)

After this theme began to emerge, we were interested in student journal entries, specifically pertaining to one question: When you can identify within yourself a bias against a person or a particular group of people, what is your professional responsibility to ensure that all individuals thrive? Students were asked to write this journal entry at the end of the semester, about eight weeks after the completion of the Social Imagination Project.

My professional responsibility is to make sure each of my students have the resources that they need to get to the place that they want to be at in order to accomplish their goals. I believe that by practicing differentiation in my classroom and allowing my students to explore themselves and truly discover who they are and how they learn, all of the individuals in my class will thrive in some way. I know that not every student will have the same goals and not every student will want to learn the same way and that it will be hard, but I believe that my role as a teacher is to ensure that every student has what they need to succeed in their own way and I will do what I think is necessary to accomplish that. (student entry, Response Journal)

I have had personal experiences as a learner where I have been treated differently than others and it has been a bad experience. Since math was not my favorite subject in middle school my math teacher had me sit with other students that also did not enjoy math. He made us feel as if we were not as important and that we were dumb. This made us be unsuccessful in the class and has made me and many other students that went through the class not enjoy math as a subject in general. As a teacher I will have to

be careful not to make any student feel as if they are being discriminated against. Each child must feel as if they are equal in every single way. (student entry, Response Journal)

I have a personal bias toward underachieving students. Yes, I want to help them as much as I can, but I think I automatically see them as a burden, rather than people who can add to the class. It is my personal responsibility to ensure that all individuals thrive and I take that very seriously, but I think I naturally enjoy being around smart, self-motivated people. I do not see this as too much of a problem for my future as an educator, but it will be something I will always have to think about when teaching. One day, I would like to get involved with education administration, and this is where I could see this bias being a legitimate problem. When making policies, I would have to be very careful to make sure I was putting them into place so that everyone would benefit, not just my idea of my students. (student entry, Response Journal)

We see the continual examination of bias as a critical aspect of professional identity development, especially in light of the bias the last student comment reveals. Again, however, it was critically important that this deeply held belief and bias be brought to the surface within the context of this introductory course and wrestled with nonjudgmentally, because it allowed us to individualize scaffolds for this student in later coursework, where possible, within his program. The dialogic and relational aspects of the course (and overall program) allowed him to continue to examine his assumptions and “to have a reaction that you might not be proud of having in a real circumstance, and you can catch yourself, take a look at your own feelings and discuss them with others—especially if you have a great teacher and a great classroom” (Lysaker, 2016, para. 9).

*Advocacy:* Carol Ann Tomlinson and Michael Murphy offered the following definition of empathy: “seeking to both understand a person’s condition from their perspective and understand the needs of others, with the aim of acting to make a difference in responding to those needs or building on the positives” (Tomlinson & Murphy, 2018, p. 23). This definition, brought to our attention by our colleague and former student, connects beliefs with action. Many quotes from student work were coded for both Examination of Assumptions Leading to the Development of Professional Identity and Advocacy. The intent to respond to needs based on a new level of understanding was evident in student comments.

I went into this with the mentality of “Oh, no another project” and to come out of it with a better understanding of not only children with special needs and their families, but also how I want my career as an educator to proceed. I want to be, and will be accepting, accommodating, encouraging, caring, and willing to “wage war . . . even if it gets bloody” for my student’s (Brodey, [2007], p. 126) just as Drusilla Belman did for her special needs kid. (student reflection, Social Imagination Project)

Unfortunately, I was one of those people that believed that children with special needs wouldn’t be a part of my area of expertise. That I would not really need to be concerned. In fact, I have never really seen that part of teaching when I was imagining

myself as an educator. It was definitely a wake-up call, this class and these books. I don't want to sound melodramatic, but I truly have learned how necessary it is that I take the education of these children with complete seriousness, because they are valued by loving parents and deserve an equal education with general [education] students. It is my job to help all students and that involves accommodating by compromise and varied teaching styles, to not be egocentric and ask "What does the student really need?" My poem was my journey from where I thought I needed to be to where I actually need to be as a teacher. (student reflection, Social Imagination Project)

This connection between themes is reminiscent of Linda Sue Park's TEDx Talk called *Can a Children's Book Change the World?* (2015), where she explains the power of empathy to ignite engagement and how readers who are led to act can change the world. Another example of readers being led to act is a project that a colleague developed based on the Social Imagination Project called Empathy and Inclusivity: Pass it On. The colleague obtained grant money to purchase multiple copies of books from the Social Imagination Project book list and inserted large stickers inside each book. On the insert, readers were prompted to sign their name after they had read the book, share thoughts on how the story affected them, and then pass the book on to another reader to make a contribution to the insert.

In our coteaching reflections, we noted that comparing student comments from their first or second year in their teacher preparation program to their development as graduating seniors was quite remarkable. For example, the student who noted the bias against low-achieving students during this introductory course took seriously our challenge to get curious about why a student might be underachieving. The student graduated with multiple job offers, including opportunities to work in highly selective schools with high-achieving students, but chose, instead, to work with "struggling" middle-grade students taking remedial courses. Another student noted that a subsequent course focusing on special education and using storytelling to help pre-service teachers understand the rights of students with special needs ignited a passion for advocacy. The student noted in a capstone project that "This class would make me a lifelong advocate for all students and their rights to get a fair education in an unrestrictive environment" (Student Capstone Presentation).

## Implications

*Ripple Effects: More Reading, Related Projects, and Programming.* During our coteaching reflections, we noted that some students in each semester read well beyond the required reading list. It was clear that they had developed a passion for reading books in this subgenre by the number of books they checked out from our class library. Noting this interest, one of the researchers developed a related assignment in a children's literature course that asked students to identify a passion area and create a text set related to the interest. The other researcher, for a course focused on developmentally appropriate instructional practices, developed an assignment utilizing young adult fiction set within a school context to practice observation protocols for case study research.

In 2016, a course was developed by one of the researchers aimed at the use of art and relationship building to redefine disability. In this course, students across the university create art in an inclusive environment at a community-based nonprofit organization. The course builds on themes of perspective taking, a complex view of human development, and personal identity development by exploring what it means to be exceptional.

Our intention when developing this project was to build the social imagination of pre-service teachers so they would better be able to understand and meet the complex needs of students with disabilities. Nearly five years later, we set out to discover whether the project does, indeed, do just that. Based on our analysis of data, comparing emergent themes to the research question, we have found that pre-service teachers have grown in their ability to empathize and have a more fully developed social imagination.

## Conclusion

In concluding our inquiry on this particular assignment, we are hopeful and optimistic. The development of social imagination is a worthwhile endeavor. We have found that using children's books featuring characters with disabilities does foster social imagination. The Social Imagination Project, we believe, may deploy the lens of disability and ability as a cognitive tool: when we learn to intentionally interrupt beliefs and assumptions in one area, we build the skills and capacity to do that in other areas too. This inquiry has influenced our own work, expanding our view of framing new assignments in other classes and also influencing students to develop professional growth goals beyond curriculum requirements, as this assignment allows an easy entry point to expand social imagination to other areas like cultural responsiveness as well.

The Social Imagination Project supports students in their ability to take perspective, to understand the complexity of human development, to examine assumptions and deeply held beliefs—even ones you might not be proud of in retrospect—in a productive way, and to shift sympathetic views of the “other” to more empathetic views. Ultimately, the goal is to move that empathy to action.

As we researched and discussed this project with students and colleagues, it became apparent that firsthand accounts and nonfiction written by school-age children would be a valuable addition to the text set requirements. Adults with disabilities who write or talk about their childhood would help us reach the objectives of the project. The researchers plan to build a list of readings and other media to supplement the existing texts.

In closing, we remain committed to our goal of developing the personal and professional identity and social imagination of teachers beyond what they may have previously imagined themselves or their roles to be. We remain committed to preparing teachers to examine their beliefs about educational and social inclusion and to expanding how teachers may view their students. We continue to regard a strong sense of identity and social imagination as a means of agency and personal transformation. We know that social imagination and empathy building are at the heart of widening people's personal frame of reference. We see empathy as the



ability to sit with another person despite your own discomfort. We know that we cannot have an empathic, inclusive classroom if we are not in community, and we cannot build that community if we exclude those with differences or if we exclude from the conversation those who haven't yet had the opportunity to widen their personal frames of reference.

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### About the Authors

**Shelly Furuness, Ph.D.** is an Associate Professor of Education for the College of Education at Butler University and a former middle school ELA teacher. She teaches courses related to learning theory, adolescent literature, content-specific methods for middle-secondary classrooms, and curriculum design. Her research focuses on investigating curricular dilemmas and problems of practice, developmentally appropriate pedagogy, teacher socialization, and dialogic and relationship-oriented pedagogy. She can be reached by email at [sfurunes@butler.edu](mailto:sfurunes@butler.edu) or on Twitter @ShellyFuruness

**Kelli Esteves, Ed.D.** is a professor of special education for the College of Education at Butler University. She teaches courses on topics related to special education, developmental theory, and children's literature. Her research focuses on inclusive practices within K-12 educational settings and multi-tiered systems of support for students. Prior to her career in higher education, she worked as a public school special education teacher. Email: [kesteves@butler.edu](mailto:kesteves@butler.edu)

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# ENGAGING WITH PLAY-BASED LEARNING

**Rebecca Anderson**  
Mangere Central School

**Herbert Thomas**  
The Mind Lab

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**Abstract** An action research approach was adopted to examine the impact of play-based learning on the cognitive engagement of Year 1-2 students (equivalent to kindergarten and first grade). Through the development of a *Rubric of Cognitive Engagement*, student's behaviors were observed during play-based and non-play-based learning tasks with the same learning goal, coded against the rubric and then analyzed to explore the differences of cognitive engagement. Findings revealed that play-based learning did elicit more indicators of deeper cognitive engagement, however, some areas of cognitive engagement needed more teacher support (e.g., self-regulation, strategizing of learning). The findings also suggested that there were other factors, such as, choice and perceived ability, that impacted on student's intrinsic motivation and cognitive engagement of a task. The research also highlighted the benefits of play-based learning in regards to cognitively engaging students during the development of key competencies and 21st century skills.

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**Keywords:** teacher action research, cognitive engagement, play-based learning, motivation

## Introduction

This research project took place in a Year 1-2 class in a South Auckland primary school in New Zealand. At the beginning of the school year, students came to school eager and ready to learn. Generally speaking, they appeared to be engaged in their learning. They were eager to work on any given activity, and were always excited to share their work as soon as it was completed. However, closer examination of the work soon illustrated that the work being completed by students was not up to the expected standards, according to the school's progressions that had been developed from the New Zealand Curriculum (Ministry of Education, 2007). Examples of this included: students who rushed their work to show the teacher in order to move on to an iPad activity; students who would complete their work but would not achieve the expected outcome/learning goal (e.g., copying down words/sentences but not being able to recall the work they had completed); and students who would sit with their books open, appearing to be on task, but who were not actually completing their work. Excuses for this were often that the work was too hard (even though the work was aimed at the current level of the students, or similar activities had been completed previously without issue) or that they simply did not want to complete the activity (i.e., unmotivated, or wished to complete other types of activities). Owing to these disparities, it was important to define and identify learner engagement in three different areas: behavioral engagement (willingness and readiness to learn); emotional

engagement (positive feelings towards learning); and cognitive engagement (the drive and effort a student puts into a learning task), to help narrow the focus for this research project (Ministry of Education, 2019). Students were willing to take part in learning and they were happy and eager to be at school - however, the drive to complete and put effort into their work was lacking, therefore, it became apparent that improvement of cognitive engagement in students would be a significant focus for the project.

It was important for the teacher to ensure that her exploration of this problem was culturally responsive to the students within her class. Not only does this mean ensuring that students had opportunities to explore their own cultural contexts throughout their learning, but it also meant that this project supported all students in becoming effective 21st century citizens, no matter their backgrounds or beliefs. Finally, it was also important that the project allowed the teacher to encourage changes in cognitive engagement in a culturally responsive way.

## Literature Review

*Cognitive Engagement.* There has been much debate over the working definition for cognitive engagement (Greene, 2015), but there is a consensus that it is the psychological investment a student makes in their work, a desire to go beyond the requirements of school, and a preference for challenge that really matters (Sinatra, Heddy, & Lombardi, 2015).

The majority of research around cognitive engagement adopts the use of self-report surveys, questionnaires and interviews to measure the cognitive engagement of students during a task (Greene, 2015). More well-known measures of cognitive engagement include the Student Engagement Instrument (Appleton, Christenson, Kim, & Reschly, 2006). Indicators for this tool are based around the self-regulating strategies of a student, the motivation a student has for a task, and the value a student places on a task. Greene (2015) reflects on the past 20 years' worth of research on cognitive engagement, and her reflections show how different pieces of research define cognitive engagement differently, and how indicators of cognitive engagement also differ from research study to research study.

A rubric of indicators that can be used to observe differing levels of cognitive engagement within the classroom was then developed from relevant research and theory in the area of cognitive engagement (see Table 1). Measures were included from a range of research projects that examined the use of different tools (such as, the Student Engagement Instrument) and self-report surveys adapted for different studies (for example, examining cognitive engagement during an uninteresting task, and measuring engagement through e-learning processes). It should also be noted that many of these self-report surveys have been developed for older students (intermediate age upwards). Rotgans and Schmidt (2011) argue that many of these self-report surveys/measuring tools often rely on broad indicators of engagement (for example, focusing on if students do complete homework) and measure cognitive engagement at school as a whole.

Research has found that cognitive engagement occurs on a continuum, thus the Rubric of Cognitive Engagement (Table 1) has three categories: *no cognitive engagement*; *shallow cognitive engagement*; and *deep cognitive engagement*. Greene and Miller (1996) found that shallow cognitive engagement in learning meant a negative impact on achievement in comparison to deep cognitive engagement. Each category provides different areas of cognitive engagement, including the motivation a student exhibits for the task, the value that the student places on the learning, self-regulation strategies, their growth mindset towards a task and the learning strategies students adopt during the task.

*Table 1: Rubric of Cognitive Engagement*

Indicators of No Cognitive Engagement	Indicators of Shallow/Superficial Cognitive Engagement	Indicators of Deep Cognitive Engagement
Off task Not completing tasks to the required standard. Doing the wrong thing. Negative talk about completing task (e.g. "I can't do this, this is too hard")	Extrinsic Motivation of Task (Jang, 2008) Meeting the minimum requirements of the task Emotional response to task is more compliant than being excited about the task. Might complain that it is boring (Jang, 2008)  Self-Regulation Strategies (Greene & Miller, 1996). Students completing the task because they have to; unable to explain the link between task and learning goals Students working towards a certain grade  Strategizing Learning (Greene, 2015; Greene & Miller, 1996). Learning is more mechanical (for example, more reliant on rote learning, or copying notes). Students work towards their learning goal using the easiest learning strategy known (for example, memorizing)	Intrinsic Motivation of Task (Jang, 2008) Students want to take part in the task Positive emotional response to task Students do not want to finish tasks, happy to keep working even when it is time to move on Going above and beyond in their task  Value of Learning (Appleton, Christenson, Kim, & Reschly, 2006) Students can talk about the importance of learning They know how the task will help them in the future Students will work on their learning outside of the set time  Self-Regulation Strategies* (Appleton, Christenson, Kim, & Reschly, 2006; Kang, Park, & Shin, 2008; Samuelstuen & Braten, 2007) Plan their learning activity Can explain their learning goals

	<p>Students focus only on what they believe is important (for example, learning what is in the test)</p> <p>Fixed Mindset Towards Task (Fredricks, Blumenfeld, &amp; Paris, 2004)</p> <p>Negative talk about the ability to complete tasks</p> <p>Perceived Autonomy</p> <p>Students beginning to monitor their own learning, still needing some guidance from the teacher and/or others in their group</p>	<p>Decide whether they have met their goals</p> <p>Talk about next steps</p> <p>Explain their learning to others (discussions, drawing, modelling)</p> <p>Reflect and evaluate their learning</p> <p>Strategizing Learning (Appleton, Christenson, Kim and Reschely, 2006; Davis, Chang, Andrzejewski, &amp; Poirier, 2009, Greene &amp; Miller, 1996)</p> <p>Apply learning across different contexts, mediums</p> <p>Seeking out new knowledge</p> <p>Problem-solving</p> <p>Offering their own ideas</p> <p>Linking prior knowledge to current task</p> <p>Find more than one way of solving a problem.</p> <p>Growth Mindset Towards Task (Fredricks, Blumenfeld, &amp; Paris, 2004)</p> <p>Taking risks</p> <p>Use of growth mindset</p> <p>Students' emotional response to the task: happy, enthralled, excited</p> <p>Asking questions when stuck/unsure</p>
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*Improving Cognitive Engagement During Learning Tasks.* The idea of intrinsic and extrinsic motivation and its impact on cognitive engagement has been explored by researchers, with findings suggesting that extrinsic motivation (e.g., rewards for completing work) leads to more compliant behaviors of engagement in comparison to intrinsic motivation (e.g., where students are taking part because they want to) (Jang, 2008). Jang (2008) argues that whilst extrinsic motivations can be used as a tool to keep students on task, they do not change the attitude of the student towards the task. An extrinsically motivated student may remain on task for a reward, whereas an intrinsically motivated student will remain on task because they want to do

it. Students who are intrinsically engaged in a task will also be more likely to persist at more difficult tasks, express creativity and volunteer to take part in tasks (Walker, Greene, & Mansell, 2006). All of these factors had been included in the *Rubric of Cognitive Engagement* (Table 1), and were included in other researchers' self-report surveys (see Literature Review; Cognitive Engagement).

Self-determination theory (Ryan & Deci, 2000) is a conceptual framework that explores our motivations and the decisions we make. Self-determination theory suggests that there are a number of factors that influence the intrinsic motivation to complete a given task. Researchers suggest the following three factors influence intrinsic motivation: (1) students' perception of autonomy, (2) students' perception of ability, (3) students' perception of the importance of the activity to their learning goals (Ryan & Deci, 2000; Blumenfeld, Kempler & Krajcik, 2006). Again, these factors are also a significant part of the *Rubric of Cognitive Engagement* (see Table 1), and reflect upon researchers' findings that intrinsic motivation is key to ensuring students are cognitively motivated during a learning task (Blumenfeld, Kempler & Krajcik, 2006).

Play-based learning programs have been found to be an important tool in intrinsically motivating students during learning tasks, particularly in the younger years (Davis, 2018; Milne & McLaughlin, 2018). Play has been much explored by educational theorists, such as Vygotsky and his Theory of Social Development (Whitebread, 2012). This theory asserts that play is key in developing children's emotional and cognitive abilities, many of which are included in the *Rubric of Cognitive Engagement* (Table 1). However, there is little research that provides evidence of the impact that play-based learning has on the intrinsic motivation of students.

Therefore, to explore cognitive engagement and intrinsic motivation, the approach of play-based learning was selected. The purpose of the research was to ascertain whether play-based learning does indeed intrinsically motivate students, and what impact intrinsic motivation has on student's cognitive engagement. The New Zealand Ministry of Education (2019) defines play-based learning, or learning through play "as a pedagogical approach where play is the valued mode of learning – where children can explore, experiment, discover, and solve problems in imaginative and playful ways". The Early Childhood Curriculum, Te Whāriki, holds play-based learning at the center of its pedagogy, however, it is not a key concept in the New Zealand Curriculum document (Ministry of Education, 2007; Ministry of Education, 2019). This allowed the research to explore the possibilities of using aspects of the Early Childhood Curriculum in a Primary setting, whilst also ensuring the program implemented was culturally responsive (i.e. the learning environment catering to needs of each individual child, taking into account their cultural and learning needs) to the students within the classroom (Ministry of Education, 2007).

Research into cognitive engagement has established that intrinsic motivation can have a positive impact on a student's cognitive engagement in a task. By being internally motivated, students are more likely to place more value on the learning task, and put more effort into the task. Because play has been argued to intrinsically motivate students, this research project



aimed to test the following hypothesis: Play-based learning will increase student's deep cognitive engagement during learning tasks.

## Methodology

The research set out to explore the hypothesis as discussed above, 'play based learning will increase student's cognitive engagement in learning'. An action research approach was adopted as it allowed the research to fully emerge within the context of the learning, and the cycles of action research meant that the project could be refined to suit the needs of the participants.

*Setting and Participants:* The project was carried out in a Year 1-2 New Zealand primary classroom, that comprised of 15 students. These student's ages ranged from 5 years old to 7 years old and had been enrolled at school from a range of 2 months to 18 months. Some of these students had been part of an Early Childhood Education program prior to beginning school, however, most of these students had started school with little formal education. All students took part in the project, with new students enrolling in school during this time participating, but not being part of the data collection.

*Interventions:* To measure the difference in cognitive engagement during play-based and non-play-based tasks, students were given one play-based task and one non-play-based task as a follow-up to an instructional lesson based on the same learning intention. These were focused on the reading and writing areas of the New Zealand Curriculum. For example, one group was learning about retelling a story. For these follow-up activities, the play-based learning activity asked students to retell their story through dramatic play, and the non-play-based learning activity was to retell the story through writing the main points down. These activities were always directly after an instructional lesson, and these lessons were carried out two days apart. Each group undertook one play-based and one non-play-based task, both relating to the same learning intention each week, for 6 weeks. Play-based activities included the following; creating letters and words out of different materials, dramatic play, play through digital devices/tools. Non-play-based learning tasks included the following; book-based work, tracing letters, retelling stories through writing, completing worksheets.

*Data Collection:* There were two rounds of the action research carried out. The first cycle of action research was based around observations of behaviors and conversations. As Sinatra, Heddy, & Lombardi (2015) propose, measurement of engagement can be regarded as taking place on a continuum, starting at one end where measurement is person-oriented, focused on the individual and their physiological responses. The other end of the continuum is based around the context of the learner and how the classroom, school and culture around the student impacts on student engagement. Measures at this end include teacher ratings, observations and self-report scales. The first cycle of the action research project sat in the middle of this continuum, where the focus is on the person-in-context perspective. This means that the measures of the project were concerned with describing the context on individuals (or in this case, different groups of students). Measuring cognitive engagement within the person-

in-context method involved observing students' behaviors against the rubric of cognitive engagement (see Table 1), as well as learning conversations of students. Students were therefore video recorded during both play-based and non-play-based learning activities, with notes being recorded on the observed behaviors/conversations.

At the commencement of the second cycle of the action research project, data collection was refined to ensure that the data being collected was creating a more detailed picture of what was happening during both play-based and non-play-based learning tasks. Mullhall (2002) states that observations in the form of field notes are unstructured, in the sense that the researcher is unaware of what may occur during the observation and whilst they will have an overall idea of what to expect, this will change as the research continues. Field notes also allow the researcher to use their eyes and ears to develop more detailed observations and in turn more developed analyses of what is being researched. Therefore, students were observed in 20-minute blocks, completing a play-based and non-play-based learning task on the same learning intention. Field Notes not only require notes on observed behaviors, but also require reflections to be made by the researcher (Mullhall, 2002). This meant that teacher reflections also accompanied the observations, giving more detailed data that offered information for both research questions.

*Data Analysis:* In the first cycle of action research, the observations from recordings of learning activities and conversations were recorded. These were then coded against the rubric of cognitive engagement, as developed by the researcher (see Table 1). This meant behaviors that reflected no cognitive engagement, shallow cognitive engagement and deep cognitive engagement were coded. In the second cycle, observations were recorded in real time, with reflections made from a teacher point of view also being included. As in the first cycle, these observations were then coded using the same three categories (no cognitive engagement, shallow cognitive engagement and deep cognitive engagement). Once the observations had been coded, the data was then analyzed by the researcher, pulling out common behaviors, common types of cognitive engagement and repeating themes, through numerous examinations of the all the raw data.

## Results and Discussion

*Theme 1: Play-based learning naturally offers students more opportunities to cognitively engage with a task.* Visual representations of the data showed that students exhibited more behaviors that reflected cognitive engagement within a task. Play-based learning gave students more opportunities to manipulate, express and explore their learning in comparison to the non-play-based learning tasks. An example of this finding includes the following image (Figure 1), which depicts the coding of behaviors of one group towards a play-based task and a non-play-based task within the same learning goal. Green coding indicates behaviors of deep cognitive engagement, yellow indicates shallow cognitive engagement and the red indicates no cognitive engagement. Each of these codes were determined by the rubric as per the literature review above.

Play Based Task	Non Play-Based Task
<ul style="list-style-type: none"> <li>Students quickly start. V goes 'copy' but continues to work on his task.</li> <li>K shares with others what he is going to look for 'soccer face'.</li> <li>K says tells the others that you can make it at the beach (make a beach scene).</li> <li>A looks over at what V is doing. He moves his iPad away so she can't see anymore.</li> <li>V expresses his thinking out loud 'I should choose this one!'</li> <li>K goes to take V's iPad so that he can help. V switches it back.</li> <li>A spends this time quietly working on her own project.</li> <li>V shows frustration at one point, but he continues on working.</li> <li>V says 'I hate you! I hate you! What the ... Oh no, I can't do it!' but keeps going.</li> <li>All three students remaining on Scratch Project for 5 minutes. A couple of times they look up to see</li> </ul>	<ul style="list-style-type: none"> <li>Students quickly grab their worksheets.</li> <li>All three students are using their books - they have these open in front of them.</li> <li>A looks around at what the boys are doing and then back at her own book.</li> <li>V looks over at what the teachers group is doing.</li> <li>K remains on task, drawing. He looks at his book to help with his drawing.</li> <li>V starts randomly laughing, the others look at him but go straight back onto task. He starts talking. K joins in, bringing the conversation back onto the story they are working on.</li> <li>All three students stay on task for 3 minutes. V then looks over at A and says that she has done nothing. There is a loud noise, they all look over at what is happening.</li> <li>K calls the teacher over and asks if he likes his robot drawing.</li> <li>They then get back on task.</li> <li>Students continue on task for another 4 minutes before becoming distracted by the going ons around them. K leaves the table, V starts looking at the camera, A looks around.</li> <li>K comes back with a toy that he begins playing with. A and V then become distracted by the toy. V does try to remain on task.</li> <li>The teacher walks past and K quickly tries to hide his toy. Once she passes he continues playing with it.</li> <li>A starts writing, you can hear her sounding out words. She does not write these down though.</li> <li>V says out loud 'now we have to draw the words'.</li> <li>A and V start talking about the teacher. K has got himself back on task.</li> <li>V tells K, you should be finished now.</li> <li>The group then worries about what other students are doing on the iPads.</li> <li>V has finished his drawings and starts annoying A. He moves her work away and starts flicking around pencils. He then starts throwing objects around the classroom.</li> <li>For the next 10 minutes students remain intermittently on task, but do move around a bit and watch other students, or play with the toy that K brought over earlier.</li> <li>The teacher comes over to check on their work - the three students see her coming over and quickly look like they are on task, they hurry to get some work done. She asks 'what have we been learning do today?' The students don't answer, but make themselves look busy by doing work. She asks again 'what are learning to do?' 'We are learning to ...' V says 'helping'. Teacher asks again - with no reply. She tells them to put their work away.</li> </ul>

Figure 1: Example of Raw Data

The play-based task was more likely to have been coded for deep cognitive engagement. The most common of the coded behaviors from the developed rubric included: an increased motivation towards a task; a growth mindset towards a task; and some (not all) strategizing for learning (for example, manipulating learning, transferring learning to different contexts).

*Theme 2: Cognitive Engagement requires a range of skills that have to be developed through instructional practice and teacher modelling.* Some indicators of cognitive engagement were observed more frequently than others. For example, indicators such as intrinsic motivation towards a task and the growth mindset displayed by students, were more prevalent than other indicators such as self-regulation and strategizing for learning. This was evidenced when coding behaviors, with the majority of behaviors coded as deep cognitive engagement being related to the intrinsic motivation section of the cognitive engagement rubric, developed (see Table 1). Some of these repeated behaviors throughout the research included students continuing with a task even when it was time to pack up and students displaying and conveying their excitement for a task.

Further research into this finding suggested that indicators, such as self-regulation and student's strategizing for learning required students to use skills and behaviors that need to be taught. Students who were more able academically, or had been at school longer were more likely to use these skills. These findings are reflected in Vygotsky's theory of social development, where he states that students must be explicitly taught self-regulation (Whitebread, 2012).

Given these observations, more research was carried out around self-regulation, one of the key indicators that most students struggled to develop and practice throughout the project. Part of the play-based learning program was concerned with students' self-assessment of their

learning through learning stories, but this was not as effective as had been envisaged since students did not have the self-regulation skills to do so. Zimmerman (2002) explores the development of self-regulation in students and argues that this process requires a three-step cycle:

1. A forethought phase, where students set goals and develop self-efficacy around the task. This is often intrinsic, or that the students value the task for its own merits;
2. A performance phase, made up of self-control (use of planning in the goal setting/planning stage) and self-observation of the use of these strategies; and
3. A self-reflection stage, where students think about their successes and challenges within a task.

Whilst play-based learning aims to encourage intrinsic motivation, or self-efficacy to complete a learning task, students need support in the goal-setting and reflective part of this cycle. Teachers can develop activities that support the student performance phase, but students still need to develop the skills needed to carry out the task. Zimmerman (2002) suggests that these skills do not develop naturally and need to be modelled by parents and teachers before students can begin practicing self-regulation themselves.

*Theme 3: Play is not always enough to ensure students are intrinsically motivated.* Whilst most students were often intrinsically motivated through play, when tasks were deemed too difficult (e.g. programming on the iPads) students' motivation and engagement decreased. Students would become easily distracted, or simply state they could not complete the task and sit with their group, without completing their work. It was not until the teacher would show them how to complete the task or guide them through the activity, that these students would attempt the task.

The first round of data collection also suggested that choice could possibly impact motivation. When students were given the opportunity to work on an activity of their choice, students appeared to be more engaged. Whilst this meant that more academic learning goals were lost through choice, students were cognitively engaging with many 21st century skills, like creativity, critical thinking and communication (Scott, 2015).

As discussed in the literature review, researchers such as Ryan and Deci (2000), discuss self-determination theory as a framework that explores intrinsic motivation. The research was reflected upon against the three different areas:

1. Students' perception of autonomy - this includes students' choices in the learning they partake in and their autonomy in completing the task. This was particularly relevant in the second cycle of action research, where students were given a choice on what activities to engage in. Whilst this had a positive impact on students and their engagement with tasks and the development of skills and competencies, it detracted from the student's targeted learning goals.
2. Students' perception of ability - this includes the perceptions of students' ability to complete a task. Cognitive engagement is concerned with a student's ability to tackle more challenging learning. Play sometimes meant students were more likely to engage

with more challenging learning, however, this was also evident in non-play- based learning tasks.

3. Students' perception of the importance of the activity to their learning goals - the students were still developing the sense of importance for each task. As discussed, self-regulation was difficult to develop during the project and is part of the next steps for this project.

*Theme 4: Play-based learning offers many opportunities for students to cognitively engage with the key competencies (from the New Zealand curriculum) and other important 21st century skills.* As already discussed, as the project developed, and students were given more choice in whether they worked on play-based versus non play-based activities, the importance of play-based learning and its impact on cognitive engagement during 21st century skill building became significant. The field notes produced during the second action research cycle included many reflections on the students' use of play-based learning stations to explore the following set of skills:

- *NZC Key Competencies:* Thinking, Relating to Others, Managing Self, Participating and Contributing, Using Language, Symbols and Texts (Ministry of Education, 2007).
- *21st Century Skills:* collaborating, communicating, creating, critical thinking/problem solving (Scott, 2015).

The development of key competencies and 21st century skills is key to ensuring that our students are ready to thrive in our ever-changing world (Hannon, 2018). Personalized learning programs are key to ensuring that educators are helping to facilitate the development of key skills, such as, collaboration, communication, creativity and critical thinking (Scott, 2015).

Personalized learning has been defined as:

“instruction in which the pace of learning and the instructional approach are optimized for the needs of each learner. Learning objectives, instructional approaches, and instructional content (and its sequencing) may all vary based on learner needs. In addition, learning activities are meaningful and relevant to learners, driven by their interests, and often self-initiated” (Office of Educational Technology, 2017).

Play-based learning offers many of these attributes, as it allows students to work in a range of contexts and address learning objectives that suit the student. It offers choice on how they learn and it is also driven by the student's interests. The play-based activities fostered a natural context for students to build these skills. For example, students worked together at the building station, and during this time they collaborated to build the tallest tower, discussing ideas and problems they faced (critical thinking) whilst thinking outside the box to make their tower even taller.

## Conclusion

The findings of this action research project suggest that play-based learning does have a positive impact on cognitive engagement as students exhibited more indicators of deep cognitive engagement when working on play-based learning tasks. Students were more likely to

persist when the learning became difficult and had more positive mindsets towards the task. Students were also more enthralled with play-based learning tasks in comparison to non-play-based learning tasks.

However, there were some indicators that were less prevalent across both play-based and non-play-based learning tasks. Self-regulation and strategizing learning were less commonly identified throughout the project. This implies the need for ensuring students have received explicit teaching of these vital skills, thus reflecting the findings of Zimmerman (2002) in regards to the development of self-regulation in learning.

It should also be noted that play-based learning activities did not always guarantee the intrinsic motivation to impact cognitive engagement. In keeping with Ryan and Deci's (2012) work on intrinsic motivation, other factors, like choice and student's previous experiences that had developed perceptions of ability and relevance were also key in ensuring that students were implicitly motivated to cognitively engage with a task.

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### About the Authors

**Rebecca Anderson** is a Primary School teacher, working at Mangere Central School, in South Auckland, New Zealand. She has experience working with students from 5 years old to 11 years old, teaching all curriculum areas of the New Zealand Curriculum. *Engaging with Play Based Learning* is based around her research project for her Master of Contemporary Education, completed at The Mind Lab in New Zealand. Email: [rebeccaanderson0891@gmail.com](mailto:rebeccaanderson0891@gmail.com)

**Herbert Thomas, Ph.D.** holds a Ph.D. in Computer Integrated Education from the University of Pretoria in South Africa. He has taught English and managed both Technology and Academics in secondary schools in South Africa. He has also developed and facilitated postgraduate-level papers on the integration of technology into the curriculum at tertiary level in South Africa and in New Zealand. His current role at The Mind Lab in New Zealand involves the planning and facilitation of postgraduate papers specifically aimed at encouraging in-service teachers to adopt technology-integrated contemporary education practices in their classrooms in New Zealand. Email: [herbert@themindlab.com](mailto:herbert@themindlab.com)

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# REVISITING SCHOOL SCIENCE CURRICULUM THROUGH SCHOOL GARDENING PARTICIPATORY ACTION RESEARCH PROJECT IN NEPAL

**Kamal Prasad Acharya**  
Tribhuvan University, Nepal

**Chitra Bahadur Budhathoki**  
Tribhuvan University, Nepal

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**Abstract** The NORHED/Rupantaran project designed participatory action research to develop science curricula discourse through school gardening activities at community schools in Nepal. To this end, as a Rupantaran sub-project, looking through the theoretical lens of complexity thinking, the present study creates a venue of science learning through garden-based pedagogy. This study explored the ways schools, science teachers, and students may foster a sense of agency in school science curricula through life-based experiential learning. The findings show that such participatory and generative approaches to developing school gardening curricula is productive for science learning. The evidence from participatory action research experiences in actual school settings provides new insights for policymakers to transform school science curricula. Further, the study findings suggest ways for collaborative knowledge production through school gardening in a contextual setting, which is often a neglected area in community school science teaching and learning. The implications of the research findings could contribute to policy level discussions pertaining to science teachers' professional development. Further, this study suggests the need for practice-oriented research and studies to continuously inform the ways to improve the national level school science curricula.

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**Keywords:** teacher action research, community schools, experiential learning, participatory action research, school garden, science curriculum transformation

## Introduction

Science curricula reforms in almost all parts of the world incorporate meaningful student engagement (Fleming, Kenyon, Kenyon, & Upadhyay, 2015; Kloser, 2013; Olitsky, 2007; Vedder-Weiss, & Fortus, 2013). Almost all the science curricula in schools in Nepal give priority to areas of study rather than to practical applications. The major concern is that school science curricula in community schools in Nepal shows epistemologically theoretical understandings (Acharya, 2016). Due to the lack of practical activities and the lack of skills development through real field experience, the desired change put forward to reform science curricula keeps an emphasis on garden-based science pedagogy. To address this need of transformation, in recent years, the

Ministry of Education, Science and Technology (MoEST), Government of Nepal (GoN) has prepared *Green School Guidelines* based on draft education policy *One Garden One School* to reform school science pedagogy throughout the country. This highlights the need for urgent improvement in students' and teachers' capabilities to develop skills, specifically *hands-on learning and teaching* through gardening activities. Science learning using school gardening activities is an immediate initiative in Nepal. Activity-based instruction in teaching and learning science helps to strengthen students' higher-order cognitive skills, such as analyzing science content and creating original thought as well as increasing knowledge (Denzin & Lincoln, 2008). In this context, Acharya (2018) suggests that students exposed to hands-on science instruction frequently achieve significantly higher scores in science than those students who experienced only minds-on activities in learning activities. Also, the policy reform documents the value of activity-based instruction through school gardening activities (Robinson, 2018).

## Literature Review

Science teachers in Nepal schools need to help students explore scientific ways of talking about *everyday practices*. They should, also, provide them with opportunities to engage in scientific discourse. Discourse between the teachers and students, with the curriculum based on school gardening activities, helps to develop new insights for learning science. Developing classroom discourse is arguably one of the greatest challenges facing teachers in the classroom (Robinson, 2018). The existing science curriculum and instructional practices provisioned by the National Curriculum Framework (NCF) has given priority to engaging students in meaningful science learning. As a school science teacher and a university science teacher educator, I am continually facing the challenges of augmenting the level of discourse in my classroom by engaging students in hands-on activities such as the study of leaves, roots, locomotion of earthworms, and measuring the pH of water and soil.

As co-researchers in participatory action research (PAR), we believe that science learning is conceptually significant when we are able to engage students in the school garden. Learning occurs in action and involvement starts with the relationships (Ping, 2015; Watts & Pajaro, 2014). My assumption as a co-researcher in PAR is that action and experience are the basis for knowledge. This research seeks to understand how students and teachers collaborate in transforming teaching and learning activities to (i) support students' learning by engaging with a school garden; and to (ii) co-create knowledge through garden-based activities. In crafting the responses to this inquiry, we (I as a co-researcher, students, and teachers) adopted two approaches: (i) learning through action (de Beer, 2018; Lee & Yang, 2019); and (ii) participatory action research, completing work on observe-plan-act-reflect phases (Boog, Slager, Preece, & Zeelen, 2019; Chevalier & Buckles, 2019; Mirra, Garcia, & Morrell, 2015).

From a theoretical perspective, I reconsidered Laudonia et al., (2018) when looking at how students engage in action learning, a pedagogical process that involves learners working and reflecting together on real situations in the students' work setting. PAR is a research process wherein students participate in actions both as subjects and objects with the explicit intention of bringing about change in the setting under study (Acharya, 2019; Laudonia, Mamlok-Naaman, Abels & Eilks, 2018). In this reflection, as a part of PAR, I explored how action learning accomplished the cycle of PAR based on the objective of converting experience into practical

learning. It completed the cycle of engaging in research, based on experience to co-create knowledge.

From a practical standpoint, we found many instructional strategies and practices that promoted the value of experiential learning by the meaningful engagement of students in the garden. Teachers used experiential activities to simulate real-life experience (Lewis, Herb, Mundy Mccook & Capps-Jenner, 2019). These real and practical endeavors, often referred to as experiential learning, can be quite effective in giving students an opportunity to use concepts in action. Connecting learning through experience, in reference to the works of Dewey, discusses that reflection plays a central role in the learning process and is vital for making meaning of the experience (Feldman & Rowell, 2019). When given ample freedom to engage in experiential activities, students actively construct the necessary knowledge to make sense of their environment (Maibaum, 2017). Research participants took part in adequate discussion and argumentation to develop the garden-based curriculum. Knowledge exploration in PAR advocates democratic relationships (Feldman & Rowell, 2019) between research participants.

We focus this article on the PAR methodology to create garden-based pedagogy for providing teachers and student-researchers with a tool that may lead, in conjunction with a framework for discussion for curriculum change, to a better understanding of how student engagement and interactions promote meaningful learning.

*Research Question.* The research question is: How can active student engagement utilizing a school garden expand scientific conceptualization through a contextual curriculum in a basic level community school in Nepal?

Tribhuvan University and Kathmandu University from Nepal, in collaboration with the Norwegian University of Life Sciences (Norway) has initiated the *Rupantaran* project (*Transformation in the Nepali language*), 2016-2021, entitled 'Innovation in Teaching and Learning through Contextualized Approaches to Increase the Quality, Relevance, and Sustainability of Education in Nepal'. NORAD funded this project to work with innovative, participatory, and rights-based approaches to improve teaching and learning outcomes of basic school students through community empowerment and sustainable improvements.

## Methodology

*Research Design and Research Participants.* A qualitative research design was used in this study based on the PAR approach. The participants of this research study included one hundred and forty students (6<sup>th</sup> and 7<sup>th</sup> graders) of an action school (Intervention school in participatory action research) and two science teachers teaching at the same level. Science teachers were experienced in their field and had taken nine months of teacher professional development training conducted by the Ministry of Education, Government of Nepal. Teachers were innovative in their own teaching practice as they had been trained in activity-based learning, however, they were lacking the self-confidence to participate in, and actively contribute to learning from school gardening activities. Also, they were lacking the confidence needed to

prepare contextual science curriculum based on school gardening activities with collaboration from the students.

We conducted this research within a rural community school located in Province 3, Chiwan, Nepal. At the beginning of PAR in the action school, sixth and seventh graders and teachers were invited to participate in a series of dialogue conferences in workshops, formal and informal conversations, and interviews conducted within and outside the school premises. The school head teacher, science teachers, and students participated in the workshops before and after the gardening experience. Out of the one hundred forty student participants, one hundred thirty accepted the invitation. Of the ten remaining, six eventually decided to participate and four chose to abstain from the gardening activities, referring to an untidy working situation with the soil in the garden.

*Data Collection Instruments and Analysis.* Participant observations, dialogue conferences in workshops, field notes during students' gardening activities, and conversations with the teachers and students were the major tools used for collecting data. Four dialogue conferences in workshops and twelve participant observations were conducted as the main method of data collection in the form of a qualitative approach. The recordings of our meetings were transcribed and analyzed using the theory of practice architectures. The reading of Habermas (1987) encouraged me to use communicative spaces as ideal in planning meetings. The progress of work followed the cyclic process of PAR via observing-planning-acting-reflecting (Hearn, Swan, & Geels, 2019; Tracy, 2019) where different steps may not always follow a chronological order. In the workshops, the main themes and concepts were discussed thoroughly and systematically. As a participatory action researcher, another ambition, linked to communicative space, was to establish a broader understanding of others' point of view and to achieve *unforced consensus* about what needs to be done to improve practice. The unforced consensus is an agreement that is not mandated upon anyone. According to Armstrong and Tsokova, (2019) only democratic dialogues between the research participants are useful for finding solutions in the workshops and conversations regarding school gardening activities. In all phases of PAR, every research participant was given an opportunity to speak freely and given time to reflect on, and bring to light, diverse opinions and understandings. Different tools and techniques designed to promote reflection and dialogue were used (Brydon-Miller, 2018; Denzin & Lincoln, 2008; Lorenzetti & Walsh, 2014).

Data were focused on the teaching and learning activities performed by the teachers and students in the garden, interactive dialogues, and preparing the garden-based sample curriculum. Reflective field notes from workshops, observations, and conversations were transcribed, translated, and analyzed using thematic content analysis. Themes emerged from the data through a process of open coding. Open coding involved reading, re-reading, and reviewing the transcripts five times, while writing notes and codes in the manuscript to describe all thematic content. Codes were transcribed into a coding sheet and formed into categories. Finally, thematic content analysis was performed in which data were coded to identify emerging themes and patterns which were then categorized and interpreted according to their relationship to the research question and theoretical perspective. Also, participant

observation and conversations were conducted during school gardening activities. Detailed field notes from all observations, conversations, and dialogue were recorded.

Since all data were collected in the Nepali language, the data analysis was performed in Nepali. During data analysis and write up of the manuscript, the original Nepali quotes were used as much as possible to prevent losing meaning as a result of translation. The quotes in the final manuscript were translated by the first author and checked by the second author.

*Co-researcher (first author) Positionality.* As a school science teacher and a university teacher educator, I have used reflections from my own teaching, learning styles, and practices. As an educator researching the practices of teachers, my research is rooted in science pedagogical orientations, yet I am uniquely positioned, as Greene (1993) has stated, as a stranger in a classroom that is not my own (Robinson, 2018). I describe my own positionality as an insider in collaboration with other insiders, having the benefit of entering this research space with new views to observe students, as a stranger might for the first time, look inquisitively and wonderingly on the world in which he lives (Greene, 1993, p. 93).

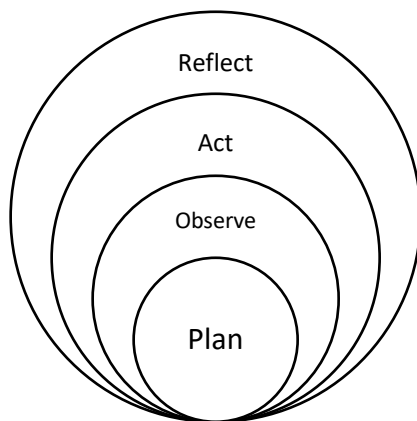


Figure 1: Nested Research Phases

*Action Research Practice: Participatory Collaboration.* In determining this participatory action research design, we maintained a cyclic thinking perspective for the research phases, with a view to the participatory and cyclical process (Carr & Kemmis, 1986; Nyanjom, 2018), wherein new knowledge arises out of actions and, in turn, informs new actions. Our design for the research cycles involved four key phases. Figure 1 shows nested circles identifying the phases of PAR and indicates how each phase arose from and embodied the previous one.

Considering the phases of the PAR, the following activities were done in collaboration with the students and science teachers.

*Observing and Planning: Dialogue Conferences through Collaborative Inquiry.* To begin PAR in an action school, planning was done to analyze the science curriculum, science textbooks, and

possible school gardening activities. The action school's needs, in terms of its probable garden area, classroom facilities, science laboratory, and science performance scores in the class of six and seven graders were explicitly studied. The existing problems in teaching and learning science with grade six and seven students and the gaps in actual classroom teaching and learning activities were explored. The science curriculum was analyzed in terms of its content, objectives, activities, and assessment techniques by meaningfully engaging students and teachers through a series of dialogue conferences in the workshops.

Students shared their experiences with the science teachers and the first author through power point presentations and by taking part in dialogue conferences in the workshops. Students and teachers designed and implemented sample curricula based on school gardening activities as a part of the teaching and learning experience. Also, science teachers were committed to applying students-designed curriculum in their further teaching. Research participants prepared the guidelines to frame the sample garden-based curriculum under the themes of science curricula, activities and learning science (Appendix A).

Different topics such as pH of soil, moisture level in the garden soil, soil textures, filtration and decantation processes, plant types based on leaves and roots, seed germination, compost manure preparation, photosynthesis, and transpiration processes were linked to the school gardening activities. The role of green plants for environmental conservation and their importance in human life can also be studied in the school garden. All these teaching-learning activities were linked with school gardening activities by the collaboration of science teachers. Intervention guidelines were prepared for research participants in the intervention phases of PAR. In the planning phase of PAR, they prepared the curriculum components and learning outcomes with detailed descriptions for effective implementation of school gardening activities (Appendix B).

To implement the garden-based curricula, students and science teachers have chosen an open area beside the main school building. They selected a garden site that would provide enough sunlight, water, and good quality clay for planting. Students prepared sample curricula based on the themes and topics, learning outcomes, and gardening activities gleaned from the series of dialogue conferences in the workshops (Appendix C). Based on the prepared sample curricula (Appendix B), learning outcomes were designed through the cooperation of students and science teachers.

Learning activities and a sample curriculum linking various gardening activities was prepared by students and science teachers working together. Curricula was prepared in the planning phase of PAR approach (Appendix D).

Based on the PAR (plan-observe-act-reflect) phases, a sample curriculum was prepared with the collaboration of science teachers and students. Garden-based science curricula was prepared through democratic dialogues and collaborative inquiry of PAR researchers, science teachers, and students.

*Acting Phase: Garden Intervention.* School gardening and intervention activities according to the PAR approach, began by using the experiences of research participants. This is the third phase of PAR in which sketches of the school garden were designed by 6<sup>th</sup> graders from a dialogue conference in a workshop. One of the best sketches was selected by teachers and students through democratic dialogues. The school garden was designed to grow vegetables and flowers. Themes for the school gardening and science curricular outline were prepared by students and teachers in collaboration (Table 1).

*Table 1: Details of Participatory Intervention Guidelines*

INTERVENTION TOPICS	FROM THE STUDENTS' NOTEBOOK	SCIENCE CONCEPTS
<b>ONE PERIOD (45 MINUTES) PER WEEK. ONE PERIOD FOR THEORY AND ONE PERIOD FOR PRACTICAL LEARNING IN THE GARDEN</b>		
<b>SOIL IN THE GARDEN TYPES OF SOIL</b>	Soil is crucial to life on Earth. Soil can be defined as the organic and inorganic materials on the surface of the earth that provides the medium for plant growth. Soil develops slowly over time and is composed of N, P, Na, K, etc. Weathering is the mechanical and chemical process by which rocks are broken down into smaller pieces. As rocks are broken down, they mix with organic materials that have originated from living organisms.	Meaning of soil, the process of soil formation, weathering, minerals, decomposition
	Sandy soil consists of small particles of weathered rock. Sandy soil is one of the poorest types of soil for growing plants because it has very low nutrients and does not hold water well. This makes it harder for the plant's roots to absorb water.	Types of soil. sandy soil, silt soil, clay soil and loamy soil
	Silt soil has much smaller particles compared to sandy soil and is made up of rock and other mineral particles which are smaller than sand and larger than clay. It is this smooth and quite fine quality of the soil that holds water better than sand. Silt soil is more fertile compared to the other three types of soil.	
	Clay has the smallest particles, tightly packed together with each other, and with very little or no airspace. This soil has very good water storage qualities, making it hard for moisture and air to penetrate it.	
	Loam is the best type of soil, formed by the combination of sand, silt, and clay. It has the ability to retain moisture and nutrients; hence, it is more suitable for farming.	

**TWO PERIODS PER WEEK (TWO PERIODS FOR SOIL PH AND TWO PERIODS FOR COMPOST PREPARATION). TWO PERIODS WERE ALLOCATED FOR THEORY AND TWO FOR GARDEN-BASED PRACTICAL ACTIVITIES.**

PH SCALE & SOIL PH

The pH scale was used to measure how acidic or basic the soil is. pH scales range from 0 (most acidic) to 14 (most basic). Pure water is neutral (pH 7). Soils with pH below 6 are considered acidic and above 8 are considered basic. We found that the pH of the garden soil was 6.5 which showed us that the garden soil is slightly acidic.

Acid, base, neutral, pH scale, and pH

**TWO PERIODS/WEEK (ONE WEEK'S LESSON)**

COMPOST

Compost manure is good for farming. It makes the soil fertile. Students collected compost manure from home for the garden. Later on, they started preparing the compost for decomposition by adding leftover food items, fruit peels, leaves, and dry grass available from the school.

Compost manure, the fertility of soil, decomposition, earthworms, organic substances

*Reflecting Phase: Assessing Where We Are.* In the last phase of PAR, students' activities were observed by science teachers and the teachers' activities were observed by the co-researcher. Major events were recorded in each phase. For the science teachers, gardening activities provided critical reflective opportunities for science teaching opportunities. As a new methodology, the school garden significantly opened up discourse to more meaningful exchanges. These were documented through observation, field notes, and increased student-to-student interactions with meaningful engagement through hands-on activities. Students demonstrated more sustained lively activities and accountability towards learning science with and without the presence of science teachers. For the researcher, garden-based activities provided an opportunity to see students learning science. Through the collaborative inquiry and with democratic dialogues, the PAR researcher and the science teachers gained a fuller understanding of the process as they watched and listened to the students share, build, and ultimately explore knowledge together.

After six-months of continuous engagement in the school garden, the action school was exemplifying overall academic quality in science teaching and learning. We (the teachers and the first author) noticed the transformation in science pedagogy from the silent mode of the lecture method to activity-based learning through outdoor activities. All gardening activities were linked to the garden-based science curricula and also linked to real learning through participatory action research.



## Results

The present study provided a rich insight into how science teachers and students may conceptualize and facilitate the concept of experiential learning from the garden. The findings relating to curriculum construction based on school gardening activities proposed by this study are an important aspect, going forward, in designing and implementing science curricula based on the *One Garden One School* education policy in Nepal. The knowledge of praxis (knowledge in action) flows from the position that action and reflection are inseparably amalgamated. And the school can transform teaching and learning science from the silent method of lecture to an activity-based pedagogy. This study, in the community school in Nepal, draws connection between action and reflection, specifically gardening activities and transforming science pedagogy with the curricula developed by the students and teachers. Students' garden experiences led to critical consciousness and could then lead to further action in transforming science pedagogy in the community schools in Nepal.

Students, generally, had a positive attitude towards learning science through school gardening activities and they frequently used a garden to link science and learning. One of the students shared his experience in this way: "The school garden provides first-hand experience for learning science and I will never forget what I studied in the garden." Similarly, another student stated:

The school garden is an important experiential class that engages us in a variety of science learning activities. Measurement of pH of garden soil, identification of layers of soil, separating humus from the sandy soil, and the importance of compost manure for the growth and development of plants are only a few topics that we learnt from the school gardening activities.

During gardening activities, students learned real-world science applications by measuring plots and recording the growth of plants. As they worked with the collaborative inquiry, they learned to care for living things and developed important discipline and collaborative life skills such as patience, responsibility, co-operation, and understanding. Science teachers believe the gardening program definitely helps in teaching science by meaningful engagement of students in the activities. Also, the school gardening program has grown further to engage students through learning from the school garden campaign, which aims to transform science pedagogy in community schools in Nepal. In working with science teachers, one of the students shared this, "Experiences change over time in engaging in the school garden activities." She further stated that "Garden activities make us realize the importance of school garden and I think it is important to provide a real taste of learning". After engaging in the garden for more than a week, she is now eager to pursue more areas of study related to garden activities. Her activities, after intervention, showed that she had developed the skills needed to handle tools and seedlings. She began to see herself as one of the members in the learning community. Through reflective dialogue conferences with the other students and the co-researcher, she became aware that her activities were part of the entire group's learning activities.

Also, the school head teacher appreciated the use of the school garden for the overall physical, mental, and social wellbeing of students. Furthermore, it was found that involving students in soil preparation, solid waste management, compost preparation, planting crops, and harvesting techniques made the science content more understandable. At the same time, science teachers linked curricula in an integrated approach with gardening activities. It became a perfect learning opportunity for students. It was found that science teachers were happy to share the work they had done collaboratively with the students in developing the 'garden-based science curricula.' One of the science teachers in an informal conversation stated:

Today I am happy. We are applying a newly framed garden-based science curriculum to fulfill the learning objective and our work is being recognized. Our curriculum is functioning. It works effectively. I am able to design curriculum and implement it in teaching science.

Another science teacher sharing in a dialogue conference after intervention in the garden said this:

The newly framed sample science curricula contain gardening activities to maximize students' exposure to learning chemistry such as pH of the soil, types of soil, humidity, nutrients, and air, water, and soil minerals. School gardening activities such as planting, tending, harvesting, preparing, and then linking to the science curricula were completed by the continuous engagement of students and teachers.

Overall, the participating students shared their perceptions about the school gardening activities in a positive way. Research participants had a chance to appreciate the way in which theory and practice link, to investigate their implicit theory, to construct collective knowledge, and to participate in reflective practices. It was also found that PAR is useful for teachers' professional development and it can reveal changes in the teachers' discourse throughout an academic session.

## Discussion

This study aimed to revisit the school science curricula through school gardening PAR activities and collaborative inquiry among the students and teachers in the community schools in Nepal.

The qualitative research on framing science curricula based on school gardening that does exist, has focused on students' and science teachers' gardening experiences, mainly reporting constructive gardening experiences (Block et al., 2012; Bowker & Tearle, 2007; Rodriguez et al., 2015; Somerset, Ball, Flett, & Geissman, 2005). However, none have shed light on the role of local people and their ideas and suggestions for improvements in designing science curricula using school gardens. As students are the main intervention manipulators, given an occasion to opine their understandings on what they believe works and what does not, exceptional contributions for school gardening activities and developments can be gleaned.

Consistent with previous participatory action research on students' gardening experiences (Block et al., 2012; Rodriguez et al., 2015; Somerset, Ball, Flett, & Geissman, 2005), this research

study illustrates that science teachers and students were passionate about learning science when gardening and the curriculum they had prepared were linked with science curriculum. Similarly, Acharya, Budhathoki, Bjønness, & Jolly, (2020) argued that school garden is an excellent venue for activity-based science learning. Similar to findings by Passy (2014), students undoubtedly preferred school gardening activities for learning. Indeed, earlier research has shown that school level students desire activity-based science learning over lecture methods, and when activity-based methods are used, the students develop a more constructive outlook towards learning science (Lawton, 1997; Selim & Shrigley, 1983). On the other hand, the head teacher did not like such activities because they presented a problem with managing extra periods for the gardening activities.

Result of this study indicated that student's main impetus for engaging in the school gardening science learning is 'having fun', which is similar to the result found by Bowker and Tearle (2007). This PAR was directed towards real-life activities to co-construct collective wisdom by the meaningful engagement of students and science teachers in the school garden. It was similar to the study done by Acharya (2019) which showed that learning by doing and learning by living are the purposes of science learning through school gardening activities. It transforms teaching and learning science from the lecture method to the activity-based method as Indraganti, (2018) argued in agreement. Furthermore, this research could lead science teachers to contribute to resetting the possible ways of involving students in activity-based learning by constructing an activity-based curriculum (Jacobs, 2018; San Antonio, 2018). Also, this research suggests there is potential for educational reforms in teaching and learning in the community schools throughout Nepal. School gardens and science learning collaborative activities could enable teachers to transform the rooted structure prescribed by policy to move teaching and learning forward. In this connection, Lewis, Herb, Mundy-McCook & Capps-Jenner (2019), found that participants in action research explore life-enhancing pedagogy. This conclusion has significant implications that could guide science teachers and school head teachers in developing new and innovative approaches to science learning with the garden.

In addition, designing school curricula through the collaborative inquiry of teachers and students proved to foster better understanding of how learning approaches help students gain a sense of pride. Furthermore, this study may help to shift the perspective of science in school education. By using the term, *a transformative perspective* (Acharya, 2018; Worthen, Veale, McKay, & Wessells, 2019; Seniuk, Ingram, Friesen, & Ruth, 2019), I mean that students and teachers involved in PAR share their perspectives through dialogic conferences, trying to reshape shared perspectives and construct new values. The teachers then, interconnect what we value concerning knowledge adoption. In this line, McNiff (2014) explains that "the capacity to negotiate values should be the main criterion in action research" (p. 181). It needs to find out how science teachers cooperating in PAR in gardening activities, can encourage students to transform by participating in hands-on activities (Kafyulilo, 2018; Otienoh, 2015; Whalen, 2016). This may be a topic for my further research.

Also, we hope that PAR to some extent may transform the silent mode of science teaching in a teacher dominated classroom to the collaborative and active engagement of students outside

the classrooms in exploring science. We hope that this study will act as an invitation to other school science teachers, the officials of Curriculum Development Centre, researchers in relevant fields, and policy-makers to engage in public debate about the current science education curricula, where teaching and learning in a classroom context has been constantly influenced by dogma. We also hope that such open debates will lead to suggesting a new perspective on science teachers' professional development programs that are more teacher-centered and based on a bottom-up approach.

## **Implications**

This research has several implications for transforming the silent mode of school science teaching to activity-based learning through gardening activities. First, it seems important to focus on the involvement of students in open ground, as teachers think this is important (Katsarou & Sipitanos, 2019; Ping, 2015). The potential to work in an environment safely and with no fear needs more emphasis (Kapoor, 2019). Second, to increase the effects on the students' learning behaviors it will be important to involve science teachers in making the school garden attractive and colorful. Furthermore, it is recommended that there be better integration of the school garden into the science curricula.

## **Conclusion**

Although the action school in this study has a school garden, the perceptions towards the school garden and perceived problems and barriers for the implementation were overall similar. In general, science teachers and students were positive about the school garden, but encountered some practical issues which needed to be solved to improve efficiency. The findings of this study have led to recommendations and tips for future school garden practices.

This study gives valuable insight into the implementation, practices, and perceptions of students and science teachers towards school gardening activities for science learning, however, it also has some limitations. At first, the school science teachers shared that time constraints were the main reason for not participating in daily gardening activities. Second, the action school is located near a town area, which may limit generalizability to schools in rural regions. A third limitation is that participating students were selected only from grades 6 & 7 based on literature and experts' suggestions, which could have resulted in bias as it is possible that the most motivated students are only from grades nine and ten.

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### About the Authors

**Kamal Prasad Acharya** is a lecturer of science education, Department of Science and Environment Education, Central Department of Education, Tribhuvan University, Kathmandu, Nepal. He is a PhD fellow of NORHED/Rupantaran project under the Graduate School of Education, Faculty of Education, Tribhuvan University, Nepal. His area of expertise is science teachers' professional development, inquiry-based learning through school gardening for sustainable society through participatory approaches. He would like to thank Birgitte Bjønness (Norwegian University of Life Sciences, Norway) for providing scholarly guidance and correction in this paper. Email: kamalacharya@tucded.edu.np

**Chitra Bahadur Budhathoki** is a professor of health education, Central Department of Education, Tribhuvan University, Kathmandu, Nepal. Interests of his research include teaching school health education, health and hygiene behavior of children and communities, and curriculum integration. His current research focuses on change in health and hygiene behavior of school children through participatory approaches. Email: cbbudhathoki@gmail.com

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**Appendix A: Gardening Science Curriculum Outline**

THEMES	STUDENTS' ACTIVITIES
<b>SCIENCE CURRICULA</b>	<p>Science curricula and sustainability, the local context for science learning.</p> <p>Sustainable agriculture at school and science learning.</p> <p>Dialogue conferences, workshops, and discussion on school gardening and science learning.</p>
<b>ACTIVITIES</b>	<p>Garden site selection, soil and compost preparation, seed preparation, and planting.</p>
<b>LEARNING SCIENCE</b>	<p>The pH of soil, filtration, decantation, sedimentation processes. Identify types of roots, leaves, and seeds. Soil types, their nature, and composition.</p>

**Appendix B: Garden-based School Science Curriculum, A Sample**

<b>COMPONENTS</b>	<b>DESCRIPTION</b>	<b>LEARNING OUTCOMES</b>
<b>CURRICULUM TITLE</b>	Science curricula have different units linking science learning with gardening activities.	To explore science contents with school gardening activities.
<b>UNDERSTANDING GOAL</b>	Articulating a goal at the beginning of each unit for understanding.	To explore the types of flora and fauna in the garden of community schools.
<b>PERFORMANCE TASK</b>	The performance task is context-based in which each student discusses, observes, and plays in the garden.	To work together to create a model school garden to support science learning in the schools.
<b>INFORMATION</b>	This section provides background information on the content.	Understanding more about how gardening activities and growing vegetables are linked to the science curricula. This provides an alternative way to study science through activity-based instruction.
<b>ACTIVITIES</b>	These are suggested activities for use in delivering the content knowledge and skills necessary for students to accomplish their performance task and meet the understanding goal.	Visit the school garden as a classroom to observe, collect, and demonstrate to the students in the presence of teachers. And finally, link it to the science curriculum.

**Appendix C: Activities and Learning Outcomes**

<b>SOIL TYPE</b>	<b>LEARNING OUTCOMES</b>	<b>ACTIVITIES</b>
<b>CLAY SOIL,</b>	To identify the types of soil on the basis of the size of soil particles.	Find soil pH, collect biodegradable materials in a pit, collect earthworms and put in the pit, mix compost manure in the soil, supply water, discuss, write-up, and present.
<b>SANDY SOIL,</b>	To identify humus content in the soil.	
<b>SILT SOIL AND</b>	To separate biodegradable and non-biodegradable solid wastes.	
<b>HUMUS</b>	To prepare compost manure by decomposing biodegradable materials.	

**Appendix D: Curricular Outcomes and Activities**

<b>PLANT PARTS</b>	<b>LEARNING OUTCOMES</b>	<b>PLANT MATERIALS</b>	<b>ACTIVITIES</b>
<b>ROOT</b>	To identify the types of roots. To collect types of roots and discuss.	Onion, garlic, radish, grass, rose, marigold, spinach, coriander leaves, tomato, short and long beans	Prepare soil, mix compost manure in the soil, prepare dams, collect types of plants, observe, discuss, write up, sketch, and present.
<b>STEM</b>	To explain the functions of the stem. To classify the types of the stem of dicot plants.		
<b>LEAF</b>	To describe the functions of a green leaf. To identify the types of plants on the basis of age. To collect different types of leaves and prepare herbarium.		
<b>FLOWER</b>	To recognize flowers as complete or incomplete. To observe the flower in the garden and draw its parts. To identify the types of flowers in the school garden.		
<b>FRUIT</b>	To identify the types of fruits from the school garden. To collect and eat fruits.		
<b>SEED</b>	To identify the types of seeds. To make a seed chart on paper and display on the wall. To germinate the seeds in the garden soil/glass and study radicle and plumule.		

# USING PREP, A PRIMARY READING ENGAGEMENT PROGRAM, TO MOTIVATE PRIMARY STRUGGLING READERS

**Jeannie Votypka**  
**Baldwin Wallace University**

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**Abstract** Primary students who struggle to read need incentive to direct their mindset onto the productive path of daily reading. Reading is daunting to the youngest readers who experience difficulties because the act of reading is difficult and tiresome. Effective reading engagement programs motivate these readers to read on a daily basis and accomplish grade level reading achievement. This study explored the reading motivation, reading frequency and reading achievement of 16 struggling readers in grades 1-3 involved in PREP, a primary reading engagement program. The core areas of foci within PREP include contingent reward, book choice and parental involvement alongside reading frequency as an ongoing aim of the program. Using mixed-methods research methods, the researcher investigated the relationship and the changes that take place over time between reading motivation, reading frequency and reading achievement for students in grades 1-3 participating in PREP. The study's results indicate that participants ( $N=16$ ) involved with PREP had higher reading motivation, reading frequency and reading achievement after participating in the program.

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**Keywords:** teacher action research, reading motivation, reading engagement, contingent reward, reading incentive program

## Introduction

Reading engagement programs are effective in building motivation for young readers, particularly those with reading difficulties. More engagement with reading means higher achievement (Cambria & Guthrie, 2010). The goal of these programs is to increase time spent reading which increases reading comprehension and hopefully leads to a lifetime love of reading. Becker, McElveny and Kortenbruck (2010) wrote of the importance of enabling early experiences of reading competence, highlighting that students lack motivation because they do not experience progress and competence. The researcher's professional experience of teaching young children to read for fifteen years informed her that reading engagement programs motivate young readers who experience difficulty in reading and set them on a successful road of intrinsically motivated reading.

With student motivation in mind, a reading engagement program was developed-PREP-Primary Reading Engagement Program that is successful in motivating struggling, primary students to read. How does PREP work? Teachers use repurposed rain gutters to display books on many

topics and levels. Students choose a book each Monday to take home for the week and practice with their parents. This display approach and many choices available make students very excited about reading.



Figure 1: PREP Library Book Display

With PREP, students receive a reading practice bag to take home nightly. The bag contains the chosen book along with a folder that holds a reading log that parents sign and a reading progress monitoring chart.



Figure 2: PREP Practice Bag and Contents

Once a student reads five times, they earn a reward. This reward is very different from other rewards teachers use in the classroom. It is called contingent reward. These scratch off rewards reveal activities directly related to reading such as reading in the cozy chair, buddy reading, playing a reading game or reading to the principal to name a few. These contingent rewards are directly related to reading and create an intrinsic motivation to read among students.



Figure 3: PREP Contingent Reward

Students become their own advocate in their reading development by consistently reminding their parents to read with them at home, every day. Most former students have developed a daily reading habit due to the consistency of this program. Many current students achieve grade level reading quickly when they follow the program with fidelity. See Appendix A for a detailed description of the PREP Teacher Manual with pictures and directions.

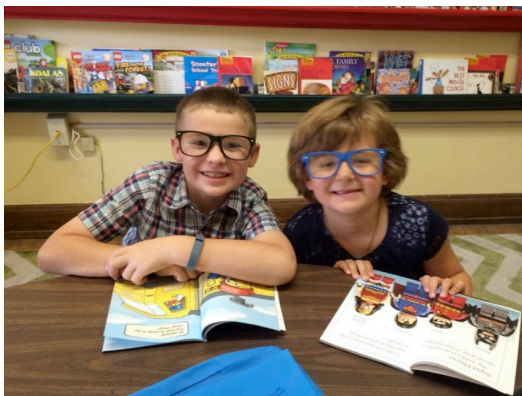


Figure 4: Happy, confident readers!

## Literature Review

The literature review aims to provide an understanding of the importance of reading motivation related to reading frequency among primary students who struggle to read. It begins with a review of motivation related to reading. Fawson and Moore (1999) determined the two types of motivation that foster engagement in reading are extrinsic and intrinsic motivation. The review proceeds to analyze reading incentive programs. Marinak and Gambrell's (2008) hallmark study found that students who were given a book as a reward and



students who received no reward were more motivated to engage in subsequent reading than students who received a token reward. Small, Arnone, and Bennett (2017) clarified that contingent rewards given to students with low intrinsic motivation involved in public library reading programs can have long-term positive impact. The review proceeds to explore reading frequency and its effect on reading motivation. Guthrie, Wigfield, Metsala, and Cox (1999) conducted a two-part study to investigate the contribution of motivation in reading amount and text comprehension with third- and fifth-grade students. Results from the study indicated that reading motivation was directly predicted reading amount. The importance of book choice related to reading motivation is analyzed within the review. According to Krashen (1993), students who choose what they read and have an informal environment in which to read tend to be more motivated, read more and show greater language and literacy development. Teachers also like to provide choice in the classroom because they believe that it increases motivation, effort and learning (Flowerday & Schraw, 2000).

This review also outlines the importance of parental involvement of struggling readers playing a crucial role in their child's reading motivation. Baker (2003) studied the role of parents of struggling readers and concluded that supportive home environments may foster reading motivation (Leseman & De Jong, 1998; Sénéchal, 2006). The review also highlights effective literacy instruction that involves the interacting relationship between motivational supports and best practices in literacy instruction that encourage powerful, varied motivations for reading that enable students to acquire reading proficiency (McRae & Guthrie, 2009).

Finally, the review explains contingent reward, reading frequency, book choice, and parental involvement which are the motivating supports of PREP, a powerful reading engagement program that motivates primary struggling readers. These factors, when effectively used together, promote intrinsic motivation for struggling readers in the primary grades.

## **Theoretical Framework**

This study focused on how reading motivation has been defined within the framework of social cognitive theory, which construes human functioning as a series of reciprocal interactions between personal influences (e.g., thoughts, beliefs), environmental features, and behaviors where self-efficacy is a central construct (Bandura, 1997). Social cognitive theory considers the way in which individuals acquire and maintain behavior, while considering the social environment in which individuals perform the behavior. The theory takes into account a person's past experiences, which factor into which behavioral action will occur. These past experiences influence reinforcements and expectations, all of which shape whether a person will engage in a specific behavior and the reasons why. Bandura conducted groundbreaking studies focused on the social origins of self-motivation and self-regulation in children. Bandura first defined the term *self-efficacy* as beliefs surrounding the personal ability to produce specific levels of success in accomplishing a task.

Expectancy-value theory also frames this study. Wigfield and Eccles (2000) explain through their expectancy-value theory, that young children's beliefs toward reading ability are directly

related to their own expectations of success. Wigfield (1997) reviewed two studies that measured reading motivation and concluded that children's beliefs and values actually determine their performance and persistence in reading.

The study was framed around the themes related to PREP, the independent variable. The first theme of PREP is contingent reward related to the reading motivation of primary struggling readers. A perspective taken into account when considering contingent reward for the study was the reward proximity hypothesis (Gambrell, 1996). The reward proximity hypothesis suggests that the more proximal the reward is to the desired behavior, the less undermining it will be to intrinsic motivation. The second theme of PREP is book choice related to the reading motivation of primary struggling readers. Students have the choice of picking among many books, both fiction and non-fiction, and magazines at their instructional reading level. eBooks are also used regularly to build reading motivation. This practice creates interest among primary struggling readers because the topics of the reading material are tuned into their interests. The final theme is parental involvement regarding reading frequency related to the motivation of primary struggling readers. Without parental involvement, primary students have little motivation to read because reading on their own is difficult and tiresome. Without a parent's involvement, young students have little chance of developing a daily reading habit on their own. A parent's involvement is crucial in developing motivation to read among primary struggling readers.

## Methodology

*Context for the Current Study:* The author, a reading specialist and doctoral student, wanted to study a reading engagement program she developed over seven years within her classroom. This study achieved its purpose through the use of a mixed methods design research to gain an in-depth understanding of the topic. Two research questions, one quantitative and one qualitative, were utilized. The quantitative question within the study is: What is the relationship between reading frequency and reading achievement on reading motivation for primary struggling readers involved in PREP? The qualitative question within the study is: What are the impacts of PREP on reading motivation, reading frequency and reading achievement among primary struggling readers? Table 1 displays the research questions, methodologies, data sources and data analyses.

*Table 1: Summary of Mixed Method Design*

Research Questions	Methodology	Data Source	Data Analysis
<b>1) What is the relationship between reading frequency and reading achievement on reading motivation for primary struggling readers involved in PREP?</b>	Quantitative	DIBELS	Pre and post DIBELS measurement-dependent t test
		Reading Logs	
		Survey	Pre and post survey-dependent t test
			Reading logs-correlated with all variables
			Correlation of all variables
<b>2) What are the impacts of PREP on reading motivation, reading frequency and reading achievement among primary struggling readers?</b>	Qualitative	Observation	NVIVO coding and interpretation
		Interview	
		Focus groups	

*Participants.* Sixteen primary elementary grades students and three of their parents were selected to serve as participants for this study. This population was chosen to participate because the study focused on the relationship between reading motivation, reading frequency and reading achievement of struggling readers in grades 1-3. These students were identified as struggling readers based on their DIBELS composite scores showing scores below their grade level. Data was collected daily over 12 weeks for all students participating in the study. Purposive sampling was used within the study based upon the researcher's familiarity with the population and school. The researcher, based on her knowledge of the students' abilities, applied expert knowledge of the population to select in a nonrandom manner an appropriate sample. The student population is predominantly Caucasian with 4% of the students identified as minorities. Three parents of different student participants agreed to be interviewed regarding their child's reading behavior and participation in the PREP program. These interviews were conducted over the phone, audio recorded and transcribed.

*Data Analysis.* The data from across the observations and interviews was analyzed case by case and a cross case analysis was developed based on themes gleaned from the data. Pre and post

DIBELS composite scores, pre and post self-concept survey measurement and pre and post PREP motivation measurement were measured using a dependent t-test and a correlated group t-test. Reading frequency numbers from the reading logs were correlated with self concept and a correlation of the all variables was performed.

## Results

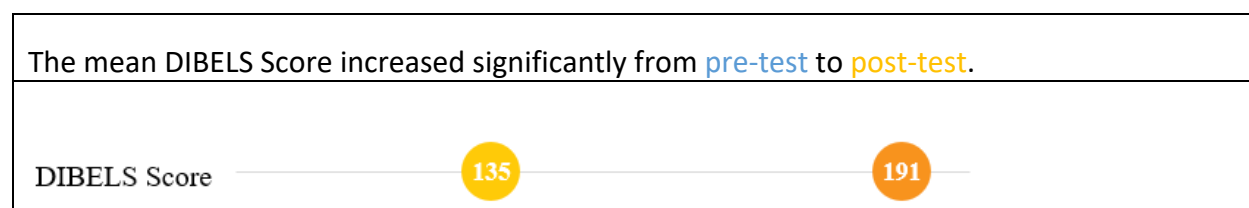
*Findings from Analysis of Quantitative Data.* Quantitative Research Question: What is the relationship between reading frequency and reading achievement on reading motivation for primary struggling readers involved in PREP?

*Descriptive Statistics.* The overall organizational scheme of the descriptive statistics in this study utilizes the mean, standard deviation and degrees of freedom of the variables to determine significance. These variables are the pre and post DIBELS composite scores, reading log counts and the pre- and post-motivation scales. The following tables and explanations further discuss the effect of PREP on students' reading achievement, reading motivation and reading frequency.

Table 2 displays the descriptive statistics for a paired-samples t-test conducted to compare Pre-DIBELS composite scores and Post-DIBELS composite scores of students participating in the PREP program. Among students participating in PREP ( $N=16$ ) there was a statistically significance between their Pre-DIBELS composite scores from September 2018 ( $M=134.81$ ,  $SD=22.46$ ) and their Post-DIBELS composite scores from December 2018 ( $M=190.69$ ,  $SD=31.66$ );  $t(5)=-2.23$ ,  $p \leq .05$ ,  $CI_{95} -109.32, -2.2$ . Figure 2 illustrates this data in a more reader-friendly way. These results suggest that the reading motivation program PREP may have a positive effect on the reading achievement of students who participate in the program. Specifically, these results suggest that the reading achievement of sixteen students participating in PREP over 12 weeks-time increased due to their exposure to the program. These results suggest that students who were exposed to the motivational constructs of PREP were able to achieve higher reading scores at the conclusion of the study.

*Table 2: Comparison of PreDIBELS and PostDIBELS Composite Scores*

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PREDIBELS – POSTDIBELS	-55.875	100.290	25.073	-109.316	-2.434	-2.229	15	.042



*Figure 5: Visual representation of DIBELS score*

Table 3 displays the descriptive statistics for a paired-samples t-test conducted to compare the overall reading motivation of students before and after participating in PREP. Among students participating in PREP (N=16) there was a statistical significance between their pre-motivation survey answers from September 2018 ( $M=45.38$ ,  $SD=.93$ ) and their post-motivation survey answers from December 2018 ( $M=48$ ,  $SD=2.36$ );  $t(15)=-2.68$ ,  $p\leq.05$ ,  $CI_{95} -4.71-.54$ . Figure 3 illustrates this data in a more reader-friendly way. These results suggest that the reading motivation program PREP does have an effect on the reading motivation of students who participate in the program. Specifically, these results suggest that the reading motivation of sixteen students participating in PREP over 12 weeks-time increased due to their exposure to the program. These results suggest that students participating in PREP were motivated to read because of the motivational constructs of self-concept, book choice, contingent reward and parental involvement within the program.

*Table 3: Comparison of Pre-motivation and Post-motivation Scales*

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	premotivation - postmotivation	-2.62500	3.91365	.97841	-4.71044	-.53956	-2.683	15	.017



*Figure 6: Visual representation of motivation score*

Table 4 displays a Pearson product-moment correlation coefficient computed to assess the relationship between reading nightly and reading achievement. There was a positive correlation between the two variables  $r(14) = .73$ ,  $p < .05$ . Overall, there was a strong, positive correlation between the amount of times students read during 12 weeks -time and their post DIBELS composite score at the end of those 12 weeks. Increases in nightly reading were positively correlated with increases in DIBELS composite scores. These results suggest that the more students read, the higher they scored on the post DIBELS test.

*Table 4: Post Reading Log Count Correlated with Post DIBELS Results*

		Logcount	PostDIB
Readinglogcount	Pearson Correlation	1	.730**
	Sig. (2-tailed)		.001
	N	16	16
POSTDIBELS	Pearson Correlation	.730**	1
	Sig. (2-tailed)	.001	
	N	16	16

*Findings from Analysis of Qualitative Data.* Qualitative Research Question: What are the impacts of PREP on reading motivation, reading frequency and reading achievement among primary struggling readers?

Qualitative data within the study was collected through observation, student and parent interviews, and small group focus groups. The organization of data with NVIVO provided a system for categorizing the various components so that data could quickly be located, pulled out, and the segments could be clustered and related to a particular research question, hypothesis, construct, or theme (Miles & Huberman, 1994). The data from across the observations and interviews was analyzed case by case and a cross case analysis was developed based on themes gleaned from the data.

*Table 5: Frequency of Codes Referenced for Themes within the Study*

<b>CODES (LABELED NODES WITH NVIVO)</b>	<b>REFERENCES FROM OBSERVATION</b>	<b>REFERENCES FROM SMALL GROUP FOCUS GROUPS</b>	<b>REFERENCES FROM STUDENT AND PARENT INTERVIEWS</b>
<b>READING FREQUENCY</b>	36	50	17
<b>BOOK CHOICE</b>	31	36	18
<b>REWARDS</b>	31	31	18
<b>READING ENJOYMENT</b>	24	24	13
<b>PARENTAL INVOLVEMENT</b>	23	23	12
<b>SELF -CONCEPT</b>	21	21	14
<b>READING LOG</b>	16	16	9

Table 5 displays the frequency of which indicators were most evident during small group focus groups, student observation and parent and student interviews. These indicators were labeled nodes within the qualitative software NVIVO. The researcher transcribed all interviews, focus groups, and observations into NVIVO and manually coded the transcriptions according to specific nodes. The indicators with the highest occurrences within the transcriptions were: Book Choice, Reading Frequency, Rewards, Reading Enjoyment, Parental Involvement, Self-Concept and Reading Log. These indicators were also evident within the quantitative findings of the study with subsequent sections showing the data that led to these findings.

## Discussion

The qualitative results were transcribed by the researcher from interviews, focus groups and observations into NVIVO and manually coded the transcriptions according to specific Nodes. The indicators with the highest occurrences within the transcriptions were: Reading Frequency, Book Choice, Rewards, Reading Enjoyment, Parental Involvement, Self-Concept and Reading Log. Reading frequency was the indicator with highest occurrence transcribed from observations, student and parent interviews, and small group focus groups. Reading frequency was coded 31 times within the transcriptions. The frequency of the topic of reading frequency demonstrates the importance of nightly reading on student reading motivation and achievement. Book choice was the indicator with the second highest occurrence transcribed from observations, student and parent interviews, and small group focus groups. Book choice was coded 36 times within the transcriptions. The frequency of book choice within the transcription highlights the importance of book choice related to reading motivation and student reading. Rewards was the indicator with the third highest occurrence transcribed from observations, student and parent interviews, and small group focus groups. The topic of rewards was coded 31 times within the transcriptions. The frequency of the topic of rewards demonstrates the importance of contingent reward related to reading motivation.

Table 6 displays a side by side analysis of the qualitative and quantitative data to provide a structure to discuss the integrated analysis of the mixed methods design and how it provides new insight into the data. The qualitative and quantitative results of the study were merged to better understand the reading motivation of students involved in PREP. The analysis compares and contrasts the themes of book choice, reading frequency, rewards, reading engagement, parental involvement, self-concept and reading log across both the quantitative and qualitative data. This display allowed the researcher to more fully understand the influences of the qualitative themes to validate the quantitative knowledge.

*Table 6: Side by Side Analysis of Qualitative and Quantitative Findings*

CODE FROM QUALITATIVE DATA	VARIABLE FROM QUANTITATIVE DATA	DESCRIPTIVE STATS	QUALITATIVE EVIDENCE	PARTICIPANT FEEDBACK EXAMPLE
READING FREQUENCY	Pre and Post Reading Frequency	Positive Correlation with Book Choice	36 coding references within data	Researcher: Why do you like Fly Guy books, Ben? Because they are easy to read. I read it 10 times in the car on the way to the credit union. Researcher: Great! How does that make you feel when you read a book 10 times? Ben: Really good! Because I know

				it will make me become a better reader.
<b>BOOK CHOICE</b>	Pre and Post Book Choice	Positive Correlation with Reading Frequency	31 coding references within data	<p>Researcher: What is one of your favorite books to choose in class?</p> <p>Jack: You can choose Epic on an iPad. It has a lot of books. Today at Miss Ryan's I read three books, one about scorpions, millipedes and centipedes. I just typed in bugs and they were all there!</p>
<b>REWARDS</b>	Pre and Post Contingent rewards	Positive Correlation with Reading Frequency	31 coding references within data	<p>Researcher: We talked about the scratch offs and all the rewards related to reading, right? Do all those things make you excited about reading? Class: Yea! Dom: Because they encourage you more and more and more to read and Mrs. V. puts them in a fun way. They are a mystery and you always can get something cool.</p>
<b>READING ENJOYMENT</b>	Pre and Post Motivation	Results show reading motivation higher after PREP participation	24 coding references within data	<p>Researcher: Is reading something you like to do? Henry: Yes!</p> <p>Researcher: Why is reading something you like to do? Henry: I like hearing the stories and seeing the pictures in my head.</p>
<b>PARENTAL INVOLVEMENT</b>	Pre and Post Parental Involvement	Positive Correlation with self-concept	23 coding references within data	<p>Researcher: Ariana who do you reading with at home? Ariana: Sometimes it's my mom and sometimes it's my Dad. It's mostly my Dad. When it's close to nighttime we read a book that I got from here or a book in my room. We don't take turns but if we get one of those We Both Read books then I'll read the kids</p>



				side and Dad will read the parent side. I have some of those books.
<b>SELF-CONCEPT</b>	Pre and Post DIBELS, Pre and Post Self Concept	Positive Correlation with overall reading motivation, Results show higher self-concept, higher reading achievement and higher motivation to read	21 coding references within data	Researcher: What is your favorite part of coming to reading class? Ben: Because I want to become a better reader. Researcher: Do you think coming to reading class helps you to become a better reader: Ben: Yes. In Kindergarten I always wanted to read a book and I wondered how it would feel to read a book. Researcher: And how did it feel? Ben: Good!
<b>READING LOG</b>	Pre and Post Reading Frequency	Positive Correlation with Post DIBELS	16 coding references within data	Researcher: What if you didn't have a reading log? Class: Oh no! Researcher: Do you think you would read as much. Class: No! Researcher: Why not? Izzy: Without your reading log, you wouldn't know how much you've read. If you forgot your reading log forever and never used it again you would never get better at reading.

## Conclusion

The current state of reading motivation among struggling, primary readers often is overlooked. Addressing reading motivation support is not an essential piece of the reading curriculum in most schools and teachers often fail to see the fundamental importance of promoting motivation within the reading process. When internal motivations such as intrinsic motivation and interest energize students' reading, students interact with text deeply and gain relatively high amounts of knowledge or aesthetic experience (Schiefele, 1999). If students' reading interests are weak, their competency grows little and their quality as readers diminishes (Guthrie et al., 2007). What is needed in a program is not only the initial development of reading motivation but its sustainment through active literacy learning.

Findings from the current study suggest that to promote reading motivation among primary struggling readers, teachers should address the motivational supports of self-concept, book choice, contingent reward and parental involvement with their students to aid reading motivation in the classroom. These factors, when effectively used together, promote intrinsic motivation for struggling readers in the primary grades. Among sixteen struggling first through third grade readers, the findings indicate that addressing these specific factors motivated students to read more frequently which positively affected their self-concept of themselves as readers. Few programs or approaches comprehensively and sufficiently address these tenets in a unified framework. PREP is a powerful reading engagement program that motivates primary struggling readers. This study proposes a practical implication of this relationship for the struggling primary reader. This study also demonstrates how contingent reward, reading frequency, book choice, and parental involvement motivate primary students who struggle to read to develop a daily reading habit and become improved, independent reading.

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### About the Author

**Jeannie Votypka, Ph.D.**, is an Assistant Professor of Literacy at Baldwin Wallace University in Cleveland, Ohio. She has taught literacy courses in higher education for the past two years. Prior to teaching in higher education, she was a reading specialist for 16 years serving struggling readers in grades kindergarten through third grade. Her current research focuses on elementary reading motivation and replicating the PREP program. Please contact Jeannie if you have interest in developing the PREP program. Email: [jvotypka@bw.edu](mailto:jvotypka@bw.edu).

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**Appendix A: Link to PREP Teacher Handbook**













<https://documentcloud.adobe.com/link/track?uri=urn%3Aaaid%3Ausc%3AUS%3A6e8952ad-d70f-4726-a1f1-d0122d6fb79b>

**Appendix B: Parent Interview Questions**




1. Do you read with your child? If so, how often?
2. What is the physical space where you typically read with your child?
3. What time of day do you typically read with your child?
4. Do you take trips to the library with your child? If so, how often?
5. Do you read your child's chosen book from his/her reading bag each night? If so, do you find the repeated reading of this book to help your child's reading fluency?
6. What are your thoughts on your child's reading progress thus far?
7. What is your opinion of the reading log?
8. What do you feel motivates your child to read the most?
9. Do you think your child gets excited about earning stickers and contingent rewards for reading in reading class?
10. How do you think your child views themselves as a reader?
11. Is it helpful for you when books are sent home or would you prefer to choose books for your child?
12. Do you ever use technology to motivate your child to read?



















### Appendix C: Student Survey

#### PREP Motivational Reading Survey Reading Self-Concept Questions















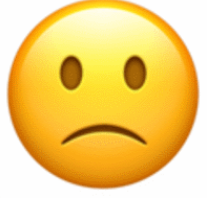
Reading is something I like to do.			
I am a good reader.			
I read as well as my friends.			
When I am reading by myself, I understand most of what I'm reading.			

#### PREP Specific Questions

<b>Book Choice</b>			
Signing out books from the classroom library to take home is fun.			

Color coded shelves in the classroom make it easy to find my just right book.			
I like to have different choices of books to choose from like comics, magazines, storybooks and nonfiction.			
Reading is easier when I practice every night.			
My reading bag helps me become a better reader.			
Earning stickers for reading books makes me feel good.			
<b>Contingent Reward</b>			
Earning prizes related to reading like scratch-offs make me feel excited about reading.			



Earning prizes related to reading like buddy reading encourage me to read more.			
Earning books on Epic make me excited about reading.			
<b>Parental Involvement</b>			
I feel happy when my parents sign my reading log each night.			
Reading with my parents makes me feel good.			
My parents help me become a better reader.			

**Appendix D: Student Interview**

1. Is reading something you like to do?
2. Do you think you're a good reader?
3. What kind of books do you like to read?
4. Do you like to read with other people?
5. Do you like to read by yourself?
6. Do you like to read silently or out loud?
7. Do you ever read with your parents at home?
8. Do you think you read as well as your friends?
9. Do you think reading is easier when you practice every night?
10. Do you like choosing books from your classroom library?
11. Do earning prizes like scratch offs, cozy chair and buddy reading make you excited about reading?
12. What is your favorite prize to earn?
13. How do you think your reading practice bag makes you a better reader?
14. What do you like best about your reading practice bag?
15. How does it feel when your parents sign your reading log each night?
16. How does it feel to earn stickers for each time you read?
17. How does it feel when they forget to sign your reading log?
18. What is your favorite part about coming out to reading class?

**Appendix E: Student Focus Group Questions on Book Choice**

1. Why is it so fun to have a choice to read the books you want?
2. Does having a choice make reading easier for you?
3. How do you usually choose a book to read from the classroom library?
4. How can you tell if a book is too hard for you to read?
5. Where do you like to choose books from the best? It could be your classroom library or in here or at a bookstore...
6. Does it make you feel better when you know the books you've chosen are at your level?
7. What are your favorite kinds of books to read?
8. Do you like to read magazines?
9. Do you like to read comics/graphic novels?
10. A lot of time reading isn't looking at paper pages. Reading can be done on the computer or iPad. What kind of reading do you like to do that way?

**Appendix F: Student Focus Group Questions on Contingent Reward**

1. How do you earn prizes in reading class?
2. What kind of prizes do you get from the prize box?
3. Why are scratch off tickets everyone's favorite prize to receive?
4. What are some of the rewards you've scratched off?
5. Why are those rewards fun?
6. We talked about the scratch offs and all the rewards they give related to reading, right? Do all those things make you excited about reading?
7. What other prizes are in the prize box?
8. Are the prizes the best part of coming to reading class?
9. Do you think the prizes keep you reading?

**Appendix G: Focus Group on Parental Involvement**

1. Today we're going to talk about how our Parents are involved in reading with us.
2. Who reads with you at night?
3. Do you have a nightly reading routine?
4. Do you have a special place where you read?
5. Do you ever take turns reading when you read with your parents?
6. Do you think you'd be a good reader if your parents didn't help you?
7. How do your parents encourage you to read?
8. How do your parents make reading fun for you?
9. Do your parents remind you to read each night?
10. Do your parents ever pick out books for you from the library or bookstore?
11. Do you ever see your parents reading?

# TEACHING MATHEMATICS WITH MUSIC TO YOUNG CHILDREN AND CONNECTING FAMILIES

**Smita Guha**

**St. John's University**

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**Abstract** This project was designed to engage children in learning mathematics through music in a pre-k classroom. The Pre-k teacher noticed that children were getting disinterested in learning mathematics but showed interest in music. In the unit on “Penguins” the teacher implemented the mathematics lessons with music. It was observed that all the children enjoyed mathematics while getting involved with music. To ensure school home continuity children were asked to make drums at home from recycled materials and bring to class for show and tell. Parents appreciated to be a part of their children’s learning process.

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**Keywords:** teacher action research, children, mathematics, music, families

## Introduction

Learning mathematics from early years is an important aspect of cognitive development. Mathematics helps children make sense of the world around them and provides vital life skills. Learning mathematics assists children to solve problems, estimate, measure, and develop their own spatial awareness. Therefore, it is important to develop a good disposition towards mathematics among young children.

Teachers play an important role in inspiring and being a role model for children by providing opportunities to learn and develop new skills. However, often teachers confront challenges that their students are not motivated in learning mathematics. By analyzing a problem in specific classroom circumstances, teachers modify their practice to become effective teachers. To examine the interests of children and teaching children according to their interests makes teaching effective. Early childhood teachers use different strategies to motivate children to teach mathematics. Among a variety of strategies, music integration is an effective strategy.

## Literature Review

The association of math, music, and cognition persisted across time and culture existed in US public education system. Horace Mann, a founding thinker of public education, used this point when arguing the importance of music education in the core curriculum (Southgate & Roscigno, 2009). Although music class exists in the school curriculum in the public schools,

yet music is regarded as a separate class in the school routine and seldom integrated in the subject area.

The theory of multiple intelligences developed by Howard Gardner (1983) has significantly influenced education. Among the nine intelligences Gardner stated *Mathematical-Logical* intelligence which is the ability to think conceptually and abstractly; *Visual-Spatial* intelligence that is the capacity to think in images and pictures, to visualize abstractly and accurately. *Bodily-Kinesthetic* intelligence that is the ability to control one's body movements and of course *Musical* intelligence is the ability to produce and appreciate rhythm, pitch, and timber. Although critiqued, yet Gardner's (1997) explanation was important: music may be a privileged organizer of cognitive processes, especially among young children. (Choy & Kim, 2008).

*Connection between Mathematics and Music.* There is a connection that exists between music and mathematics (Chandler, 2008; Guha & Chakrabarty, 2015). From the works of Pythagoras and Rameau, basic mathematical ideas are inherent in music. (Papadopoulos, 2002). It is true that mathematics can help investigate hidden patterns and structure in music and that approach can be effective in pedagogy of mathematics and STEAM (Mannone, 2019). Chandler (2008) in his study indicated that there is a connection that exists between music and mathematics. Another way that mathematics and music are related is that both feature abstract, rules-based, and are non-phonetic (Chandler, 2008). According to Shilling (2002) the linkage of music and mathematics builds children's perspective of the world.

Studies also have been done to examine a relationship between music and mathematics in terms of memory. Schmithorst & Holland (2004) hypothesized that the correlation between musical training and mathematics proficiency may be associated with improved working memory performance and an increased abstract representation of numerical quantities. They found in their research a statistically significant difference in the neural correlates of mathematic processing between musicians and non-musicians. The musicians were employing a more "abstract" representation of numbers and especially fractions. Spatial task performance was superior after listening to fast tempo music rather than slow, and music presented in major rather than minor mode. The findings are consistent with the view that the "Mozart effect" is a consequence of arousal and mood changes (Husain, Thompson, & Schellenberg, 2002).

The connections between **music** and mathematics are always present. Music, especially, classical music can also help students learn mathematics in a much more enjoyable manner (Crowder, 2008). Music is more than notes conforming to mathematical patterns and formulas; it is exhilarating because of the intricacies of occurring patterns. Whether these patterns resemble mathematics has no relevance to many musicians. Musicians are inclined to practice music because of the wonders and awe that they feel for music even if they are not aware of the mathematics that is in music (Zhan, 2008).

*Music and Mathematics Skills.* Many research studies suggest that music enhances mathematics skills. Evidence supports the positive effects of music on one's mathematic ability. Research suggests that young children, who were trained in music, tend to have improved mathematic skills (Zhan, 2008). From young children to adult, studies indicate that music helps in mathematics. Functional Magnetic Resonance Imaging (fMRI) was performed on fifteen adults, seven adults with musical training since early childhood and eight without, while they mentally added and subtracted fractions. They found that the correlation between musical training and mathematic proficiency may be associated with improved working memory performance and an increased abstract representation of numerical quantities (Schmithorst & Holland, 2004).

Further, Rauscher (1993), found that mathematics test scores for preschool-age students increased for those who received instruction in piano, rhythm or singing. The students who studied rhythm had the biggest impact. According to Rauscher (1993), rhythm is, after all, "the subdivision of a beat". It is about ratios and proportions, the relationship between a part and a whole -- all material from math classes. The ability to write mathematical proofs is also associated with Spatial-Temporal (ST) reasoning. Proof writing requires intuitive sense of natural sequences and the ability to think ahead several steps (Zhan, 2008). In the same study, Zahn (2008) mentioned that medical doctors found certain regions of the brain such as the corpus callosum and the right motor cortex, were larger in musicians who started musical training before the age of 7. Researchers suggested that the Mozart's effect on the Spatial-Temporal reasoning is crucial in mathematics. Geometry and aspects of calculus require ST reasoning due to the transformations of images in space and time (Zhan, 2008). The part of the cortex containing the repertoire of Spatial-Temporal firing patterns can be excited by music and is utilized in higher brain functions such as ST thinking in mathematics. Music targets one specific area of the brain to stimulate the use of Spatial-Temporal reasoning useful in mathematical thinking. Zhan (2008) emphasized sequential skills, rhythm and pitch improve children's math ability. There are two types of reasoning, Spatial Temporal (ST) reasoning and Language Analytical (LA) reasoning. LA reasoning is involved in solving equations and quantitative results. ST reasoning is utilized in activities like chess when one needs to think ahead several moves. The effect of music on mathematics can be termed the *Mozart effect*. The *Mozart effect* was named after the discovery that listening to Mozart's compositions, which are very sequential, produces a short-termed enhancement of spatial-temporal reasoning.

*Integration of Mathematics and Music.* Since there are a lot of skills that overlap in music and math, music could be a great avenue to teach children mathematics. Often, music teachers are being asked to integrate mathematics standards with their general music curriculum (Jones & Pearson, 2013). The integration of mathematics with **music** will help children achieve national, and state learning standards in mathematics and creative arts. Edelson & Johnson (2003) focuses on an interdisciplinary teaching method with a mathematics and music combination. They emphasized pattern activities within mathematics and **music** combination. Pattern work prepares children for number system patterns, such as alternating odd and even numbers.



Integrating **music** with mathematics does not require musical training or expensive equipment. This enables children to easily learn mathematical concepts, while having fun. Although a number of critiques by art educators have expressed concerns about the use of the arts only as a tool for teaching core disciplines, however, Edelson & Johnson (2012) mentioned that components of developmentally appropriate practice for young children, as defined by the NAEYC (Bredekamp & Copple, 1997), state that mathematics needs to be integrated with songs; children need to understand notation, rhythm, and explore their relationships; children should also have daily opportunities for aesthetic expressions through art and music. Geist, Geist & Kuznik (2012) indicated that children have the potential to be more engaged when listening to steady beats than when listening to verbal-only instructions. According to Edelson & Johnson (2003) teachers can use **music** to enhance the understanding of difficult mathematical concepts and skills. Moreover, Jones & Pearson (2013) demonstrated how a musician and a mathematics educator created elementary school lessons integrating music and mathematics. Students learned basic music theory for example identifying notes and learning their fractional values. They learned about time signatures and how to determine correct note values per measure. The purpose was to illustrate how music teachers could collaborate music with math. The lessons described in this article provided strategies to help music educators and elementary school teachers integrate music with mathematics. These lessons provided strategies to integrate music (reading and notating music) and mathematics (development of understanding fractions). Students were introduced to the concept that rhythm measures time. When putting music on paper, the notes were divided into measures (or bars) each representing a unit of time. (Jones & Pearson, 2013) Similarly, Rauscher and Hinton (2006) in their study assert the part-whole concept necessary for understanding fractions, decimals, and percentages are highly relevant in understanding rhythm. Garland & Kahn (1995) showed that time signatures resemble fractions. The “numerator” telling us the beats in each measure and the “denominator” telling us the type of note that gets the beat. In the study by An, Capraro & Tillman (2013) teachers integrated a variety of music activities with different mathematical content. They found that the music-math interdisciplinary lessons had positive effects on multiple mathematical ability areas.

There are a number of strategies that teachers have adopted in harnessing the power of music to teach mathematics to the children. Educators need to look for different ideas around the world to examine how through music lessons, children could learn mathematics skills. Young (1971) mentioned that music educators have come to recognize the need to include a variety of world music in all music curricula.

*Enhancing Mathematics Curriculum with Music.* As Diamond & Hobson, (1998) mention music enhances a math curriculum, it creates an atmosphere free of undue pressure and stress; infuses pleasurable intensity, promotes exploration and the fun of learning, and allows the child to be an active participant rather than a passive observer. Since music has the power to enhance the curriculum and creates relaxation and enjoyment for children, then, it is important to integrate music in the curriculum. It is, therefore, important that the teachers of young children realize the power of music and modify their practice to become effective teachers.

Although the above literature supports music integration in mathematics curriculum, the problem still exists how teachers could integrate music with existing curriculum. An important focus of this study was for a pre-k teacher to take initiative with music integration when children were getting unmotivated in the mathematics classroom. As a university faculty, I worked with the Pre-k teacher to initiate a qualitative action research project to integrate music in teaching mathematics with the existing curriculum.

*Objective of the research.* The objective of this research was to motivate the children in a Pre-k class to learn mathematics through music. “How can music be integrated in mathematics teaching so that children enjoy learning mathematics?” was the research question. The prediction was the students would enjoy learning mathematics if mathematics is integrated through music.

## **Methodology**

*Participants.* The school was located in Queens, New York. Ninety percent of the children were Chinese American. There were 41 four-year old children in two classrooms. Twenty (20) children were in Treatment group and 21 children in the Control group.

*Setting.* In this school, mathematics was taught in the traditional method using workbooks in the class with few manipulatives. The children were not showing any interest in learning mathematics. However, children showed interest in music during circle time. They wanted to continue with music and expressed dissatisfaction when it was mathematics time. Therefore, to nurture children’s interest in music, in the upcoming scheduled unit on “Penguin”, the Pre-k teacher and I planned three ways to integrate music into mathematics: through song, dance and instrument. This idea resonated with the musical intelligence by Campbell, Campbell & Dickinson (1996), focusing on singing, musical notation, curriculum songs, and musical instruments. Further, to make a school-home connection and to continue learning at home, music bags were created so that the children could take those bags home to work with their parents. In that way parents will be involved in children’s learning and this project will help connect with families with school. The teacher and I looked at the Common Core Standards and The Mathematics standards to make sure we addressed the standards appropriately. (See Appendix A)

*Study Design.* In the current study, a qualitative research design was implemented to examine how music could be integrated with mathematics curriculum to motivate and engage children in mathematics learning. The Treatment group had all the lessons integrating music with the mathematics curriculum. There was another similar class where there was no integration of music with mathematics. Children were exposed to music as part of their routine. This class was regarded as the Control group.

In the Treatment group, the lessons included prekindergarten foundation for the common core in mathematics and music. The mathematical concepts that the children were supposed to learn were numbers, quantities, cardinality, positional words, addition,

measurement, patterns, measuring, graphing data, counting and math operations. The teacher decided to assess the project's impact by asking question before, during and after the lesson.

*Procedure.* In the Treatment group, the classroom was set up in centers. The small groups of students would sit on the rug and the teacher would introduce the activity of that day. Next, the students would go to the art, music, or manipulative center. Based on the activity, the table would be set up with the materials and procedures. When the students were done with the activity, they would go back to the rug to discuss what they learned and discovered.

There were five different lessons for the children (see Table 1). At the beginning of every lesson, either a book was read or a song/video was played on the Smart Board. Every lesson had different learning materials.

*Table 1: Procedure of Integrating Mathematics and Music with Learning Materials*

LESSONS	LEARNING MATERIAL/ BOOK	MANIPULATIVE	MATH SKILL	TYPE OF MUSIC
<b>LESSON 1</b>	<i>The Five Little Penguins Slipping on the Ice</i>	penguin counting cards; match penguins to penguin erasers; penguin popsicles	Counting; one to one correspondence; Subtraction: how many penguins were left	Song
<b>LESSON 2</b>	<i>Penguin Addition</i>	Drums, pencils	Patterns; addition	Time distribution with each note; quarter note; rhythm or beats with a drum
<b>LESSON 3</b>	<i>Where is this Penguin Hiding?</i>	Velcro book	Positional words: right and left flippers	Song and dance

<b>LESSON 4</b>	Bolang gu	Made Bolang gu instrument with different amount of beans	Compared sounds with different amount of beans and with traditional instrument	Video; Bolang gu instrument; dance;
	<i>Intro to Music</i>	Music math cards and addition flashcard for music notes. Rhythm Round About games	Binary number with zero and one	Music notes
<b>LESSON 5</b>	<i>Pat -A-Cake</i>	measuring cups and ingredients- cooking- bake a cake; flash cards	Measurement	Pat-a-cake rhythmic song; song, dance

The *Five Little Penguins Slipping on the Ice* learning material was integrated with the penguin counting cards and with a song. The song involved counting cards where the children had to match penguins to penguin erasers, to find out if the children can identify one to one correspondence. At first, the teacher sang the *Five Little Penguins Slipping on the Ice* to the students. Before the teacher changed the page, the student predicted how many penguins were left. Then the teacher made penguin popsicles and took one away each time. Lastly, the students used penguin erasers to match the number that correlates on the penguin counting card.

The *Penguin Addition* learning material was taught with drums to teach patterns. This book was made after exploring the Internet to find out the length of time needed for each note. The teacher discussed the concept of addition by taking a few pencils. While reading the book the teacher demonstrated the beats on a real drum. The teacher then asked the students if they saw any patterns in the book. The teacher asked questions about quarter notes and addition throughout the book. Lastly, the students explored the different drums and played different beats on it. The students also added the number of beats they played. *Where is this Penguin Hiding?* was with a song on Youtube. The song involved learning positional words and the children danced as they were learning. At first, the teacher put on the penguin song on Youtube. The teacher asked the positional words while reading the book then asked the students where the right and left flippers was. Lastly, the student interacted with the Velcro book to learn about positional words.

The *Bolang gu* learning material was integrated with the bolang gu instrument. First, the teacher showed the students a video of a women playing the bolang gu. Then the students played with the traditional bolang gu. The students made two different bolang gu with different amount of beans. The students put two beans in one bolang gu and put ten in the other bolang gu. Then the students compared the sounds of two different bolang gu that they made. The students also compared the sounds of the bolang gu they made to the traditional one. The teacher then replayed the video and the students danced to the video with their bolang gu. Lastly, the student made two bolang gu based on the traditional bolang gu. Later, they danced to the video with their bolang gu.

*Intro to Music* learning material was taught with music math cards and addition flashcard for music notes. Then the teacher asked the students question about music notes. The students then went to the manipulative center to play with Rhythm Round About and the Music Math Cards. They applied what they learned about math notes to the games. They learned binary numbers of zero and one with the music notes.

*Pat -A-Cake* learning material was kept together with the measuring cups and ingredients. The procedure for *Pat -A-Cake* involved cooking. At first, the teacher sang the Pat-a-cake song. Then, the teacher discussed with the student how to bake a cake. Third, the teacher showed the students flashcards of the steps to make a Nutella mug cake. The students then measured the ingredients for the Nutella mug cake. Lastly, the student sequenced how to make the Nutella mug cake and measured the ingredients. Then the cake was put in the oven while the children sang and danced.

The teacher prompted the students to think about open ended questions before and after the experiment by making charts and having discussions. Students who needed more help, were paired up with students who were more advanced. For the bolang gu activity, the teacher helped them staple/glue the two plates together if the students needed help. Then the cake was put in the oven while the children sang and danced.

*Role of the Researcher.* Once a week the researcher interacted with the classroom teacher for half an hour for 14 weeks. The researcher kept notes and spent time with the teacher discussing about the plan, about the interaction of the children and about the music lesson to find out if the children were more motivated and engaged. The researcher shared new musical ideas based on the children's participation and together the researcher and the teacher identified moments of success and rooms for improvement.

*Data Collection.* An effective way to keep track of the children's reaction was to keep documentation in a field journal by using running record and anecdotes with dated clips. The field journal was enriched with three semi structured interviews with the classroom teacher conducted at the beginning, middle and at the end of the collaboration with the researcher. The questions focused on the attitude of the teacher about teaching mathematics with music and the ways music could be integrated in the teaching. A systematic data collection took place throughout the unit. The teacher gave a check when the students participated in music and a double check when the students showed

enthusiasm in math activities. She entered a star when the students learned mathematics through music intervention.

Further, the teacher provided weekly logs on the integration of music in the classroom and how the children participated. The logs included an overview of the lesson and the activities each day. The teacher also reflected about the success and challenges of each day's lesson and children's participation record. At the end of the study, the teacher shared about ideas for future improvement.

## Results

The children learned numbers, quantities, cardinality, positional words, addition and measurement through music. (Table 2 showing Learning Outcome).

*Table 2: Learning Outcome of Children*

THE CHILDREN LEARNED NUMBERS, QUANTITIES, CARDINALITY, POSITIONAL WORDS, ADDITION AND MEASUREMENT.
THEY ALSO LEARNED ABOUT DIFFERENT INSTRUMENTS FROM DIFFERENT CULTURE, FOR EXAMPLE THE BOLANG GU AND THE AFRICAN DRUMS.
THE STUDENTS DID THE MATH ACTIVITIES WITHOUT KNOWING THAT THEY WERE LEARNING MATHEMATICS CONCEPT BECAUSE THEY WERE HAVING SO MUCH FUN PLAYING WITH THEIR FRIENDS.
TWO CHILDREN HAD DIFFICULTY WITH INTRO TO MUSIC BECAUSE THEY HAVE NEVER SEEN MUSIC NOTES BEFORE BUT ONCE THE TEACHER REVIEWED IT, THEY STARTED TO HAVE FUN WITH THE ACTIVITY.
AS THE CHILDREN WERE PLAYING WITH THE DRUMS, THEY WERE COUNTING THE BEATS WHILE HITTING THE DRUM ACCORDING TO THEIR SONGS THAT THEY WERE SINGING.

They also learned about different instruments from different culture, for example, the bolang gu and the African drums. The students did the math activities without knowing that they were learning mathematics concept because they were having so much fun playing with their friends. Several different learning materials involving mathematics and music made a huge difference. As the year progressed, the children asked when we are going to sing; three children also asked if they would make drums again. As children were involved with music on their own with mathematics learning, the teacher continued putting stars and we were happy to see the increasing number of stars.

All the children earned checks, double checks and stars continuously. Emily said: "I like cooking with chocolate" (- Pat-A-Cake lesson). Eric exclaimed: "This is so much fun. Can I make another one?" (-Bolang gu lesson). Isabella mentioned: "The penguin is flapping his flipper, so funny" (-Where is the Penguin Hiding? lesson). (Table 3 showing children's enthusiasm).

*Table 3: Children's Enthusiasm During the Unit*

EMILY SAID: "I LIKE COOKING WITH CHOCOLATE" (- PAT-A-CAKE LESSON).
ERIC EXCLAIMED: "THIS IS SO MUCH FUN. CAN I MAKE ANOTHER ONE?" (-BOLANG GU LESSON).
ISABELLA MENTIONED: "THE PENGUIN IS FLAPPING HIS FLIPPER, SO FUNNY" (-WHERE IS THE PENGUIN HIDING? LESSON).
THE STUDENTS ENJOYED BRINGING HOME RECYCLED MATERIAL TO MAKE THE DRUMS. DURING SHOW AND TELL, ALL THE STUDENTS WERE EXCITED TO TALK ABOUT THEIR DRUMS AND HOW THEY MADE AND WHO MADE IT WITH THEM. THE BEST PART WAS WHEN THEY WERE EXPLORING WITH EACH OTHER'S DRUM AND DISCOVERING THE DIFFERENT SOUNDS THAT DRUMS COULD MAKE.
THREE CHILDREN ALSO ASKED IF THEY WOULD MAKE DRUMS AGAIN.
ALL THE CHILDREN EARNED CHECKS, DOUBLE CHECKS AND STARS CONTINUOUSLY.

Overall, the students seem to have fun during the activities. They like working with each other to figure it out. Two children had difficulty with Intro to Music because they have never seen music notes before but once the teacher reviewed it, they started to have fun with the activity. (Table 2: Learning Outcome)

There was no change in the other class. Parents in the comparative group came to know about the drums and asked us if we are also going to do a *show and tell* with drums in their class. The control group was allowed to experience the treatment of integrating music with mathematics after the study was finished.

During the project, music bags were created for the students to take home. The bag consisted of an introductory letter to the parent explaining the content of the bag, materials and books and musical instruments, procedure and a survey questionnaire to find out how the child enjoyed working on music and mathematics at home. One of the items was to make a drum with recycled materials. The step-by-step procedure of making a drum was explained in the bag. The parents and the students enjoyed bringing home recycled material to make the drums. During show and tell, all the students were excited to talk about their drums and how they made and who made it with them. The best part was when they were exploring with each other's drum and discovering the different sounds that drums could make. As the children were playing, they were counting the beats while hitting the drum according to their songs that they were singing. Overall, the parents loved taking home the music bag and spending time with their children to learn about the week's theme.

The parent survey questions were: How much does your child enjoy music? How important is to incorporate music in the academic curriculum? One parent mentioned that she would rather have children sing math songs than play video games. Another parent mentioned

that with learning music “my child not only learned math but also English”. Since the children were Chinese American and not all the parents spoke English fluently, hence English songs were very much appreciated. Making drums and bringing to class for *show and tell* was the excitement of all. The children were so happy to show off their drums they made. They described the whole process of how they made their drums. All the parents agreed that mathematics and music are important part of the academic curriculum.

## Discussion

The action research study helped the teacher and myself to take a fresh look at our efforts to encourage children to enjoy learning mathematics with music. Learning mathematics is an important area and so also learning music. Looking at the enthusiasm of the students and the support from the parents, the teacher wanted to continue teaching mathematics involving music as it contributed to effective teaching.

This research is aligned with Horace Mann’s thinking that music should be integrated with the core curriculum. Indeed, this research echoed the same as Gardner’s (1997) statement that music was the organizer of cognitive process. This study confirmed the connection that exists between music and mathematics as also indicated by Chandler (2008), Chandler (2008) and Guha & Chakrabarty (2015). Similar to the study by An, Capraro & Tillman (2013), the UPK teacher in this study also integrated a variety of music activities with different mathematical content. The music-math interdisciplinary lessons had positive effects on the children with learning of mathematics. The findings in this study were consistent with the view that the “Mozart effect” is a consequence of arousal and mood changes (Husain, Thompson, & Schellenberg, 2002).

Since there are a lot of skills that overlap in music and mathematics, therefore this study indicated that music could be a great avenue to teach children mathematics. This study echoed the same as the study by Edelson & Johnson (2003) who focused on an interdisciplinary teaching method with a mathematics and music combination. Here also the teacher emphasized pattern activities within mathematics and **music** combination. Further, this research demonstrated that integrating **music** with mathematics did not require musical training or expensive equipment. As mentioned by Edelson & Johnson (2012) that components of developmentally appropriate practice for young children, as defined by the NAEYC (Bredekamp & Copple, 1997), stated that mathematics needs to be integrated with songs; children need to understand notation, rhythm, and explore their relationships; children should also have daily opportunities for aesthetic expressions through art and music. The UPK teacher incorporated all of the above developmentally appropriate practices. In agreement with Geist, Geist & Kuznik (2012) this study also indicated that children have the potential to be more engaged when listening to steady beats. The biggest impact on the students was in rhythm with the drum making and that is similar to the findings by Rauscher (1993).

Music enabled children to easily learn mathematical concepts, while having fun. Children practiced mathematics because of the wonders and enjoyment they felt for music and tend



to have improved mathematics skills as in the study by Zhan (2008). This study resonated the same tune with Diamond & Hobson, (1998) mentioned music enhances a mathematics curriculum, it creates an atmosphere free of undue pressure and stress; infuses pleasurable intensity, promotes exploration and the fun of learning, and allows the children to be an active participant rather than a passive observer.

Since music has the power to enhance the curriculum and creates relaxation and enjoyment for children, then, it is important to integrate music in the curriculum. From this study therefore, it can be concluded that it is important that the teachers of young children realize the power of music and modify their practice to become effective teachers.

In the future, to further music and mathematics concepts, we would introduce air instruments and string instruments. Then we would compare instruments from different countries based on their sounds and structures. The limitation of the study was all the lesson plans were on penguins as *penguin* was the scheduled unit, so for future lesson plans we would include different animals and what sounds they make to communicate with each other. Although integrating music with mathematics is not a novel idea however, this project indicated that children need different ways other than traditional method to learn mathematics. The excitement that was generated among children and among parents was a rewarding experience. The parents really liked the idea how music was integrated with mathematics learning.

### **Implications**

This project was effective because not only did the children enjoy the project, but the parents appreciated too. This project has taught us that music helped students grasp mathematical concepts effectively and in an enjoyable manner. The project made us think about individual student and their needs and interest. Two children were falling behind in mathematics and those children became enthusiastic learners with integration of music. New York State has placed emphasis on teaching the standards and this kind of action research project helps us integrate teaching children, addressing teaching standards, while children enjoy learning. Like Mannone's study (2019), this research was effective for the pedagogy of mathematics and STEAM. Music helped students be better learners. Students started loving mathematics and hopefully will continue loving mathematics through their educational career and in life.

### **Conclusion**

The purpose of the study was to motivate the children in a Pre-k class to learn mathematics through music. The children learned numbers, quantities, cardinality, positional words, addition and measurement through music. They also learned different instruments from different culture. It was amazing to see the students do mathematics activities without realizing that they were learning mathematics concept because they were having so much fun playing with their friends. With the increase in the number of stars children were receiving, it was obvious that the children were enjoying the combination of mathematics with music.

The teacher although was nervous at the beginning to integrate music with mathematics but became more comfortable gradually. Her confidence level gradually increased while she was integrating mathematics with music. She told me how it was challenging at the beginning when the children were disinterested in mathematics. She tried so many ways but, she felt music integration was the most effective strategy of all. She mentioned how she enjoyed every lesson and the excitement that was generated with the drum *show and tell* was the rewarding experience. Overall, the project of integrating mathematics with music was very successful for the children as well as for the teacher and made the families happy and involved in the children's learning process.

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#### **About the Author**

**Smita Guha, Ph.D.** is an Associate Professor at St. John's University in the School of Education and in the Department of Curriculum and Instruction. She received her Ph.D. from State University of New York at Buffalo. Her research on childhood and early childhood education, focuses on teacher education in the area of math and science education. She has over ten years of experience working directly with children and over 23 years of experience teaching in higher education. To build foundation in teacher education, her research focuses on health and nutrition and also teaching mathematics and science through music. She has written two books *Today's Youth, Tomorrow's Leaders* and *Healthy Children*. Her third book *Teacher as Researcher: Becoming Familiar with Educational Research to Connect Theory to Practice* is in press. Her articles have been published in peer reviewed scholarly journals. She presented at numerous conferences at International, National, State and Regional levels. Email: guhas@stjohns.edu

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## **Appendix A: Link to Standards**

**New York State Pre-Kindergarten Foundation for the Common Core:**

<http://www.p12.nysed.gov/earlylearning/standards/documents/PrekindergartenFoundationfortheCommonCore.pdf>

